THE PARADIGM THAT APPLIES TO ALL RAINFOREST RESTORATION IS ADAPTIVE MANAGEMENT

Adaptive management is all about having or being able to find a Plan B. If you have to do something: begin with what is known, then watch. If it goes awry, work it out, change course and adapt: it is simple really! The fledgling Golden Whistler (above) is applying this principle in that 'Plan A' is camouflage, but if I get too close he'll move (notice it has its right eye on me): in case he needs Plan B. Keep an eye on things and experiment: weed control can give natural regeneration (Left); take every chance to learn so you can adapt too, such as Roldana coming up after fire (Right).

General principles

There are a number of general principles that underpin the rainforest restoration methods that have been devised for the restoration, repair and maintenance of rainforests. Each Method has its own advantages, disadvantages and application. It is important to apply the appropriate method according to the site's location, its condition, the threatening processes operating and your resources (Chapter 5). It is therefore very important to understand your restoration site as well as its position in the landscape relative to existing remnants or other intended restoration works (Figure S222). In so doing, you will anticipate problems and take action to avoid the pitfalls we have had, before your restoration site turns to weeds and fails to establish!

There are five basic principles associated with the art and science of rainforest restoration:

1. **Understanding that rainforest ecology is essential** (and we've worked that out for you and if you have the aptitude you should still be able to get an acceptable result). In a nutshell, observe nature, work with it and not against it. This principle is dealt with in Chapter S4
2. **Understand your proposed restoration site's soils, landform, climate and landscape position** (what limits this places on you as well as what benefits it may provide)
3. **Think carefully about what you really want to achieve and what resources you have at your disposal** (Gran can't go on planting for ever, nor will your friends!)
4. **Choose the appropriate restoration technique for your site** (you wouldn't use a fly swat to catch a butterfly!)
5. **If you still wish to proceed, but find the process too daunting**: get someone with the expertise to undertake your rainforest restoration on your behalf.

But who would you choose to do the work for you or to teach you?

Accreditation

Introduction

Although selecting the appropriate method for your restoration site is paramount, it is as equally important that the plants, advice and assistance that you use on your site are sourced from appropriately trained, experienced and/or accredited individuals and contractors. Such an approach will ensure that you get people who know how to do the job while ensuring high standards are maintained. This does not mean that everyone who works on the project or the site has to be accredited, but it does mean that at least one accredited or trained person with the necessary experience should be involved to advise and/or direct you along the way.

The reasons for this are several. Rainforest restoration is a complex task and it requires a high level of insight into the myriad of ecological processes that underpin the restoration methods and, just like getting someone to build a house for you, it requires skill and an ability to integrate and coordinate the steps that are required. Such skills and the necessary insights are not readily acquired and are less easily applied. Accreditation tests knowledge, but it does not necessarily say anything about ability. Ability requires aptitude, considerable organisational skills, experience and/or training. Because rainforest restoration cannot be successfully undertaken by the novice alone, it requires the input and help of experienced people and experts: those who are well versed in rainforest restoration methods (knowing when and how to apply them). So ask around; look at sites that have been restored by practitioners, ask about their reputation and get a feel for their ability before you ask them to help. This is especially important if you are paying for the service.

For you (the consumer of such services), it is important that you can be assured that the people that supply these goods or services to your restoration project can actually deliver what they say they can. This requires an accreditation process. Extensive training should precede any accreditation. To date in East Gippsland, extensive training and accreditation has already been conducted for rainforest nurseries and rainforest regenerators. The accredited rainforest nurseries, rainforest regenerators and training bodies are listed in Useful Contacts. It is strongly recommended that you at least talk with these highly skilled individuals and organisations before jumping into any rainforest restoration project.

Rainforest nurseries

Rainforest nurseries were provided with a year of technical training and advice from the East Gippsland Bushcare Facilitator through the auspices of the East Gippsland Catchment Management Authority. This was followed by an assessment process. To date, there have been three rainforest nurseries accredited in south-eastern Australia (Useful Contacts) and most now have 7 years experience as of 2008.

KNOW YOUR SITE BEFORE YOU BEGIN: HURRY UP AND WAIT

Figure S222. Maramingo Creek confluence with the Genoa River, Victoria. Hasten slowly. Find out as much as you can before you begin. Documenting what is there and identifying key threatening processes are the first step in rainforest restoration. Here, volunteer Dan Ford is recording species present and the effects of Sambar on Littoral Rainforest along the *estuarine* reaches of the Genoa. This data showed the site to be one of a number of stands of the Victorian endemic floristic community: *East Gippsland Deltaic* Littoral Rainforest. Note the height of Sambar browsing over his left shoulder: Dan is 6’ 4’’ in the old scale (1.93m)!

Rainforest regenerators

Rainforest restoration workers were provided with at least three year's training and advice by the East Gippsland Bushcare Facilitator through the auspices of the East Gippsland Catchment Management Authority to become restoration ecologists. This was followed by an extensive accreditation assessment process to confirm their skills. To date, there have been two rainforest restoration companies provided with accreditation in south-eastern Australia (Useful Contacts). The accreditation process was extensive. It took the form of an examination undertaken by prospective rainforest restorers that was then independently assessed.

Note that even with extensive and comprehensive accreditation, only knowledge is tested. It does not evaluate capability or practical onground application of knowledge when removed from the theoretical and applied to the field. This can be especially problematic on large and/or complex sites. Skills not tested by the rainforest accreditation process that are still nonetheless very important for undertaking on site restoration include:

- Setting priorities for onground works
- Organisation skills (before, during and after the onground restoration)
- Appropriate delegation of tasks, training and supervision
- Attitude to the task at hand (ability to follow direction, adaptability when on site conditions or the season alter).

Nonetheless the 20 subject areas that were tested in the accreditation of rainforest restoration contractors were very useful:

1. EVC habitat

Context: Being able to identify the key habitat differences between EVCs ensures that ecological restoration contractors restore the appropriate EVC in the appropriate habitat. This means that on degraded sites contractors will be able to choose the correct habitat, plant in the right niche and at the appropriate planting stage. The ecological vegetation classes are: Warm Temperate Rainforest, Gallery Rainforest, Littoral Rainforest, Riparian Shrubland, Riverine Wetland, Estuarine Wetland, Estuarine Scrub and Riparian Forest.

List the habitats for 8 ecological vegetation classes using the following criteria:

- River Reach (freshwater/estuarine)
- Bank position (levee/bank/toe)
- Flood energy (high/medium/low).

2. EVC differentiation

Context: Contract restoration ecologists need to be able to identify these EVCs in the field to be able to study reference sites for each EVC (from which useful benchmarks that guide restoration can be derived), which in turn ensures that the ecological processes that your restoration works are seeking to reinstate can be examined and understood as needed. The ecological vegetation classes are: Warm Temperate Rainforest, Gallery Rainforest, Littoral Rainforest, Riparian Shrubland, Riverine Wetland, Estuarine Wetland, Estuarine Scrub and Riparian Forest.

Identify the principle differences between 8 ecological vegetation classes by their:

- Dominant canopy species
- Other differences if known (between the eight listed).

3. List sun weeds

Context: Timely, effective and efficient weed control is critical to the successful ecological restoration of riparian habitats. Ecological restoration contractors need to have a demonstrated knowledge of the most appropriate techniques to ensure that sun weeds can be controlled.

List three sun weeds and their management (identify the most serious in a given area):

- Means of reproduction
- Methods of control
- Do methods of control change according to the extent and maturity of the infestation? If so, how?
- What restrictions apply?

4. List shade weeds

Context: Timely, effective and efficient weed control is critical to the successful ecological restoration of riparian habitats. Ecological restoration contractors need to have a demonstrated knowledge of the most appropriate techniques to ensure that shade weeds can be controlled.

List 3 shade weeds and their management (identify the most serious in a given area):

- Means of reproduction
- Methods of control
- Do methods of control change according to the extent and maturity of the infestation? If so, how?
- What restrictions apply?

5. Understand which native species may become weedy

Context: Timely, effective and efficient control of potentially weedy native species can be critical to riparian and rainforest restoration. Ecological restoration contractors need to have a demonstrated knowledge of the most appropriate techniques to deal with these potentially troublesome species.

List two problematic native species that can act as weeds (identify the most serious in a given area):

- Species #1
- Species #2.

6. Specialised spraying techniques required where weeds and natives are intermingled

Context: Weed control using herbicides on restoration sites is a fine art and requires specialist techniques that are the stock-in-trade of ecological restoration contractors.

Describe the techniques used in specialised and targeted spraying on sites where there is a matrix of target and non-target species with reference to the following criteria:

- Spray equipment
- Droplet size
- Spray pressure
- Height of spraying
- Site preparation techniques
- Times of day to avoid
- Weather conditions to avoid.

7. Knowledge of *Integrated Weed Management*

Context: Timely, effective and efficient weed control of multiple weeds is frequently necessary on restoration sites. Ecological restoration ecologists need to show a demonstrated knowledge of the most appropriate techniques when faced with a range of scenarios as well as being able to demonstrate their weed management is integrated.

Dealing with multiple weeds on a site. Of the four integrated weeding techniques currently used (Herbicide only, herbicide and plant, Bradley Method and Wingham Method), which is most appropriate to the following scenarios and why? List the herbicide and particular techniques applicable for each of the following scenarios:

- Scenario #1: Site in full sun+Kikuyu
- Scenario #2: Site with a patch of existing native ground-ferns with a light infestation of Cape Ivy
- Scenario #3: Site with a diverse rainforest remnant with diverse and (in places) abundant weed infestations
- Scenario #4: Site with mature Periwinkle killed in previous year that has been planted with Kangaroo Apple only
- Scenario #5: Fourth year of established rainforest restoration
- Scenario #6: Site with mature Periwinkle killed in previous year that has been planted with Sword Tussock-grass *Poa ensiformis* and Seaberry Saltbush *Rhagodia candolleana*
- Scenario #7: Dense groundcover planting mixed with Kikuyu.

8. Conservation of remnant vegetation on the rainforest restoration site

Context: Preservation of existing native vegetation provides considerable advantages during restoration, including: maintenance of bank stability, habitat for native wildlife, reduction in the area to be planted and allows these native plants to flourish once weeds are controlled. Ecological restoration contractors need to able to implement these techniques to conserve such vegetation.

Protection of remnant vegetation is an important part of riparian restoration. Explain the methods used to conserve the native species in the following scenarios:

- Scenario #1: Kikuyu **Pennisetum clandestinum* sward with Common Reed *Phragmites australis* diffusely scattered across the site
- Scenario #2: Kikuyu sward with Silver Wattle *Acacia dealbata*, Blackwood *Acacia melanoxylon* and Swamp Paperbark *Melaleuca ericifolia* suckers throughout
- Scenario #3: Bracken *Pteridium esculentum* with infestation of Blue Periwinkle **Vinca major*
- Scenario #4: Kikuyu **Pennisetum clandestinum* sward with Large Bindweed *Calystegia sepium.*

9. Site assessment

Context: Site assessment is a critical step in undertaking ecological restoration. It begins the planning process and is the first step in adaptive management. Ecological restoration requires constant appraisal and reappraisal of site priorities. This exercise is designed to illustrate the skills of the ecological restoration contractor.

For the following sites list the actions required and the priority order [1(being highest) to-5 (lowest)] for the works to be undertaken. The choice of actions (not all actions may be necessary for each site) available to you are:

a. Monitor regeneration, and then depending on results take appropriate action
b. Draw up a site map of weeds and cover, natural regeneration, hazards
c. Assess extent and distribution of planting niches
d. Determine EVC
e. Undertake weed control.

Site #1: Mature Mahogany with Kikuyu+Blue Periwinkle

Site #2: Bare sand bank where cattle grazing has just been removed

Site #3: Bank slope in riverine reach covered in mature willows (levee planted with Warm Temperate Rainforest in the previous year). Note: 200m away, there is a Warm Temperate Rainforest remnant connected to this restoration site.

10. Adaptive Management

Context: Adaptive management allows ecological restoration contractor to observe a problem, come up with a number of possible causes, test these hypotheses and change management to improve the result. Most of what is done on restoration sites is a series of trials that help improve restoration techniques on a day-to-day basis. The application of adaptive management skills reduces costs, improves results and quickens the reinstatement of ecological processes.

The following steps are part of the adaptive management cycle. Apply to the scenario given below, the following steps:

- Adaptive management step 1: Identify the problem (i.e. develop an hypothesis)
- Adaptive management step 2: What are the possible causes
- Adaptive management step 3: List evidence for each possible cause
- Adaptive management step 4: Test your hypothesis
- Adaptive management step 5: Obtain results and adapt your management accordingly.

a. Scenario: Your newly planted plants are disappearing from your site (Adaptive management step 1) but the cause is not known. Possible causes (Adaptive management step 2):
    Theft
    Swamp Rats
    Snails
    Sambar
    Swamp Wallabies
    Swamp Hens
b. List the observations and physical evidence that would allow you to determine the culprit/s' identity (Adaptive management step 3).
c. Your investigations and some simple tests (Adaptive management step 4) reveal that it is Swamp Wallabies that are the cause.
    - What actions could be taken to reduce Swamp Wallaby impact (Adaptive management step 5) and what are the risks/costs associated with each action?
d. Alternatively: Your investigations and some simple tests (Adaptive management step 4) reveal that it is Swamp Hens that are the cause.
    - What actions could be taken to reduce Swamp Hen impacts (Adaptive management step 5) and what are the risks/costs associated with each action?

11. Weed species identification

Context: Plant identification skills are a fundamental part of restoration ecology work and range across: knowing what plants are growing on the site, what species are being delivered to the site and where they must be planted; to the recognition of native and weed species germinants. Ecological restoration contractors need to demonstrate a broad competency in plant identification irrespective of the age of the specimen at hand. Being able to discriminate between native species and weeds in the field is also important when undertaking site preparation or maintenance duties.

Pick the weed from the native plants

- Identify from the 11 photographs provided the weed species in each.

12. Identifying mature weeds

Context: The appearance of weeds differs from germination to maturity. Rainforest restorers must be able to recognise mature weeds.

Mature weed species identification

- Identify from the 9 photographs provided the weed species in each. For each weed identified, answer the following question: In the context of Warm Temperate Rainforest, is this species a transforming weed or a *background weed*?

13. Identifying germinant weeds

Context: The appearance of weeds differs from germination to maturity. Rainforest restorers must be able to recognise germinating weeds.

Germinant weed species identification

- Identify from the 8 photographs provided the weed species in each. For each weed identified, answer the following questions: Is the species a sun weed or a shade weed? Does this species always need to be controlled? How would you control it?

14. Identification of native species germinants

Context: The appearance of weeds differs from germination to maturity. Rainforest restorers must be able to recognise germinating natives.

Native species germinant identification

- Identify from the 13 photographs provided the native species in each. Note that some photographs may have more than one species present in them.

15. Nursery plant identification (young plants)

Context: Juvenile plants can look quite different to the adult plant. Being competent in the identification of young plants as they arrive on the restoration site from various nurseries is an important skill for the rainforest restoration contractor. Plants will not always have labels, labels may have been mixed up or plants can be mislabelled.

Nursery plant identification

- From the 23 photographs provided identify the 61 seedling plant species.

16. Identification of root suckering rainforest plants

Context: Many rainforest species reproduce from suckering or root coppicing. It is important for the rainforest restoration contractor to be able to identify such regeneration so as to conserve it during maintenance cycles on restoration sites.

Native species root coppice identification

- From the 5 photographs provided identify the native species that are root coppicing in each.

17. Identification of mature species

Context: Rainforest restoration contractors need to be able to identify mature native rainforest plants, to be able to conserve them on restoration sites, collect seed from them and observe their ecological function.

Mature native species identification

- From the 13 photographs provided identify the native species in each.

18. Field identification of ecological vegetation classes

Context: Being able to visually identify the rainforest ecological vegetation classes in the field that are to be restored is necessary in order to be able to study them in their natural state. This provides important information to the rainforest restoration contractor, including: disturbance response, landform, habitat, species composition and disposition across the sites that they occupy. The ecological vegetation classes to be identified include: Warm Temperate Rainforest, Gallery Rainforest, Littoral Rainforest, Riparian Shrubland, Riverine Wetland, Estuarine Scrub and Riparian Forest.

EVC identification

- Identify from the 7 photographs provided the ecological vegetation classes present.

19. Translocation experience relevant to rainforest restoration

Context: Rainforest restoration can require plant *translocation* and plant rescue. Experience in these techniques and the ethical questions that arise when undertaking this task are important skills for rainforest restoration contractors.

List the translocation experience that you have used during rainforest restoration.

20. Ecological restoration experience

Context: Ecological restoration requires experience and we would like to you know of your experience in the field.

List the ecological vegetation classes that you have experience in restoring.

Project planning and implementation

Planning occurs at all sorts of levels, from what you will do on your restoration site today, to who you need to talk to get funding or technical advice. It is inherent in any complex project, irrespective of its scale. A comprehensive set of guidelines for developing and managing ecological restoration projects has been compiled by Clewell *et. al*. (2005) and it is worth consulting and adapting them if you find any part of our explanation lacking in content or detail. Hopefully someone has already done most of the necessary regional or national planning for you, but it is worth knowing the process that underpins rainforest restoration in south-eastern Australia. If you are a regional planner, you will probably be familiar with most or all of these elements. As a *NRM* planner, if you just want to start a project you should read on, but you will probably be most interested in the advice starting at the section: So you have found a restoration site (as well as: An Operationalisation Plan for Rainforest Restoration).

Regional planning

Because of the importance of rainforest in the landscape (Chapter S2), it is imperative that its conservation and restoration is incorporated into regional planning. For the most part, this process is well underway and you do not have to feel personally responsible for this task. If it is not complete, you may wish to give it a go. To do this, you must convince the relevant people in authority and the community as a whole about the importance of rainforest and the need to conserve, protect and restore it and its habitat, if it has been cleared (*EGRFCMN* 2007). The following steps may be useful in this task and these are set out under specific headings.

Is the site of regional, state or national conservation significance?

This step has, in many cases, already been undertaken by the relevant community group, conservation or land management agency. So, for example, following the publication of Rainforests and Cool Temperate Rainforests of Victoria (Peel 1999), the data in it was used as the basis for a number of successful nominations under the *Flora and Fauna Guarantee Act 1988* to list various rainforest communities in East Gippsland as threatened (Appendix S1). From a purely pragmatic perspective, this then provides the community with a lever to ensure protection and gain access to funds for restoration works from local, state and federal governments.

This process may not have been completed if the rainforest type has only recently been described, as is the case with Littoral Rainforest in Victoria, (although the data and information contained in this work has directly led to the Federal *EPBC Act*-listing of this vegetation in that state). The steps required are as follows:

- Establish the conservation status of the floristic community (or ecological community) of rainforest you are proposing to restore or protect and list the past and ongoing threats to its continued survival (the usual ones are: loss of whole stands, habitat loss, loss of ecotones, grazing, weed invasion, urban development and/or recreation).
- Make an application to list the community based on your findings (this provides a legal status for the vegetation and requires that governments, agencies and the community must act in its favour to ensure its evolutionary potential to survive and evolve in perpetuity)
- List the rare or threatened plant and animal species that are partially or fully reliant on that community (this adds further weight to the value of the rainforest itself) and widens the scope of conservation or restoration works, as well as the potential pool of funding agencies. A good example is the World Wide Fund for Nature (WWF) that has funded two rainforest restoration projects at Lakes Entrance: one for restoration of Grey-headed Flying Foxes' habitat (with the North Arm-Colquhoun Landcare Group as the implementation vehicle) and the other for Swift Parrot habitat restoration (with the Lakes Entrance Golf Club Inc. as the host organisation). Both were possible because good record-keeping could prove a direct link between restoration works already completed and subsequently use by these nationally threatened species. List the past and ongoing threats to each rainforest type's continued survival (your restoration and conservation works will help to reduce these threats).

Mapping

There is no substitute for mapping out your project, whether it's at the project scale, such as the Snowy River Riparian and Rainforest Restoration project (Map S3), or introducing rainforest restoration as a principle at the regional scale through ***pre-1750s vegetation mapping***. Mapping is simply another form of planning. The map is as important as the process of doing the map. The map forces you to consider the issue from all sorts of angles and ensures that you approach the problem logically and come to defendable conclusions.

Try dividing your restoration site up into zones based on the restoration method that you intend to apply and then try to overlay the sequence of works: now you can see what mapping can do for you. If you undertake this simple exercise, you will already see that you must make logical decisions about:

- The level of resources you have at your disposal
- Over how many years will you need these resources
- What parts of the site lend themselves to what restoration method
- What contingencies you may need to put in place if money doesn't come through or the season is too dry or too wet, and so on.

There are a series of steps that are necessary for either level of mapping and these have been set out as a guide to help you along the way. Mapping may not have occurred if:

- The rainforest type has only recently been recognised (e.g. Littoral Rainforest in south-eastern Australia)
- The rainforest stands themselves have always been small
- The rainforest type is largely cleared.

Pre-1750s mapping

Pre-1750s mapping of rainforest distribution are a synthesis of this approach. They are aided by a building-block (iterative) approach, starting with what is known (mapping what remnants still exist) plus, using historic records, talking to the old timers, visiting remnants (to determine composition and ecology), gathering site information (landform, aspect, soils, climate, Figure S223) and then putting it all together. One model for doing this is to use the ***Rainforest Divination Tool*** approach (Chapter 3).

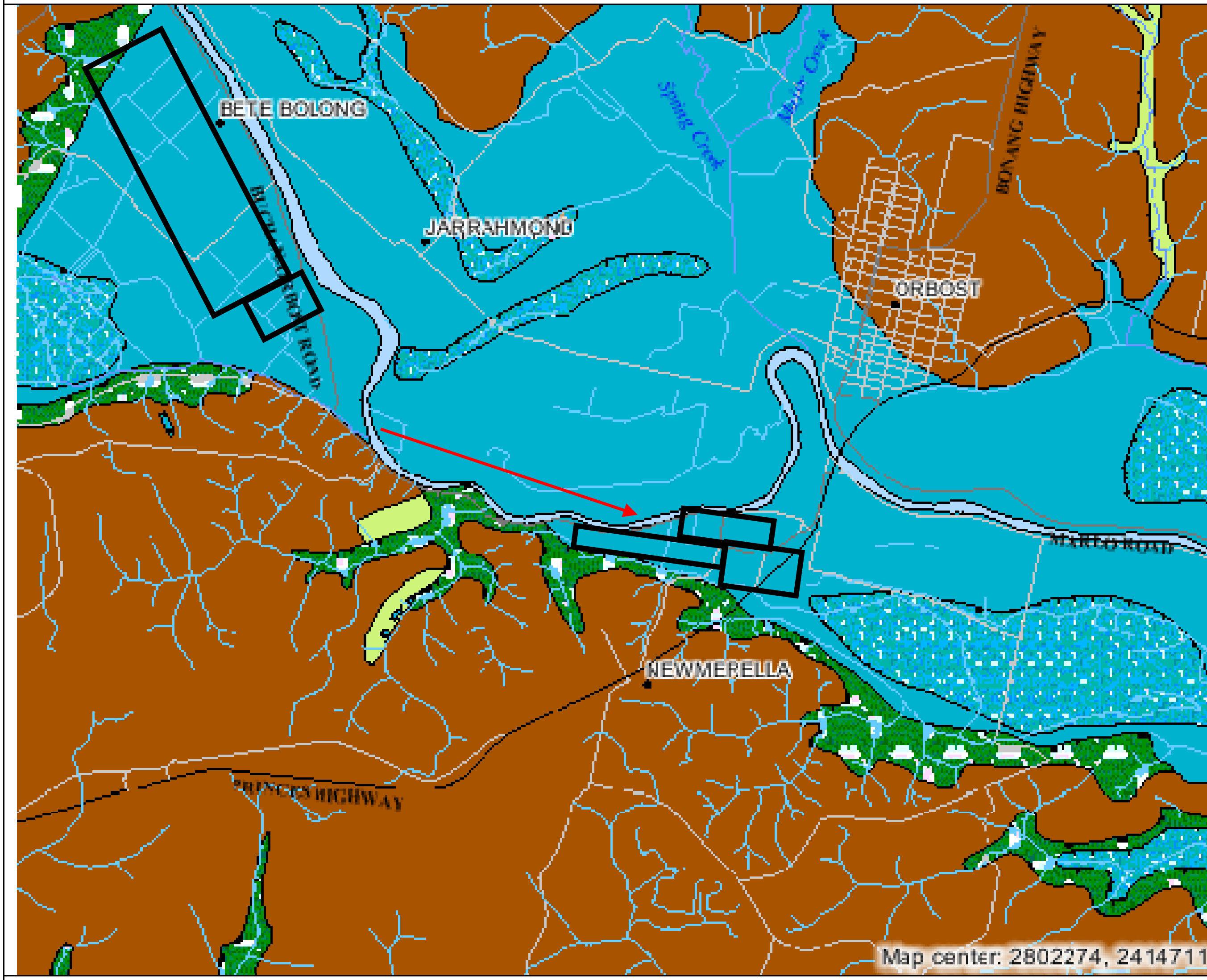
The intersection of fire protection, seed source and landform are overlain by pre-1750s map makers and then rainforest habitat is identified. A subset of these potential past rainforest sites are then investigated for evidence of rainforest occupation by looking for remnant species that have persisted until the present (e.g. Figure 3.10). Often, if the mapping predictions (modelling) is good, there will be some jewels uncovered in some still intact remote or special spot that is tucked away, which no-one has especially noticed before.

So, if the mapping (pre-1750s extent) has not been done, then these are the steps required:

- Map the rainforest types' current extent
- Determine the habitat parameters of the particular rainforest type/s with which you are dealing (Definitions and Synonymy: Differential Rainforest for south-eastern Australia)
- From this information, model its pre-European extent and map it
- The difference between the past extent in ha and its current extent represents its level of depletion. In Victoria, if less than 10 % remains the ecological community is regionally endangered, if 10-30% remains, it is vulnerable, if 30-50% remains it is considered to be depleted.

Because pre-1750s mapping was done at 1:100,000 or rarely 1:25,000, many of the past rainforest sites (cliffs, scree, narrow levees, etc.) cannot be illustrated (mapped) at this small scale. For this reason, you may have to confirm past historic rainforest occupation of your intended restoration site for yourselves. In anticipation of this, we have compiled a list of features (see below) and species fidelities used to model the past distribution of rainforest when doing pre-1750s mapping. There are four basic categories: historical evidence; landforms (including geology); fire protection and rainforest species (those that have obligate or high fidelity to rainforest are most useful) (Appendix S6: Rainforest fidelity columns). These have been combined into a Rainforest Divination Tool (Figures 3.2 to 3.4).

START BY MAPPING EVERYTHING THAT IS THERE



Map S3. Pre-1750s EVC map, lower Snowy River Victoria. The red arrow indicates the view line of the photograph in Figure S223. The blue area is Riparian Forest on the floodplain. Note that the 1:100,000 scale of the original mapping precluded the identification of specific localities of historically documented stands of Warm Temperate Rainforest and Gallery Rainforest. Later mapping would have classified it as a mosaic of Riparian Forest, with both rainforest types. Bruce's (1865) mapping of rainforest (not available to the original vegetation mapper at the time of the pre-1750s reconstruction) is indicated by black rectangles. This factor indicates an important principle, closer regional or onsite examination will often turn up a better and more detailed result: therefore remember the limitation of the tools that you are using to refine your search for vegetation patterns and past rainforest distribution. Local information, and using the Rainforest Divination Tool, will almost always be more accurate than mapping done at the regional scale.
Map source: Department of Sustainability and Environment.

COMBINING THE PAST PRESENT AND FUTURE INTO A COHERENT PLAN FOR RESTORATION ACTION

Figure S223. Lower Snowy River, Victoria. The sinuous reach of the Snowy River during the 2007 flood looking downstream on 26-07-07 at 10.20 am. This illustrates the flood-based habitats of the river and its adjacent levees and past swamps based on landforms. Compare this to the pre-1750s mapping. The vegetation mapping of Bruce (1865) indicated that the left (now cleared bank) was Riparian Forest, but that the right bank (yellow arrow) was "jungle" or what we call Warm Temperate Rainforest today (the green rectangles on Map S3). It is thought that the Riparian Forest was modulated by frequent flooding rather than fire (note morass on the left), and that under today's reduced flooding regime (due to the Snowy Hydro Scheme), restoration efforts will see the left bank (blue arrows) become rainforest. The remnant Mahoganies at this site that grow along the ***riverine cliff*** in the lee of cold westerly winds are an important communal breeding site for White-faced Herons *Egretta novaehollandiae* (red arrow). Photograph Tim East.

The necessary fire regimes that rainforest require can be created by one or a combination of the following:

- Wet or moist sites in dry or drought-affected climates: south- or east-facing gullies, which are most important for the moisture-dependent rainforest types (Subtropical, Warm Temperate, Cool Temperate) (Figure S224)
- High and reliable summer rainfall: This keeps the landscape more moist during periods of the highest fire risk. This rainfall seasonality is important and relevant in montane zones (of all bioregions) such as along the Monaro escarpments, Howe Range, Errinundra Plateau, Central Highlands, Strzelecki Ranges, Wilsons Promontory and Otway Ranges, which largely support Cool Temperate Rainforests. High and reliable summer rainfall is also a key fire retardation factor in the north of the region for Subtropical Rainforests (Figures S8, S9); such as around Gulaga (Mount Dromedary).; However, this rainfall seasonality does not apply for the majority of the lowlands of south-eastern Australia because of their ***Mediterranean climate*** which is characterised by drier summers and high fire risk.
- Landforms that can reduce fire frequency, access or intensity:
    - Steep sided gullies (Figure S224)
    - Open water: tidal creeks, which foster habitat for Littoral Rainforest by intercepting fire before it can reach the stand (Figure S225) as well as their associated ***halophytic vegetation*** (see below)
    - Rock scree and/or tor fields that are important for Dry and Littoral Rainforests (Figures S37, S38)
    - Gorges, riverine cliffs and dolines that deny access by fire to Dry Rainforests (Figure S226);
    - Marginal bluffs and cliffs (Figure S39) and/or their scree slopes (Figure S227)
    - Open water: rivers, billabongs, wetlands, which foster habitat for Warm Temperate and Subtropical Rainforests by intercepting fire before it can reach the stand (Figures S223 and S228)
    - Lakes, bare sand (dunes/beaches) provide fire protection for Littoral Rainforest (Figure S229)

  - o Perennial streams which ensure the survival of Gallery Rainforest even during crowing wildfires because they maintain high humidity beneath the rainforest canopy (Figures S25-S30)
- Vegetation composition that reduces fire intensity or frequency:
  - o Grassy or herb-rich types: Plains Grassy Forest, Plains Grassy Woodlands, Grassy Woodlands, Herb-rich Woodlands, Grassy Wetlands (Figure S224) or heathlands, Dry Valley Forest (Figure S230), Brogo Wet Vine Forest, Bega Dry Grass Forest,. These are more important for some sites and rainforest communities than others such as Dry Rainforest (Figure S226) and Littoral Rainforest
  - o Saltmarshes, estuarine wetlands and mangroves: these saline and wet communities provide un-burnable vegetation protection for Littoral Rainforest (Figure S231)
- Vegetation structure that reduces fire intensity or frequency:
  - o Old-growth salt-impregnated scrubs: that have lower flammability due to salt accretion on fine fuels (Additional Reading: Influence of salt on ignition times: on fine fuels of Coast Tea-tree) and a separation between ground and canopy fuels: Estuarine Scrubs/Swamp Scrubs of Swamp Paperbark *Melaleuca ericifolia*, Coast Dune Scrubs of Coast Tea-tree *Leptospermum laevigatum* and Headland Scrubs of Giant Honey-myrtle *Melaleuca armillaris*. This type of fire protection is most important for Littoral Rainforests (Figure S232)
- Gap-filling species that are fire retardant:
  - o Halophytic gap species of Littoral Rainforest: although restricted to this EVC, this repair mechanism can hold the line against another fire while the rainforest is repairing itself from a previous disturbance event, with species such as Coast Wattle *Acacia longifolia* ssp. *sophorae*, Common Boobialla *Myoporum insulare* and Seaberry Saltbush *Rhagodia candolleana* (Figure S233) having slow ignition or failing to ignite altogether (Additional Reading: Ignition times).

STEEP TOPOGRAPHY PROVIDES WET MOIST SITES FOR RAINFOREST AND WETLANDS REDUCE FIRE

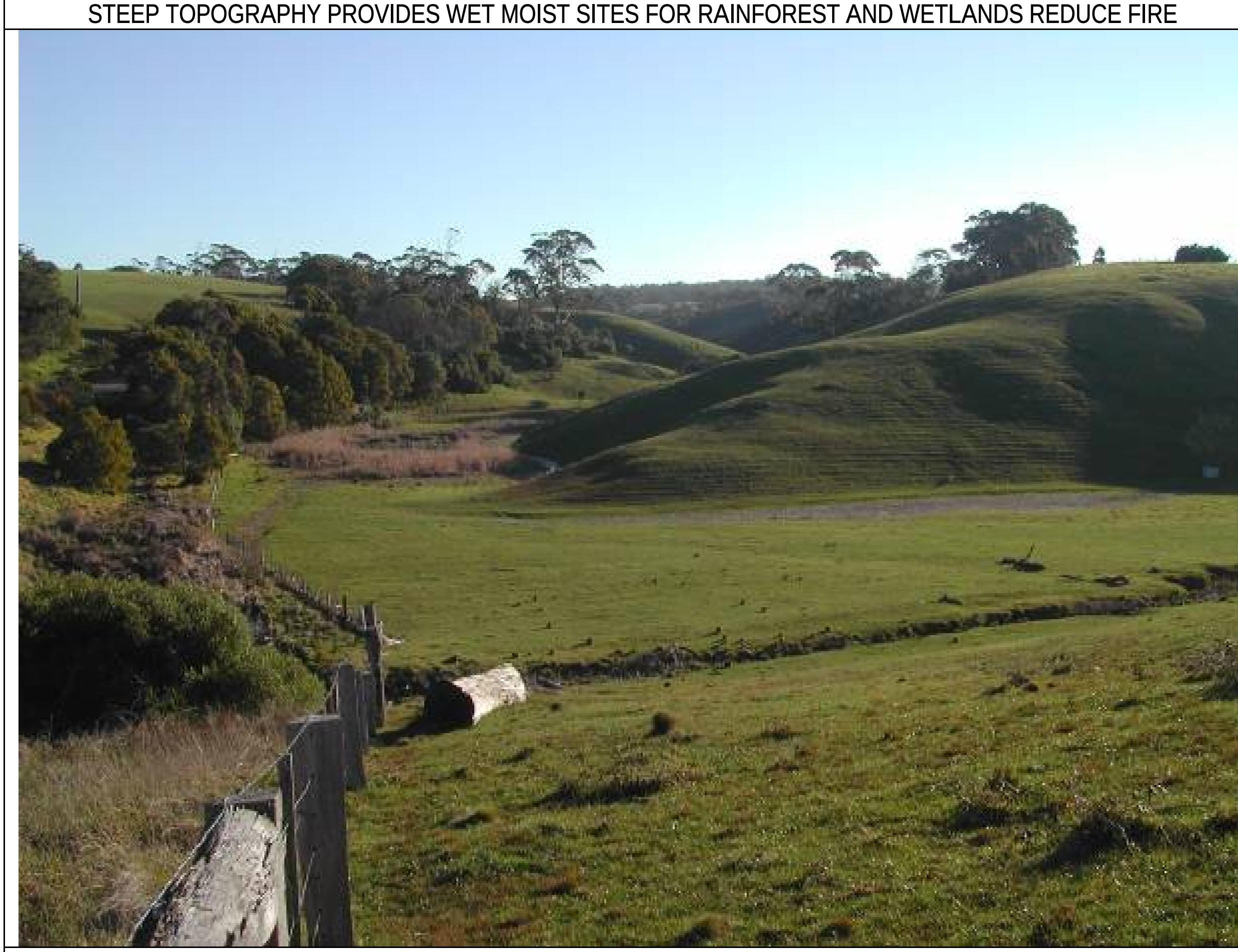


Figure S224. Bunga Creek, Victoria. Steep-sided gullies retain moisture and suppress fire, as do grassy wetlands with open water. In the 1940s and 50s, Jim Willis (one of the state's most eminent botanists) used to stop here for lunch on his expeditions to the wilds of East Gippsland, so he (and his party) could explore the extensive jungles in this creek!

FIRE BEHAVIOUR IS MODIFIED BY OPEN WATER, *HALOPHYTES*, CLIFFS AND GRASSY VEGETATION

Figure SS225. Calendula Nature Reserve, New South Wales. Other than mangroves and the estuary pictured, the Littoral Rainforests in this reserve also have fire protection features (Figure S19 and Figure S20).

Figure S226. The Anticline, Murrindal River valley Murrindal, Victoria. Cliffs, grassy woodland, rainforest and a river protect this *East Gippsland Karst* Dry Rainforest from fire.

ROCK SCREES AND OPEN WATER HELP TO BREAK UP THE LANDSCAPE AND MODERATE FIRE

Figure S227. Mimosa Rocks National Park, New South Wales. Rock scree protects these stands of Littoral Rainforest from fires sweeping south along the coast.

Figure S228. Downstream of Lochend Jungle, Snowy River Victoria. The river to the north prevents fire reaching this rainforest.

BARE SAND AND OPEN WATER AT HIGH TIDE

Figure S229. Bithry Inlet, New South Wales. Bare sand and Wapengo Estuary protect the Bithry Inlet Littoral Rainforests from fire.

DRY VALLEY FOREST HELPS GALLERY RAINFOREST

Figure S230. Iguana Creek, Glenaladale Victoria. This area of Dry Valley Forest on the creek flats has a grassy understorey (left of the red dotted line) that has helped to reduce fire intensity, which, has protected the adjacent Gallery Rainforest (right of line) along the creek from fire, so much so that the rainforest is extending across the flat!

OPEN WATER AND SALT IMPREGNATED VEGETATION HELPS PROTECT LITTORAL RAINFORESTS	
	
Figure S231. *Marl* Island, Victoria. Saltmarsh (foreground: currently inundated by the high lake stand level) and the Estuarine Wetland on the margin of the island are both dominated by halophytes that concentrate salt and water in their foliage. This combination provides a very effective fire break for the Littoral Rainforest (background) that covers all suitable habitats on the island. Note: high stand levels are more likely during droughts, enhancing the fire protective features of Intermittently Closing and Opening Lagoon Systems (ICOLS).	Figure S232. Wingan Point, Victoria. Salt-impregnated fine fuels and the salty rime that coats the foliage of Headland Scrub reduce the risk of fire (Additional Reading: Influence of salt on ignition times: on fine fuels of Coast Tea-tree). Old-growth stands, where there is an additional separation between the ground-fuels and the canopy (in this case, Giant Honey-Myrtle *Melaleuca armillaris*), are a further protection. All of these factors contributed to save the bulk of the huge Littoral Rainforest stand behind the photographer during the 1983 wildfire.

FIRE RETARDENT GAP AND EDGE SPECIES PROVIDE TIME FOR RAINFORESTS HEAL FOLLOWING FIRE

Figure S233. Wingan Point, Victoria. The predominant edge and gap-filling pioneer species to regenerate in this Littoral Rainforest stand following the 1983 wildfire was Seaberry Saltbush *Rhagodia candolleana* (red arrows), so it's no wonder we use it, where appropriate, in urban rainforest restoration to reduce fire risk (Figures M176 and M177).

Figure S234 provides an excellent example of a combination of local protective elements all combining to protect rainforest from fire, while some modes of fire protection are more obvious (Figure S235). Both are better understood when viewed at the landscape scale (Figure S236).

<table>
<tr><th colspan="2">COMBINATIONS OF LOCAL FEATURES LEADING TO FIRE PROTECTION FOR RAINFOREST</th></tr>
<tr><td></td><td></td></tr>
<tr><td>Figure S234. Fisheries Bay, New South Wales. The list of local features protecting this Littoral Rainforest stand from fire are impressive: marine embayment, sandy beaches, rock outcrops, marginal bluffs, sea cliffs, salt impregnated vegetation, halophytes and other rainforest stands. Its development is only constrained by the storm events that enter Two-Fold Bay and the likelihood of increased frequency and magnitude of such events that are predicted to accompany climate change in this region.</td><td>Figure S235. Mitchell River National Park. This Ephemeral Streams Gallery Rainforest is protected by the vertical walls of the gorge in which it grows. Both Powerful and Sooty Owls roost in these shady refuges. Photo: Rohan Bilney.</td></tr>
</table>

So you have found a restoration site

You or your group have established that the site used to once be rainforest and you are ready for the next step. Firstly, you need to establish who owns it and whether or not they will agree to your proposals. To help in that regard you will need to establish the wider ecological, aesthetic, river and water health benefits of rainforest restoration at that particular site. If you like, you could set it out in a similar fashion to that of the two Case Studies S2 and S3 in Chapter S5. Then it is up to you to tailor this basic layout to the needs of the site's owners (don't leave out traditional owners in this process), yourself, the neighbours, the authorities, land managers or community to whom you wish to sell your project. Now it is time to start selling your well conceived project to the key people and community leaders.

Community engagement and networking

This is one of the most important steps along the way and may take years. If rainforest restoration is an accepted practice in your region, this may just be a formality. If it is the first time for your area, the amount of groundwork you may need to do could be much greater. Depending on the scale of the issue, it may require the involvement of relevant state departments (land management and planning), local councils, state political representatives, councillors, local community members and land managers. The basic methods for consulting with the relevant people are detailed in Chapter S3: Human Factors: the social context. The Snowy River Rehabilitation Plan of Works (DSE 2004b) is an example of one method of community engagement. However, few documents will have the same impact as face-to-face contact and talking.

Community and government response: ensuring rainforests can survive and evolve in perpetuity

Provided all has gone well with the preceding steps, hopefully the relevant regional planning responses fall into place. By now, you know what is threatened or listed, where it still survives, what its habitat is/was, and how to conserve and restore it. Now it is time for the planning authorities and the community to commit land and resources to protect the existing rainforest estate and to restore rainforest to some of the sites where it once grew. This should ensure that it can be recovered (restored) and the threatening processes managed. This requires that both the existing remnants and the restored sites are protected in perpetuity. Hopefully, with time, this may lead to the threatened rainforest type being de-listed (as a threatened community) because it has been saved from extinction by the collective effort of yourselves and that of your community!

COMBINATIONS OF LOCAL FEATURES LEADING TO FIRE PROTECTION OF RAINFOREST

Figure S236. Baycliff, New South Wales. The only rainforest present in this whole scene is found on Baycliff (middle background centre): a near-shore island at the end of a sandy isthmus captured by hidden *tombolo*. The fire protection is afforded by the sea (Disaster Bay), sandy beaches and Wonboyn Lake. This is an excellent example (that is rarely seen from the ground) of the landscape level and context for fire protection.

Cultural landscapes: a word of caution

Cultural landscapes are landscapes ‘owned’ by people. The first Australians culturally own all of the land, irrespective of our current arrangements. In a more contemporary sense, cultural landscapes occur everywhere people have been and that includes what they have seen with their eyes, but not necessarily visited, which may sound strange. Cultural landscapes are those areas of our environment that we do not privately own, but regard as ours (a universal dominion if you like): the places of our ancestors, the places we walk, the places we fish, the things in our landscape that we value and look at every day. This is most often the case for areas that are publicly accessible or public land. If someone, or some agency, changes that without consulting us, we are all offended at some level, and many of us may even be outraged. But such feelings are cultural in origin and come with a cultural context. This is why, when you undertake your restoration project, you should consult as widely as possible. This lets people participate in the evolution of their cultural landscapes and allows you to negotiate the social contract with your community that you will need to operate on the site when undertaking your restoration process (Definitions and Synonymy: Ecological Restoration Section 1: Overview).

The reality is, however, that there are some people who are so fond of what they have grown up with, or have moved to a particular area to enjoy (views and access are two classic examples), that they will not support your project. Provided you have done your networking well and you have broader community support, this may not be a serious problem, but you will probably ruffle some feathers along the way.

Pilot projects and trials

Set up a pilot or trial site and show what you can do with the available resources. Remember to start small and make an impressive show: this will help to engender broader community support and to sway decision makers at all levels of the community. Your pilot project should also aim to be on a site with the right amount of public exposure: if you are sure you will succeed, put it in a high profile locality so that you impress the public from the start. If you are not sure that you will quickly or easily succeed (i.e. you need to trial some techniques or your site is inherently difficult), choose a more discrete site that will allow you to work away from the public gaze. When you overcome your problems, then you can bring the public in to observe the success. You should always be up-front about the restoration journey (i.e. littered with mistakes, pitfalls and successes) because these are an important part of convincing people that you can do the job: that is, it shows that you can learn and adapt.

Project planning

Once you have a project site, you need to plan your project. Table S16 lists what you should know about your restoration site before you begin. Table S17 lists the steps that you should take while planning and implementing your project (the level of complexity depends on your position and role in the matrix). The broad general principles that require attention include:

- Use as much existing information as possible (species selection, restoration methods etc.)
- Knowing your site well before you begin (Chapter 7: Site assessment and project planning)
- Knowing what you need to do and when to do it (Chapter 8: Site preparation)
- Running a series of trials to deal with site specific problems (browsing, weeds, flooding, high water tables, etc.) (Adaptive management)
- Learning how to manage pest animals (Chapter 8: Pest management)
- How you will manage weeds (Integrated weed management).

Project implementation steps

Your site has a number of hidden facts that are relevant to the task of rainforest restoration and the troubleshooting you need to do as a rainforest restorer. You must uncover these before you can successfully apply your chosen rainforest restoration method. If you miss this step, you will learn a lot but at the expense of your time, money and resources. Rainforest restoration is relatively easy to set up and to implement, but it does consist of a number of logical steps that should be followed so you don't get into a muddle about what your role is, where you fit in to the process (Table S17) and what must be done to get the restoration project up and going (Table S18).

Reference sites

Introduction

Reference sites are very useful when it comes to restoring rainforest where little of the original structure or species composition remains. They help you to understand niches, as well as structure and conformation. Reference sites provide information on:

- Habitat preferences and boundary demarcations for different rainforest and other EVCs as well as for rainforest floristic communities on your site (e.g. *East Gippsland Coastal* Warm Temperate Rainforest on limestone gully sides versus *Alluvial Terraces* Warm Temperate Rainforest on the alluvial flats of the gully floor). The differences between species lists of these floristic communities in Appendix S6 attest to these habitat differences
- Habitat preferences for individual species (exposure, aspect, geology, landform, soils, water-logging, water table depth, salinity, etc.)
- Disturbance responses (what light niches species' need, in what order species regenerate)
- Which restoration method needs to be applied, what species are likely to be in the soil seed bank and therefore may not need to be planted, and so on.

Choosing a good set of reference sites is therefore very important. For the comparison to have the greatest validity, you should have sites that are close geographically and:

- The same geology, landform, soils, aspect, inundation and flooding regime
- The fire frequency and intensity should be comparable (as judged by a similar disposition of fire moderating features in the landscape compared with your restoration site)
- The two sites should have a similar exposure.

Having more than one reference stand to develop your ideas about how to restore the rainforest on your site is highly desirable because this allows you to pool your observations (averages if you like). These give you a better 'feel for the usual habitat of species and communities' and their responses to a range of disturbance types. It is a bit like going to a new town for the first time, though you don't consciously do it, you get a feel for the place. This is exactly what you do when you use a reference sites and relate them back to your restoration area. The major difference being, that for rainforest restoration, you need to be systematic about your observations and conclusions.

Fortunately, much of the time you would normally have to spend on this process has already been expended on your behalf in that we have compiled most of the rainforest quadrat data and analysed them to come up with floristic communities of rainforest (this represents the averages we talked about earlier). The habitat of these floristic communities has been comprehensively described by: Peel (1999), Beukers and Miles (in prep.), Tindall et. al. (undated), as well as by this publication. The synthesis of all of this data is embodied in the various keys to rainforest (Definitions and Synonymy) and you can use this important information for the repair and reconstruction of your rainforest restoration site.

Table S16. What you need to know about your restoration site before you begin.

The question	How to find out	Why you need to know
History: was it ever rainforest?	Look up old maps, histories, consult pre-1750s mapping, analyse the landform and fire protection, talk to older or past residents, contact historical societies for records or photos etc. Use the Rainforest Divination Tool.	You are wasting your time if it never was rainforest because of the land form (lack of fire protection, rainfall, too much frost or exposure, soils or drainage may be inappropriate). Stick to known sites where nature will help your efforts.
Are reference sites available?	Look for rainforest on the same (or equivalent geology) and landform.	This will help you to be able to answer the next important question.
Has the site changed since rainforest was cleared?	Are there any remnant patches left, are there any remnant plants, have the watercourses been swamped with silt (water tables could be a problem: as rainforest needs at least 30cm of water-free soil); has the catchment been cleared (frost may retard establishment or salinity might require another vegetation type)?	Remnants will be useful for identifying the community to be restored and can provide propagation material as well as reassuring you that the existing conditions will support rainforest. A cleared catchment means a much colder catchment and specific techniques will have to be applied because of increased frost effects (Chapter S7: Frost and frost management).
What are the dominant pastures: Kikuyu, Yorkshire Fog/Rye, Water Couch?	Assess the ground layer for evidence of water-logging. See Table 7.4..	Kikuyu (severe frost unlikely); Yorkshire Fog/Rye Grass (severe frosts likely); Water Couch (plant Swamp Scrub first) rainforest not suitable in the first instance as water tables are too high, etc.
If it never was rainforest, is the site suitable for it today?	Analyse the site for protection from fire and flood.	If something has changed (flooding regimes or fire regimes), then you may wish to proceed in some instances. For example, include teaching sites and some urban amenity plantings for demonstration purposes. However, from the conservation perspective, past rainforest habitat is more important to restore in the first instance.

It is most important, though, to visit the reference sites that you have chosen yourself. There is no substitute for actually visiting your chosen reference sites (and often) because they change with the seasons, disturbance (flood, fire and browsing), the climate (drought, floods, etc.) and over time. Sadly, we are currently witnessing the demise of many of our most important rainforest stands to feral deer. If no-one was out there looking at these sites from the perspective of them being reference stands for rainforest restoration, then it is likely that this devastation would have gone on largely un-noticed.

Having said all of this, if there are no sites that are directly comparable, it is allowable to have some of the factors a little bit different between your reference and restoration site: you simply have to cope with the discomfort that comes from making less direct comparisons and getting some of your conclusions a bit awry. Restoration can sometimes be an uncomfortable melding of science and art, but the discomfort is worth it because the process works and works well. The following examples will help you, as will your intuition.

Lochend Jungle and the lower Snowy River like for like: but with a bit missing

This beautiful rainforest stand is located on the right bank of the lower Snowy River between Orbost and Marlo in Victoria. It is a very special remnant of about 4ha on a narrow alluvial terrace beneath a riverine escarpment and a fertile floodplain that is now largely cleared. It has probably survived land clearing because it is very narrow (10-30m wide) and was not worth the effort to clear for agriculture. It is a reference site for the Warm Temperate Rainforest restoration work on the lower Snowy River, but something is amiss about the site (Figure S237).

Table S17. Project implementation steps and who should participate [local experience and Clewell *et. al.* (2005)].

Item	Stakeholder					
	Communities	Agencies	Managers	Ecologists*	Landholders	Restorers
CONCEPTUAL PLANNING						
Identify site and extent						+/-
Determine ownership						
Develop case for restoration						
Decide what will be restored						+/-
Identify *restoration goals***						+/-
Identify physical changes needed						+/-
Identify ecological brakes						
Identify weed control/planting						+/-
Identify landscape restrictions						+/-
Identify funding sources						+/-
Identify labour and equipment						+/-
Obtain permits and permissions						
Identify legal constraints						
Set project duration						+/-
Ongoing stewardship						+/-
PRELIMINARY TASKS						
Document site history						+/-
Find and document reference sites						
Document existing state of site						+/-
Conduct pre-project monitoring					+/-	+/-
Trial restoration techniques					+/-	
Scope project and goals						+/-
Prepare budget					+/-	+/-
Network with agencies					+/-	+/-
Network with community					+/-	
Involve agencies and public					+/-	+/-
Construct necessary infrastructure					+/-	
Accredit and train restoration staff						
PROJECT IMPLEMENTATION						
Appoint restoration practitioner					+/-	
Appoint contractors/staff					+/-	
Define tasks and set standards					+/-	+/-
Produce schedule of works					+/-	
Obtain/contract supplies					+/-	
Mark out works areas+monitoring					+/-	+/-
Undertake works					+/-	
POST IMPLEMENTATION TASKS						
Natural regeneration (maintenance)					+/-	
Reconnoitre site to find problems						
Maintain monitoring projects					+/-	
Feed knowledge back to new projects					+/-	
EVALUATION OF PROJECT						
Use monitoring to assess success					+/-	
Conclude project and report						
Engage key stakeholders and report						
Publicise results					+/-	
EXAMPLES SUMMARIES (to illustrate project scale)						
Snowy restoration project: $7M	State/Orbost	Treasury DSE	DSE/CMA	Peer review	Farmers	5 companies
Infill Gullies project: $50K			EGCMA	Author	*C-NALC*	

*Restoration ecologist and/or specialist technical advice (depending on stage or task: e.g. engineer, zoologist, etc.);
**Restoration goals: *recovery*; *replacement*; and/or *transformation*).
+/-: the participation of this group is sometimes necessary, sometimes not. It depends on the expertise of the other participants and whether individual groups have multiple roles.

Table S18. Project implementation steps: using the Bairnsdale Urban Landcare Mitchell Walk project's early years.

Step	Actions required	Result
1. Define limit of site	• Set clear limits that match you or your groups' ability to implement the project.	Lind Bridge to Princes Highway Bridge on both sides of the Mitchell River.
2. Investigate past vegetation	• Consult the pre-1750s EVC map • Consult archives (+local histories) • Talk to old-timers • Examine remnants (Littoral Rainforest on cliffs) • Consult local agencies • Consult local vegetation experts (see Useful contacts).	Used to be: • Warm Temperate Rainforest on the river flats (historic records, oral history); • Littoral Rainforest on riverine cliffs (remnants); and • More frequent burning on flats maintained the grassy Dry Valley Forest.
3. Decide Ecological Vegetation Class/Ecological Community	• Revealed by previous investigation.	• Warm Temperate Rainforest • Littoral Rainforest • Dry Valley Forest.
4. Decide Floristic Communities	• Look for quadrats or equivalent vegetation on same landforms.	• Nearest sites at Calulu or in Mitchell River National Park.
5. Assess frost risk	• Check nearest weather station (Bairnsdale) records.	• Months where frosts occur <2°C: 8 (April to November) • Mean frost days of <2.0 °C: 30.4 • Months where severe frost occurs <0.0°C: 6 (May to October) • Mean frost days of <0.0°C: 9.7 • Total mean frost days annually: 40.1. Conclusion: Significant frost impacts.
6. Undertake site plan (map)	• How many sub-units or works areas (include area in m^2) • What native species are present • What significant weeds • Which restoration method • What order of priority.	• 24 sub-units of various sizes • Varies see relevant species lists • Varies see relevant species lists • Mix of Framework, Maximum Diversity or Natural Regeneration • See attached species list.
7. Apply for funding	• Which funding source suits your abilities (scale) and your project (based on site features and goals).	• Envirofund • World Wide Fund for Nature • Shire or state grants.
8. Decide your restoration method and from this the species mix; order plants and collect seed	• Which Restoration Method for which sub-units.	• Develop species lists and the order of planting by sub-units (based on Restoration Method: see relevant lists).
9. Order plants based on funding and planting season	• Place nursery order and choose planting season (see Tables S29 and S30).	• Nursery order placed • Planting season is autumn for frost-hardy pioneers and spring for frost sensitive rainforest species (except Dry Rainforest sites).
10. Site preparation	• Target weeds, spray for planting.	• Weeds targeted or removed (Poplars), spraying for planting done.
11. Planting YEAR 1 First planting Second planting	 • Autumn-Spring • Spring.	 • Only frost hardy species establish • Frost sensitive species establish.
12. Maintain previous plantings	• Do maintenance as necessary • Do not overspray.	• Suppress emerging weeds, ensure plant establishment.
13. Planting YEAR 2	• Repeat steps 8-12	• And the project is on its way.
14. Review progress (Table S22 The observation action cycle)	• Conduct a review of successes and failures: return to the appropriate action above.	• Learn and adapt your next actions and work cycles to improve efficiency and efficacy.

HOW TO CONSERVE GROUND FERNS WHEN BLANKET SPRAYING PERNICIOUS SHADE WEEDS

Figure S237. Lochend Jungle, Snowy River, Victoria. This site was covered in the transforming groundcover weeds Wandering Jew **Tradescantia fluminensis* and Blue Periwinkle **Vinca major* that were mixed in with Lacy Ground-fern *Dennstaedtia davallioides*: a colonial species. As you can see, the site is now clean as a whistle. This was achieved by pruning off the fronds, waiting a week, then spraying the weeds. The ferns then re-sprouted unaffected. Note the importance of multiple reference sites (the absence of tree-ferns due to poaching here) compared with Figure S239. The Lacy Ground-fern probably remains because it does not transplant well.

Although most of its structure and species composition are comparable to the historic accounts of the lower Snowy River (Additional Reading: Comprehensive account of historic information for rainforest on the lower Snowy) and other stands nearby, it is lacking some key components. The components that are lacking are thought to be associated with the good public access and high level of use the site receives. There has been a long history of both local gardeners and commercial collectors raiding the rainforests of East Gippsland for 'desirable' plant specimens. This has led to the poaching of several fern species (noted as late as 1954 by Wakefield) that should otherwise be abundant on the site, including Black-stemmed Maidenhair *Adiantum formosum,* Rough Tree-fern *Cyathea australis*, Soft Tree Fern *Dicksonia antarctica*, Fragrant Fern *Microsorum scandens* and Mother Shield-fern *Polystichum proliferum,* as well as Butterfly Orchids *Sarcochilus australis* (Figure S238) These species are abundant in similar habitat in more remote localities nearby such as the Brodribb or Bemm Rivers (Figure S239). This is a very clear example of the importance of having several reference sites when making decisions about what should be done on your restoration area and what species should be there. Sadly, the populace are still in a poaching frame of mind, and we have had Gippsland Waratah *Telopea oreades* seedlings stolen from our restoration plantings on the Marlo Road.

Goalen Head and Bass Point; an indirect comparison using the next best choice

Goalen Head is situated between the Murrah River and Bunga Head in southern New South Wales. Geologically it is composed of gabbro (an ***plutonic intrusive igneous*** geology), which is rich in iron and other important plant nutrients that produce luscious red clay loams and its soils are, as a consequence, highly fertile. Not surprisingly therefore, it has been almost entirely cleared. It is a very restricted geology in the study area and elsewhere on the east coast of Australia. The headland's climate is subtropical. The site had good fire protection afforded by large areas of the grassy ecosystem Bega Dry Grass Forest in the immediate hinterland. It is thought (based on the few scattered species left on the site) and the abundance of Subtropical and Littoral Rainforests nearby (within meters) on other geologies, that the headland used once to have had substantial areas of very species-rich Littoral Rainforest present on the site (Appendix S6: worksheet: Littoral Rainforest).

USE MORE THAN ONE REFERENCE SITE TO BE SURE YOU GET THE FULL PICTURE

Figure S238. Goldsmith's Rainforest Gully, Colquhoun Forest Victoria. The very beautiful Butterfly Orchid *Sarcochilus australis* (cited as an endangered species in the Victorian rainforest flora IUCN Red List): was poached by the sugar bag full from the Warm Temperate Rainforests of East Gippsland. Sadly it never establishes in gardens (Elliot and Jones 2002) and so all the thievery was wasted. Those that escaped in the wild, are now under threat from deer and megafires. Photo: Rohan Bilney.

Figure S239. Bemm River on the Princes Highway, Victoria. This is how Lochend Jungle should look (with abundant tree-ferns and epiphytes), but none remain today as illustrated in Figure S237.

Normally when faced with this scenario, the rainforest restorer's first option should be to seek a reference site on the same landform and geology in the same climatic zone as a reference site for the structure, composition and conformation of the rainforest stand that is to be reconstituted. Unfortunately, no other intact or partially intact gabbro headland is available in the South East Corner Bioregion. Even further afield, these options are limited. The next best thing is to find a reference site on an alternative geology that is the chemical equivalent of gabbro on the same landform and in the same climatic zone as the restoration site.

Fortunately, such an option does exist: in the form of Bass Point: a beautiful and precious Littoral Rainforest remnant in the Illawarra region located between Minnamurra Spit and Shellharbour. This headland is partially composed of basalt, which is the volcanic ***extrusive*** (and chemical) equivalent of gabbro (Bell and Wright 1985). This site is some 250km further north of Goalen Head. At this latitude, many new species have been added to the Littoral Rainforest and several have been lost through a process called ***latitudinal sifting***. At this point, it is worth remembering what similarities and differences there are between these sites, so as not to over-extend the comparisons that would invalidate conclusions that the rainforest restorer might be tempted to make:

Dissimilarities: latitude, directly comparable species composition;
Similarities: soils, climate zone, landform, exposure, aspect and ecological vegetation class.

What then are the conclusions that can be reasonably drawn from such a comparison and how are these constrained by the dissimilarities and similarities between the sites? Here are some pointers:

Valid conclusions:

1. The vegetation's structure would be comparable, because both sites had or carry Littoral Rainforest, (and structure is caused by wind and salt exposure rather than being determined by any of the dissimilarities)
2. Conformation is comparable (adaptation and structure of the rainforest and individual species to the headland: which shared species occur in the frontline, which species are emergents, canopy or subcanopy plants, etc.). This is because prevailing winds, climate and exposure are similar (note that this also importantly includes planting sequences based on succession visible at Bass Point)
3. Life-form categories represented (because the climate, exposure, EVC and soils are similar)
4. The stands' disposition with respect to aspect and exposure on the headland: niches, gaps, mature rainforest, ecotones stages of success, etc.

Less-valid conclusions:

1. Species that occur in the hinterland of Goalen Head were present on the headland. This conclusion is more shaky than those previously listed because it is regularly noted that species at the edge of their biogeographic range can occur inland, but not on the coast at the same latitude and vice versa. For example, Small-leaved Fig *Ficus obliqua* occurs on rhyolite as far south as Tanja (J. Miles pers. comm.), but is absent from Littoral Rainforests on rhyolite on the coast at the same latitude. This species does occur in Littoral Rainforests on the same geology, but further north at Bunga Head. Conversely, Tasman Flax Lily *Dianella tasmanica* is abundant in Littoral Rainforests as far north as the Bega River estuary, but absent from Littoral Rainforests further north, even though it is still abundant in the Warm Temperate Rainforests of the hinterland and escarpment ranges further north
2. The composition of the Littoral Rainforest stand and the hinterland types will be similar (Warm Temperate and Subtropical Rainforests). This is unlikely, even if they grow contiguously. This is because exposure to salt-laden winds, saline water tables, saline geologies with connate salts or saline inundation events that individually or collectively cause Littoral Rainforests to be full of coastal species, but lacking moisture dependent species. Consequently, the composition of Littoral Rainforest differs markedly to that of the juxtaposed hinterland rainforest vegetation that grows in a more sheltered locality. See Table S19 and S20 for just such a comparison for *Bung Yarnda* Littoral Rainforest and *East Gippsland Coastal* Warm Temperate Rainforest.

So, how do you work out what species should be part of your restoration effort? Because of latitudinal sifting, it is more appropriate to consider the nearest Littoral Rainforest stands (even though they are on different geologies) and the contiguous Subtropical Rainforest stands than it would be to use all of the species found at Bass Point as your reference site template for the past plant assemblage at Goalen. This is because, even though Goalen Head is on gabbro and the nearest rainforest stands that can be used for reference are on rhyolite (a very different geology). Species from Bass Point must also have the latitudinal gradient sieve applied to them; that is, those that are not recorded that far south should not be included in any proposed planting at Goalen.

Sooner or later, you all will be faced with getting down to the nitty-gritty of deciding exactly what species you would recommend be used on your restoration site. We have used Goalen Head based on the author's knowledge of rainforest stands in the neighbourhood, as well as at Bass Point, to show you the logic behind the process and how to go about it for your own site. You will note that the species lists are divided into life-forms to help you to get your head around the likely structure of this extinct Littoral Rainforest that you hope to reconstruct. The former composition of *Goalen Head* Littoral Rainforest is reconstructed from a number of different sources and the species annotated in decreasing order of reliability and probability:

1. The composition of remnant rainforests (Littoral, Subtropical, Dry) growing within 3 km of Goalen Head
2. Individuals or groups of plants on the same geology (gabbro) associated with Goalen Head
3. Species that occur both in the Littoral Rainforests of the subtropical zone within the study area (and also present in rainforest remnants associated with Goalen Head)
4. Trees listed for similar habitat: seacliff north of Thirroul (Fuller and Badans 1980)
5. Trees listed for similar geology: on the Volcanic Soils on the Coastal Plain (Berkeley and Flagstaff Hills in the Illawarra (Fuller and Badans 1980), which still occur as far south as Goalen Head.

The reader (land manager and rainforest restorer) may conclude which species are the most likely to have existed in this community in the past. Species recorded in other Littoral Rainforest stands in the area are underlined; **bolded species** are Littoral Rainforest species (Floyd 1990 and by default, (based on habitat, by Fuller and Badans 1980). The composition of *Goalen Head* Littoral Rainforest may once have contained some or all of the following species:

Trees: Lightwood *Acacia implexa*[1, 2, 3], Maidens Wattle *A. maidenii*[1, 2, 3, 5], Black Wattle *A. mearnsii*[1, 2, 3, 5], Blackwood *A. melanoxylon*[1, 5], Bower Wattle *A. subporosa*[1, 2], Yellowwood *Acronychia oblongifolia*[1, 2, 3], **Wild Quince *Alectryon subcinereus***[1, 2, 3], **Drooping Sheoak *Allocasuarina verticillata***[1, 2, 3, 4], **Coast Banksia *B. integrifolia***[1, 2, 3, 4], Kurrajong *Brachychiton populneus*[1, 2], Oyster Bay Pine *Callitris rhomboidea*[3], Brittlewood **Cloaxylon australe**[1, 2, 3], Southern Kurrajong *Commersonia rossii*[1, 2, 3], , **Giant Stinging Tree *Dendrochnide excelsa***[1, 5], Sassafras *Doryphora sassafras*[1], Koda *Ehretia acuminata*[1, 5], Forest Red Gum *Eucalyptus tereticornis*[1, 2], Cherry Ballart *Exocarpos cupressiformis*[3], Sandpaper Fig *Ficus coronata*[1, 3], Small-leaved Fig *Ficus obliqua*[1, 3, 5], Rusty Fig ***Ficus rubiginosa***[1, 2, 3, 4, 5], Austral Mulberry *Hedycarya angustifolia*[1, 2, 3], Cabbage Fan Palm ***Livistona australis***[1, 3, 4], Mangrove Boobialla ***Myoporum acuminatum***[1, 2, 3, 5], Muttonwood *Myrsine howittiana*[1, 2, 3], Large Mock Olive *Notolea longifolia*[1, 2, 3, 5], Large Mock Olive *Notolea venosa*[1, 2, 3, 5], Sweet Pittosporum ***P. undulatum***[1, 2, 3, 4], Yellow Elderberry ***Sambucus australascica***[1, 4], Yellowwood ***Sarcomelicope simplicifolia***[1, 3], Scentless Rosewood ***Synoum glandulosum***[1, 2, 3, 4] and **Lilly Pilly *Syzygium smithii***[1, 2, 3, 4, 5].

Shrubs: Coast Wattle *Acacia longifolia* ssp. *sophorae*[2, 3], Sea Box *Alyxia buxifolia*[2, 3], Coffee Bush *Breynia oblongifolia*[1, 2, 3], Chef's Cap Correa *C. baurelinii*[1, 2], Bolwarra *Eupomatia laurina*[1, 2, 3], Coast Beard-heath *Leucopogon parviflorus*[1, 2, 3], Hillock Bush *Melaleuca hypericifolia*[1, 2, 3], *Myoporum beattae*[1, 2, 3], *Myoporum bonariense*[1, 2, 3], Bleeding Heart *Omolanthus nutans*[1, 2, 3], *Omalanthus stirligifolius*[1, 2, 3], Spicy Everlasting *Ozothamnus argophyllus*[1], Orange Thorn *Pittosporum pauciflorus*[1, 2], Rough-fruit Pittosporum *P. revolutum*[1, 2, 3], Kangaroo Apple *Solanum aviculare*[1, 2, 3], Violet Nightshade *Solanum silvestre*[1, 2, 3], Devil Thorn *Solanum stelligerum*[1, 2, 3] and Coast Rosemary *Westringia fruiticosa*[1, 2, 3].

Vines: Gum Vine *Aphanopetalum resinosum*[1, 2, 3], Staff Climber *Celastrus australis*[1, 2, 3], Jungle Grape *Cissus hypoglauca*[1, 2, 3], Wombat Berry *Eustrephus latifolius*[1, 2, 3], Scrambling Lily *Geitonoplesium cymosum*[1, 2, 3], Trailing Guinea-flower *Hibbertia scandens*[1, 2, 3], Dusky Coral Pea *Kennedia rubicunda*[1], Yellow Milk Vine *Marsdenia flacescens*[1, 2, 3], White Milk Vine *Marsdenia rostrata*[1, 2, 3], Seaberry Saltbush *Rhagodia candolleana*[1, 2, 3], Pearl Vine *Sarcopetalum harveyanum*[1, 2, 3] and Austral Sarsaparilla *Smilax australis*[1, 2, 3].

Forbs: Bidgee Widgee *Acaena novae-zelandiae*[1, 2, 3], Karkalla *Carpobrotus rossii*[1, 2, 3], Austral Stork's-bill *Pelergonium australe*, Shade Plantain *Plantago debilis*[1, 2, 3], *Plectranthus graveolens*[1, 2, 3] and Pastel Flower *Pseuderanthemum variable*[1, 2, 3].

Graminoids: Stout Bamboo-grass *Stipa ramossima*[1, 2, 3], Bergalia Tussock *Carex longebrachiata*[1, 2, 3], Margined Panic *Entolasia marginata*[1, 2, 3], Rough Saw-sedge *Gahnia aspera*[1, 2, 3], Basket Grass *Oplismenus hirtellus*[1, 2, 3] and Sword Tussock-grass *Poa ensiformis*[1, 2, 3].

Ferns (including lithophytes and epiphytes): Common Maidenhair *Adiantum aeothipicum*[1, 2, 3], Black Stem Maidenhair *Adiantum formosum*[1, 2, 3], Climbing Fishbone Fern *Arthropteris tenella*[1], Bird's Nest Fern *Asplenium australascicum*[1, 2], Necklace Fern *Asplenium flabellifolium*[1, 2, 3], Prickly Rasp-fern *Doodia aspera*[1, 2, 3], Sickle Fern *Pelleae falcata*[1, 2, 3], Bracken *Pteridium esculentum*[1, 2, 3], Elkhorn *Platycerium bifurcatum*[1, 2, 3] and Leathery Shield-fern *Rumorha adiantiformis*[1, 2, 3].

Although you may make some errors in your choices when reconstructing the past species compositions of such very degraded sites (because the soils and their chemical and drainage characteristics may differ or the microclimate is wrong, etc.), these will soon become apparent: the inappropriate species will simply fail to thrive or they will die. The overall conclusion then is that the closer your reference stands' features are to your restoration site, the stronger the similarities and the safer (i.e. the more accurate) the conclusions that can be drawn. .

Using data from the author's floristic analysis of Littoral Rainforest quadrats in south-eastern Australia, Table S19 and Table S20 show what can be deduced in terms of ecological information if you are familiar with the plants of your area and are observant about where (and why) they grow where they do. This comparison clearly illustrates the principle of ecological vegetation class differences between these two juxtaposed rainforest vegetation types. This exercise illustrates the very important process of applying ecological knowledge to species lists so you can derive understandings about plant distribution as mediated by environmental and niche conditions. The case examines moisture and life-form, which are linked in the fashion of: niche and community structure. Both of these themes, as well as the all-important light niche, are documented in the various Appendices that help you decide where and when to plant.

Note the following categorisations of the species listed in Table S19 and Table S20: ***characteristic species***: >27% frequency; less common but usual species: <27% frequency. Species highlighted in yellow are coastal species; species highlighted in blue are moisture-dependent species.

Table S19. Comparison of characteristic species between two adjacent EVCs of rainforest at Lakes Entrance, Victoria.

Characteristic species		
Only in: *Bung Yarnda* Littoral Rainforest	Species common to both	Only in: *East Gippsland Coastal* Warm Temperate Rainforest
Emergent trees: Coast Banksia *B. integrifolia* Blue Box *Eucalyptus baueriana* Eurabbie *Eucalyptus globulus* ssp. *bicostata*	Emergent trees: Blackwood *Acacia melanoxylon*	Emergent trees:
Canopy trees: Black Wattle *Acacia mearnsii* Cherry Ballart *Exocarpos cupressiformis* Swamp Paperbark *Melaleuca ericifolia* Common Boobialla *Myoporum insulare*	Canopy trees: Muttonwood *Myrsine howittiana* Sweet Pittosporum *P. undulatum* Hazel Pomaderris *P. aspera* Lilly Pilly *Syzygium smithii*	Canopy trees: Yellowwood *Acronychia oblongifolia*
Shrubs: Hops Goodenia *G. ovata* Coast Beard-heath *Leucopogon parviflorus* Sticky Daisy-bush *Olearia viscosa* Tree Everlasting *Ozothamnus ferrugineus* Bootlace Bush *Pimelea axiflora*	Shrubs: Prickly Currant-bush *Coprosma quadrifida* Tree Violet *Melicytus dentatus* s.l. Mock Olive *Notelaea venosa* Snowy Daisy-bush *Olearia lirata*	Shrubs: Musk Daisy-bush *Olearia argophylla*
Vines: Rusty Dodder-laurel *Cassytha phaeolasia* Twining Glycine *G. clandestina* Bower Spinach *Tetragonia implexicoma*	Vines: Staff Climber *Celastrus australis* Forest Clematis *C. glycinoides* Wombat-berry *Eustrephus latifolius* Scrambling Lily *Geitonoplesium cymosum* White Milkvine *Marsdenia rostrata* Wonga Vine *Pandorea pandorana* Austral Sarsaparilla *Smilax australis* Bearded Tylophora *T. barbata*	Vines: Jasmine Morinda *M. jasminoides*
Forbs: Southern Tick-trefoil *Desmodium gunnii* *Euchiton gymnocephalus* Maori Bedstraw *Galium propinquum* Yellow Pennywort *Hydrocotyl foeveolata* Hairy Pennywort *H. hirta* Stinking Pennywort *H. laxiflora* Grassland Wood-sorrel *Oxalis perennans* Shade Plantain *Plantago debilis* Jagged Fireweed *Senecio biserratus* Shrubby Fireweed *S. minimus* Slender Fireweed *S. prenanthoides* Prickly Starwort *Stellaria pungens* Trailing Speedwell *Veronica plebia* Ivy-leaf Violet *Viola hederacea* Sprawling Bluebell *Wahlenbergia gracilis s.l.*	Forbs: Kidney-weed *Dichondra repens* Northern Cranesbill *Geranium homeanum* Slender Dock *Rumex brownii* White Elderberry *Sambucus gaudichaudiana* Forest Starwort *Stellaria flaccida* Scrub Nettle *Urtica incisa*	Forbs: Forest Nightshade *Solanum prinophyllum*
Graminoids: Striped Wallaby-grass *Austrodanthonia racemosa* Common Grass-sedge *Carex breviculmis* Bergalia Tussock *Carex longebrachiata* Tasman Flax-lily *Dianella tasmanica* Knobby Club-rush *Isolepis nodosa* Variable Sword-sedge *Lepidosperma laterale* Spiny-headed Mat-rush *Lomandra longifolia* Common Wood-rush *Luzula meridionalis* Sword Tussock-grass *Poa ensiformis* Common Tussock-grass *P. labillardierei* Grey Tussock-grass *P. sieberiana*	Graminoids: Hedge-hog Grass *Echinopogon ovatus* Black-fruit Saw-sedge *Gahnia melanocarpa* Weeping Grass *Microlaena stipoides* Basket-grass *Oplismenus hirtellus*	Graminoids:
Ferns: Bracken *Pteridium esculentum*	Ferns: Necklace Fern *Asplenium flabellifolium* Sickle Fern *Pellaea falcata* Tender Brake *Pteris tremula*	Ferns: Common Rasp-fern *Doodia media* ssp. *australis*
Unique characteristic species 43	Shared characteristic species 30	Unique characteristic species 5

Table S20. Comparison of usual species between two adjacent EVCs of rainforest at Lakes Entrance, Victoria.

Less common but usual species		
Only in: *Bung Yarnda* Littoral Rainforest	Species common to both	Only in: *East Gippsland Coastal* Warm Temperate Rainforest
Emergent Trees Coast Grey Box *Eucalyptus bosistoana*	Emergent Trees	Emergent Trees
Trees	Trees Blanket-leaf *Bedfordia arborescens* Yellow Elderberry *Sambucus australasica*	Trees
Shrubs Sallow Wattle *Acacia longifolia* ssp. *longifolia* Coast Sallow Wattle *A. longifolia* ssp. *sophorae* Sweet Bursaria *B. spinosa* Shiny Cassinia *C. longifolia* Coast Cassinia *C. maritima* Giant Hop-bush *Dodonaea viscosa* Blue Oliveberry *Elaeocarpus reticulatus* Blue Howittia *H. trilocularis* Austral Indigo *Indigofera australis* Shrubby Spurge *Phyllanthus gunnii* Gunyang *Solanum vescum*	Shrubs Kangaroo Apple *Solanum aviculare*	Shrubs Three-nerved Cassinia *C. trinerva*
Vines Love Creeper *Comesperma volubile*	Vines Small-leaved Bramble *Rubus parvifolius*	Vines Forest Bindweed *Calystegia marginata* Jungle Grape *Cissus hypoglauca* Yellow Milk-vine *Marsdenia rostrata* Twining Silkpod *Parsonsia brownii* White Supplejack *Ripogonum album* Pearl Vine *Sarcopetalum harveyanum* Star Cucumber *Sicyos australis*
Forbs Dune Thistle *Actities megalocarpa* Sea Celery *Apium prostratum* Common Cotula *C. australis* Rounded Noon-flower *Disphyma crassifolium* Nodding Saltbush *Einadia nutans* Rough Bedstraw *Galium gaudichaudiana* Wandering Bedstraw *G. migrans* Germander Raspwort *Gonocarpus teucrioides* Broad-leaved Stinkweed *Opercularia ovata* Cockspur Flower *Plectranthus parviflorus* Small Poranthera *P. microphylla* Jersey Cudweed *Helichrysum luteoalbum* Greenhood Orchid *Pterostylis* spp. Dwarf Skull-cap *Scutellaria humilis* Annual Fireweed *Senecio glomeratus* New Zealand Spinach *Tetragonia tetragonioides*	Forbs Shade Pellitory *Parietaria debilis* Indian Weed *Sigesbeckia orientalis* Forest Nightshade *Solanum prinophyllum* Eastern Nightshade *Solanum pungetium* Rose-leaf Bramble *Rubus rosifolius* Forest Hound's-tongue *Austrocynoglossum latifolium*	Forbs Shining Pennywort *Hydrocotyle sibthorpioides* Rough Fireweed *Senecio hispidulus s.s.*
Graminoids Leek Lily *Bulbine semibarbata* Knob Sedge *Carex inversa* Shiny Flat-sedge *Cyperus lucidus* Reed Bent-grass *Deyeuxia quadraseta* Paroo Lily *Dianella caerulea* Pale Flax-lily *Dianella longifolia* Coast Blown-grass *Lachnagrostis billardieri* Pale Rush *Juncus pallidus* Common Blown-grass *Lachnagrostis filiformis* Sandhill Sword-sedge *Lepidosperma concavum* Coast Sword-sedge *L. gladiatum*	Graminoids Tall Sedge *Carex appressa*	Graminoids
Ferns	Ferns Kangaroo Fern *Microsorum pustulatum*	Ferns Gristle Fern *Blechnum cartilagineum* Lacy Ground-fern *Dennstaedtia davallioides* Downy Ground-fern *Hypolepis glandulifera* Shiny Shield-fern *Lastreopsis acuminata* Fragrant Fern *Microsorum diversifolium* Mother Shield-fern *Polystichum proliferum* Jungle Brake *Pteris umbrosa* Rock Felt-fern *Pyrrosia rupestris*
Unique less common but usual species: 40	Shared less common but usual species: 11	Unique less common but usual species: 19
TOTAL UNIQUE: 83	TOTAL SHARED: 41	TOTAL UNIQUE: 24

The differences in niches between these two different rainforest ecological vegetation classes are listed as follows (note that the geology is the same):

Bung Yarnda Littoral Rainforest:

- Seacliffs and marginal bluffs
- Exposed to strong and regular oceanic winds that are sometimes storm-force
- High levels of salt derived from salt haze, connate salts (in the limestone geology) and roosting seabirds
- Steep topography leading to droughty soils
- Niche is drier due to:
    - Greater coastal wind exposure
    - Steeper landforms
    - More frequent *canopy attrition* and failure.
- Niches are warmer in winter (due to less frosts, shorter frosts, less severe frosts)
- Niche is cooler in summer due to humid and persistent sea breezes
- Major disturbance regimes:
    - Regular canopy attrition, leading to:
    - Occasional *canopy decapitation*
    - Landslips
    - (Rarely) Fire.

East Gippsland Coastal Warm Temperate Rainforest:

- Deeply incised gullies
- Topographically sheltered from strong winds
- Lower levels of salt with connate salts (in the limestone geology) the only source
- Less steep topography leading to moister soils
- Niche is wetter due to:
    - Greater shelter in the gully from wind
    - Gentler gradients on slopes
    - Longer persistence of dews
    - Greater soil moisture associated with drainage lines
    - More intact canopies for longer periods.
- Niche are colder in winter (due to more frosts, longer-lasting frosts, more severe frosts)
- Hotter in summer due to position in gully being sheltered from sea breezes
- Major disturbance regimes:
    - (Rarely) Fire.

For your restored site to have biodiversity value **always remember** that you are trying to restore a representation of what grew there previously rather than to produce a regional arboretum of all species or a biased planting based on what you like. **You are not gardening you are restoring**! Read your environmental cues: use our niche annotations in the planting appendices and give it a go and see how you get on.

Funding sources and extension advice

Now that you have a fair idea of the scale and locality of your project, now is the time to approach the people who can help with the dollars and the relevant technical or funding advice. Table S21 provides information on organisations that can provide extension advice while Appendix S13 provides help with who can fund what works in your rainforest restoration project. Make no mistake: rainforest restoration is an expensive process (Table 6.1.). It requires careful planning and constant vigilance on your part to reduce costs at every point in your project. **Start small and don't overreach yourselves: an early success is worth much more to your credibility and the morale of your workers than a grand scheme that stumbles at the first hurdle.**

Table S21. Examples of sources of extension and technical advice relevant to rainforest restoration*.

Information needed	Source of advice	Contact details
Animal and plant identification and permits to collect seed	**Victoria**: Department of Sustainability and Environment NSW: National Parks and Wildlife Service	Orbost Switch: 03 5161 1222 Bairnsdale Switch: 03 5152 0600 Merimbula Switch: 02 6495 5000
Covenanting	**Victoria**: Trust for Nature NSW: Bush Heritage Australia	03 5153 0457
Erosion control	**Victoria**: Department of Primary Industries NSW: Southern Rivers CMA	Bairnsdale Switch: 03 5152 0600 <www.srcma.nsw.gov.au>
Funding advice	EGCMA Community Partnerships Officer	Bairnsdale Switch: 03 5152 0600
Pest plants and animals	**Victoria**: Dept. of Primary Industries. **General**: This Manual NSW: Department of Natural Resources	Orbost Switch: 03 5161 1222 Bairnsdale Switch: 03 5152 0600 <www.dnr.nsw.gov.au>
Project planning	Trust for Nature: Stewardship officer EGCMA Bushcare Facilitator EGCMA Community Partnerships Officer	Bairnsdale Switch: 03 5152 0600 Bairnsdale Switch: 03 5152 0600
Seed sources	**Greening Australia's Gippsland Seed Bank** **Rainforest restoration nurseries**	Generally only pioneer species All species: see appropriate entry
Rainforest restoration advice	This Manual or Rainforest restoration companies and practitioners	East Gippsland CMA Useful contacts
Rainforest restoration advice updates	*EG* RfCMN: *TfN*: Stewardship officer	<www.egrainforest.org.au> Bairnsdale Switch: 03 5152 0600
Training	Accredited rainforest restoration companies	See previous company entries
	Forestech (East Gippsland TAFE)	03 5155 6800; Fax 03 5155 6828

*Use this information to contact the relevant (and equivalent organisation) in your district or region.

Tax deductibility

This Manual is not able to give professional advice on tax deductibility of rainforest restoration works or the activities undertaken during these projects, so any specific queries should be directed to your professional taxation or accounting advisor. However, in Appendix S2 of the Big Scrub Rainforest Landcare Subtropical Rainforest Restoration Manual (2005) information on the subject of tax deductibility has been compiled that was reviewed by the Australian Taxation Office and was current as of February 2005. The following is a summary of this information from that source:

1. **Landcare tax deductions**: expenditure combating land degradation (including the degradation of native vegetation) are fully tax deductible in the year of expenditure, provided the taxpayer is a primary producer or carries on a business, the purpose of which is to earn income from rural land.
   a. **What activities qualify**: Provided rainforest remnants have been used for stock shelter, then activities that would qualify for tax deductibility include eradication of weeds in the remnant, revegetation (including site preparation), mulching, labour for planting of indigenous rainforest trees and fencing to exclude stock from the rainforest remnant or revegetation site.
   b. **Who qualifies**: You qualify as a primary producer if your business:
      i. Cultivates or propagates plants, fungi or their products or parts (including seeds, spores, bulbs or similar things) in any physical environment
      ii. Maintains animals for the purpose of selling them or their bodily produce including natural increase
      iii. Manufacture dairy produce from the raw materials that the taxpayer produced
      iv. Planting or tending trees in a plantation or forest that are intended to be felled
      v. Felling trees in a plantation or forest
      vi. Transporting trees or parts of trees felled in a plantation or forest to the place where they are first to be milled or processed; or from which they are to be transported to the place where they are to be first milled or processed
      vii. Stockfeed growers who sell on to other primary producers or have primary producers graze that feed in the taxpayers paddock (agistment)
      viii. Includes some fishing and related businesses
      ix. Includes horse riding schools, nature parks or a plant nursery.

      NOTE: Taxpayers who dabble in any of the above activities as part of a hobby or for general interest **would not qualify**.
2. **Income deductibility**: If the taxpayer is an individual and their primary production business incurs a loss (after deductions of Landcare and other eligible expenditures), then that loss can be deducted from other income of the taxpayer only if at least one of the following tests is satisfied:
   a. The assessable income (equivalent to gross income from turnover) exceeds $20,000

b. The assessable income from non-primary production is less than $40,000 (excluding any net capital gains)
c. The total assets in real property used for the primary production business exceed $500,000 (the value used is the greater of reduced cost or market value)
d. The other assets of the primary production business exceed $100,000 (excluding motor vehicles); the value of particular assets is usually their tax value
e. The primary production business had a tax deductible income (i.e. had a net profit) in 3 of the last 5 years.

The income deductibility tests also apply to the individual taxpayer that is a member of a partnership that carries on a primary production or rural business, but do not apply to trusts or companies that do the same thing.

What constitutes 'carrying on a business'? The Australian Taxation Office has no set precedents for the activities that constitute carrying on a business: all cases are individually assessed. However, the elements of the activities that are considered include:

- The purpose, scale and nature of the profit-making
- Repetition and regularity of the activities
- Whether the activities are organised in a business-like manner
- The volume of the operations and the amount of capital employed
- Whether the activities are actually hobbies or recreation
- The degree of control held by the person of the development and maintenance of the land.

Adaptive management

Adaptive management is a process that promotes flexible methods or pathways of achieving your stated goals on any restoration site. It is the most useful tool that you will acquire in your endeavours to restore rainforest. It is easy to do, but does require good observation skills, some forethought, planning and an open mind. You will need an open mind because you may have to abandon methods that did not work as expected, as well as take on new ways of doing things. A new method derived from adaptive management must satisfy two fundamental tenets before it is implemented: firstly, it should do no more harm than the previous method; and secondly, it must be an improvement on the technique that you are replacing. If you can manage adaptively then you will save a lot of time, money and effort by getting a better result quicker and more cheaply. Monitoring what you are doing with the express intention of improving is adaptive management.

Monitoring methods

Adaptive management is achieved through experimentation and monitoring the results. There are two experimental methods that can advise your adaptive management: the experimental approach and the comparative approach. Monitoring can tell you many things. A major reason for undertaking it is to judge your success and how effective you have been. Another reason is to judge the use of your site by some of your native species. This can include fauna surveys and natural regeneration. Either way, you have to learn the signs that nature shows you and what they may mean (Figure S240).

Swamp Rats are adaptable animals that often persist in degraded weedy riparian environments. Their populations crash as weed control is undertaken (i.e. removal of Kikuyu), but soon return when the cover and food resources supplied by your restoration works come on line. Often, animal signs and natural regeneration are linked (Figures S240, S241) and provide a good means of monitoring the return of ecological processes (a major aim of restoration). The pitfall is to panic at the first observation (rat populations crash), and risk seeing the pay-off, but you have to wait because this species returns as work progresses.

There are two ways of monitoring: the experimental method and the comparative method. The experimental method is difficult to achieve in restoration ecology because it requires that all things are equal between the two situations, except one variable that you can manipulate.

The experimental method

The experimental method is often used in what are euphemistically called the 'hard sciences': a term coined to denigrate the 'natural sciences' whose practitioners are rarely able to do such clean-cut experiments. For example, if you want to know whether the amount of a particular chemical produced by a chemical reaction is affected by heat, you simply control the heat of the two experiments and measure the difference in yield. In nature, this type of experiment is rarely possible. Rainforest restoration ecology can only rarely have the experimental method applied to it and is therefore not a hard science, but this does not mean that you cannot set up experiments and monitor the results to great advantage. You simply have to use the comparative method.

One exception where we have been able to employ the experimental method is that of determining which animal species disperse what seed. This is easily done by knowing (watching) when your subject animal defecates, then collecting the dung and sending it off to your (very cooperative) local rainforest nursery for processing and sowing.

The comparative method
This method for monitoring involves setting up an experiment and controlling for as many variables as possible and repeating the experiment a number of different times to be sure of the result. Where several variables can be influencing the outcome, you simply alter the method to test another variable and use logic and observation to discount the possible affects from other sources. In time, you build up a picture of what is going on rather than getting a precise answer after one experiment. The comparative method requires an expansive mindset and more of an open mind than does the experimental method. The comparative method recognises that much of nature and its features are not readily reduced to boxes with sharp boundaries. Instead nature (and rainforest restoration), is more often a continuum with multiple factors affecting the phenomenon that you are observing.

MEASURING SUCCESS: ANIMALS SIGNS THAT MEAN FREE PLANTS ARE ON THE WAY

Figure S240. Site 20 lower Snowy River, Orbost Victoria. Swamp Rat *Rattus lutreolus* burrows around the base of a Fireweed Groundsel *Senecio linearifolius* on the Snowy River Riparian and Rainforest Trial Demonstration Site. During autumn, this species is a seed eater and may disperse seed because it is also a seed hoarder, and forgotten larders may go on to germinate.

Figure S241. Site 70f Marlo Road, lower Snowy River Victoria. Not only did the male Satin Bowerbird *Ptilonorhynchus violaceous* find the 3-year-old restoration works worthy of building a bower, he and his mates brought seed onto the site (green arrows) the results of which can be seen a year later in Chapter S8: Figure S329. Bowerbirds are major dispersers of seed in south-eastern Australian rainforests and their presence is a good sign of the success of your rainforest restoration efforts.

Nonetheless, useful causes and effects can easily be observed and these 'natural facts' can then be employed to get great improvements on your restoration site. The following example illustrates some of these principles of the comparative approach and the cautionary tale of clear thinking that is required to avoid jumping to incorrect conclusions:

The auger versus the Hamilton Tree-planter debate
For most of the time that rainforest restoration has been practised over the past 8 years in East Gippsland, the Hamilton Tree-planter has been used as the sole method of planting.

This metal 'pogo-stick' (with no bounce) is designed to produce a hole that closely matches the shape and size of a ***forestry tube***. It has been developed to ensure a close fit between the roots of the propagated plant and the soil into which it is being planted. Then along comes an enterprising contractor who suggests that using a motorised soil auger would be quicker, more efficient and better for the plant.

Here are the very valid arguments used by the contractors to support their contention:
- The auger produces a larger area of ***tilth*** for the new plant's roots to grow into
- This tilth overcomes the time constraints of using a shovel where the clods have to be manually broken down to ensure a good soil root contact; it also allows site preparation for planting in dry periods before rain arrives
- The tilth also allows quicker and more access by rainfall (especially lighter rain) as it does not run off but preferentially soaks in around the newly planted plant
- The planting can proceed more quickly (i.e. in open areas free of obstruction).

On the basis of these well-composed points, the contractor was encouraged to use this method during September 2004 to plant three creek flats on Maringa Creek at Nyerimilang. As you can see when you compare Figures S242 and S243, the result of this single planting event have been dramatic, but is the result due to a change in planting technique alone?

MONITORING SORTING OUT WHAT YOU "SEE" FROM WHAT HAS ACTUALLY HAPPENED	
	
Figure S242. Maringa Creek Middle Flat, Nyerimilang Heritage Park, Victoria. November: 2 months after planting using augers in September 2004.	Figure S243. Maringa Creek Middle Flat, Nyerimilang, Victoria. August 2006: 2 years after adaptive management altered planting to frost-hardy species: Varnish Wattle *Acacia verniciflua*, Fireweed Groundsel *Senecio linearifolius*, Tree Everlasting *Ozothamnus ferrugineus*, Hazel Pomaderris *P. aspera.*

Unfortunately, although the issue of a trial to compare auger versus. Hamilton Tree-planter was discussed before the work began, this trial did not happen. Was the successful result (Figure S243) due to the new method or other compounding (complicating) factors? Of course the contractor was keen to press the case that it was the auger that made all of the difference. But consider the following factors:

- In previous years poor results for plant establishment have been proven through other trials to be the result of these factors:
  - Planting through the worst drought since records began
  - Inappropriate planting sequences (primary species being put in before secondary species)
  - Inappropriate niche plantings (late secondary species such as Hazel Pomaderris *P. aspera*) being planted in full sun instead of its required light niche of semi-shade
  - Heavy browsing by Hog Deer and Black Wallabies demolishing plantings
  - Inappropriate planting to deal with browsing (planting palatable species before camouflage or deterrent species were established)
  - Wrong planting time: autumn-winter, leading to severe frost mortality which upon that realisation dictated that planting be moved to and restricted to spring.
- The good results obtained in the September 2004 spring planting using the motorised auger are probably due to the following:
  - This was an excellent year climatically for planting (good preceding rains, few hot days to follow and excellent follow-up rains)
  - Appropriate planting sequences: frost-hardy pioneer and secondary species before frost-sensitive primary species (Figure S244)
  - Appropriate niche plantings (late secondary species planted in semi-shade)
  - Heavy browsing reduced by fencing to exclude 20-25 Hog Deer and leaving only 4 or 5 individuals
  - The widespread use of camouflage species (to reduce grazing impacts) Figure S245
  - Correct planting time (October: spring) to avoid frost mortality.

The conclusions about this excellent establishment result are as follows:

- There was no trial begun at the same time to determine any differences between the two planting methods, so no firm conclusions on this issue could be made as to which planting tool was better
- However, even during drought, excellent establishment success has been achieved using Hamilton Tree-planters on this and other sites. It is therefore unlikely that the use of soil augers alone is entirely responsible for the excellent outcome (although the hard work of the contractors definitely was a contributor)

- In reality, all of the factors in favour of success (excellent year, appropriate species, planting sequences, control of browsing, right planting time, huge effort by the workers, etc.) have masked any potential advantages or otherwise of using augers
- The only observed shortfall of the use of augers was that air pockets developed in some holes causing the plant to die (Figure S246)
- Clearly, though, there are no major disadvantages to using augers or the planting being discussed would have died (despite the favourable conditions)
- Augers are a quick and efficient method of planting *greenfield sites* where there is extensive open ground and few obstructions or tight planting niches (such as under existing bushes). Consequently, augers will be used again in the future.

TWO WAYS OF DEALING WITH BROWSING WITHOUT THE NEED FOR ARTIFICIAL PLANT GUARDS

Figure S244. Maringa Creek Top Flat, Nyerimilang Heritage Park, Victoria. To avoid browsing impacts by Hog Deer and Swamp Wallabies frost hardy pioneer and late secondary species such as Black Wattle *Acacia mearnsii* (background) and an advanced Eurabbie *Eucalyptus globulus* ssp. *bicostata* were planted. This photograph was taken 6 months after planting the advanced specimen. Eighteen months later, the Eurabbie was 5m high!

Figure S245. Maringa Creek Middle Flat, Nyerimilang Heritage Park Victoria. Three-month old un-browsed Blackwood *Acacia melanoxylon* emerges above 5-month old Fireweed Groundsel *Senecio linearifolius* that was used as a camouflage for the highly palatable Blackwood. Both Hog Deer and Black Wallabies were present on the site at the time. See Figure S247.

The real question is therefore: are there any features of the two planting methods that might be more useful in some situations than others? This issue is canvassed along with the other commonly used planting tool *Potaputkis* in Table S22 where planting rates are also listed. All of these methods employ 1 or 2 operators (with people on foot) because most sites are uneven and have other obstacles that preclude the use of machines. If, however, your site is flat and long-cultivated, the use of tractors with direct seeders can considerably increase rates of initial plantings (see: Chapter 8, Step 6: Planting). Mechanised tree-planters require ripping (not advised on floodplains: the usual flat rainforest habitat in south-eastern Australia), and planting rates (with site preparation) are comparable to hand planting of tubestock (Bridget Moss pers. comm.).

The observation-action cycle

Adaptive management is a cycle. It is related to the actions set out in Table S22, but it is not the same thing, because that example still requires multiple testing of the hypotheses that: "Mechanical augers are better than Hamilton Tree-planters' and appropriate adjustment of management actions based on those results. Adaptive management begins with an observation, your desire to understand a process or problem and then continues by: devising a test for your hypothesis; observing the result; and then modifying your actions or view about the initial observation and your hypothesis (see subject area 10 in the Accreditation section earlier this chapter).

Adaptive management can be applied to almost any task in rainforest restoration, and really represents what we do on a daily basis as individuals to just get by. If you fail to adapt to a particular problem by addressing the threat then you and your restoration site will continue to suffer. This may mean that your efforts fail, and if these involve others, your support can quickly evaporate. A classic example involves a project sites where people return to do the same task each time, but progress is minimal (or going backwards). This is a critical time for a project review so as to allow people to apply adaptive management and redirect their efforts and improve results and therefore morale. Two examples are provided in Appendix S14. Remember, a failure to achieve a particular restoration action is of itself not a problem. It only counts as a failure if you do not understand why the particular action did not work and you repeat the same doomed actions again!

Most of the methods and advice provided by this manual and its supplement are the result of the observation-action cycle and the adaptive management that we have applied following the results of our experimentation.

Consider the following example: one or more Kangaroo Apple species are a major plank in rainforest restoration in the lowlands of south-eastern Australia because they are ubiquitous and are keystone species that regularly regenerate after disturbance in Warm Temperate and Littoral Rainforests. Establishing these plants on your restoration site is an apparently simple task, but Kangaroo Apple failure can happen. Table S23 canvasses a series of 'real-life' trials or questions as examples of adaptive management in action.

<table>
<tr><th colspan="2">AUGERS VS HAMILTON TREE-PLANTERS</th></tr>
<tr><td></td><td></td></tr>
<tr><td>Figure S246. Maringa Creek, Nyerimilang Heritage Park, Victoria. Augers are a successful alternative to the use of Hamilton Tree-planters, but be aware that, unlike the tree-planters, there is a risk of creating an air pocket between the root ball and the surrounding surface. If this occurs (as this example shows), then the planted tubestock will die.</td><td>Figure S247. Middle Flat Maringa Creek Nyerimilang Heritage Park, Victoria. Here, Blackwood Acacia melanoxylon and Large Kangaroo Apple Solanum laciniatum are planted using Hamilton Tree-planters at the same time and have similar growth rates in their first year. In the second year the unpalatable Kangaroo Apple's growth slows and the Blackwood emerges (see Figure S245).</td></tr>
</table>

Use these adaptive management steps to understand the results presented in Table S23:

1. **Observe a result** (Kangaroo Apple grew): then continue as planned, **but** if it did not grow: **why**?
2. **Is there a problem: develop a hypothesis to explain the result by listing possible reasons for failure**: frost, low rainfall, snails, no mulch, browsing, weeds or cultivation; or **success**: right plant, right niche and right climatic conditions before, during and after. Note the importance of not ignoring a positive result: you **must learn from your successes as well as your failures**
3. **Test supposed reasons for success or failure**: by observation or setting up some simple trials
4. **Obtain results and adapt your actions** for the next time you plant Kangaroo Apple
5. **In future, look out for early signs of trouble** and act quickly to overcome the threat based on what it is that you have learned from your previous adaptive management.

Table S22. The observation action cycle: a comparison of mechanical augers and Hamilton Tree-planters in adaptive management.

	Mechanical auger	*Hamilton Treeplanter*	*Potaputkis*	Action
Advantages	• Better on drier soils • Better on hard setting soils • Advantageous if there is a prospect of rain and the site is a bit dry • Loams that make tilth; • Better rainfall infiltration • Planting rate may be a little faster	• Any damp soils • Easier if planting beneath existing vegetation (frost sensitive or palatable species) because the planter is physically smaller • Requires only one operator • Always has excellent soil-root ball contact (no air pockets).	• Faster on uneven ground: but soils must be friable • Less bending • In snake-ridden sites, less bite-hazard • Planting rate in loamy soils excellent: 700 plants per person per day (Neil Baker pers. comm.).	• Encourage use for appropriate too for site and site's conditions • Encourage use of augers on greenfield sites where there are no obstructions and large areas can be covered quickly.
Disadvantages	• No good on clay soils that don't make a fine tilth • Requires two operators • Not good for planting beneath existing vegetation (operators and machinery are fouled) • Can encourage soil-stored weed seed to germinate adjacent to the plants on sites that have an otherwise effective mulch (e.g. dead Kikuyu) • Extra care is required to ensure air pockets do not persist following planting (Figure S246).	• Planting rate may be a little slower (400 plants per person a day is good going).	• Soil texture must be just right; and • Not suited to heavy clay soils.	• Encourage use according to most efficient and appropriate planting tool for the site at the time of planting; • Use Hamilton Treeplanters on sites where niche plantings require the use the shelter of other plants; and • Use the right tool for the soil conditions.
Comparable	Damp loams			Personal preference

All of these scenarios have been encountered and have been investigated during rainforest restoration in south-eastern Australia. The successful resolution of these questions and the changes that resulted to methods has led to much higher levels of establishment success of Kangaroo Apple on restoration sites across the region.

Two other examples; one of a broader range of restoration challenges and the adaptive management used to deal with the problems at Nyerimilang and another regarding a failing Littoral Rainforest restoration site at Sea Acres in northern New South Wales are canvassed in Appendix S14.

Table S23. Adaptive management pathways to successful establishment of Kangaroo Apple*.

Possible causes for failure of Kangaroo Apple	Relevant observations/questions	Solutions
Frost	This implies that it grew well in spring and summer but was killed or damaged over winter.	Monitor minimum temperatures, talk to locals about the relative severity of the year for frosts. Check your restoration site did and can still carry rainforest.
Low rainfall	Check records for rainfall deficiencies in first month after planting (establishment phase) and the seasonal rainfall records (persistence phase).	If rainfall was low, then plant again in the following year. Check seasonal climate outlooks produced by the Bureau of Meteorology.
Snails	Evidence of damage (slime trails, eaten leaves, stems, etc.).	Lay snail bait or course mulch, beware of effects on domestic dogs and native predators such as Blue-tongue Lizards.
Lack of mulch	Was rainfall adequate, but high temperatures have led to ***collar burn*** (ringbarking and killing the plant at the soil level)?	Mulch or plant in afternoon shade (Figures S133 and S134). Choose ***hot feet species***, not ***cold feet species*** (Appendix S6: worksheet: hot feet-cold feet species).
Browsing	Although generally unpalatable, snails will eat it and new plants out of the nursery may be attacked by Wallabies or rabbits for a time.	Control snails and rabbit browsing, wait out wallaby attack as this will generally pass and plants will re-sprout.
Weed competition	Failure to control weeds retards growth or plants die.	Mowing reduces competition, but plants fail to reach maximum growth potential. Herbicide control of weedy competition produces maximum growth rates.

*Examples taken from both the lower Snowy River and Nyerimilang rainforest restoration sites.

Current or ongoing monitoring projects

Within the region, rainforest restoration is progressing apace and consequently there are many monitoring projects underway for which results are not yet available. Even though the main body of trials are complete, there are still many questions that we want to ask, some of the answers to which you may be able to supply. Use the adaptive management philosophy wherever you go: everything you do should be an experiment so that you can build your understanding and adapt and thereby produce better, more efficient and cheaper restoration outcomes. The current monitoring projects that we are still undertaking include:

- Direct seeding in 2006 using frost-sensitive primary species in an area on Second Flat below the established frost-hardy secondary species. Species included in the direct seeding trial include: Yellowwood *Acronychia oblongifolia*, Jasmine Morinda *M. jasminoides*, Common Boobialla *Myoporum insulare*, Muttonwood *Myrsine howittiana*, Sweet Pittosporum *P. undulatum*, Seaberry Saltbush *Rhagodia candolleana,* Rose-leaf Bramble *Rubus rosifolius* and Lilly Pilly *Syzygium smithii*.
- Failure of these species to establish may be related to the very high browsing pressure from Hog Deer *Axis porcinus* and/or Swamp Wallabies *Wallabia bicolour* (due to the original vermin-proof fence now keeping artificially high population within the restoration area).
- As a consequence, the gates were opened to drain the high population density into the wider landscape
- Additional species were re-seeded in 2008: Cherry Ballart *Exocarpos cupressiformis* (northern edge) and Lilly Pilly *Syzygium smithii* (whole plot); and 2009: Tasman Flax-lily *Dianella tasmanica*.

Consult the East Gippsland Rainforest Conservation Management Network website: <www.egrainforest.org.au> for updates.

Integrated weed management

Introduction

Weeds are invasive (largely exotic species) that compete with indigenous species for their habitat. Some also add toxins to soil and water and many change the structure and composition of vegetation (including rainforests) as well as disrupting ecological processes such as nutrient cycling and fire regimes. Weeds come from all over the world, with a fairly even balance in Australia, coming from: the Americas (31%), Europe (27%), Africa (26%) and Asia 10% (Lindenmayer 2007). Interestingly 2% have come from our own country, but only 3% are recorded as arriving from nurseries (Lindenmayer 2007). However, this appears to be a narrow definition that does not apply to our region, because an estimated 79% of the transforming weeds species in the rainforests of south-eastern Australia come from horticultural sources (Appendix S3)! Our definition of 'horticultural' being: sold or exchanged for gardening. Of the emerging rainforest weeds in our region 76% are of horticultural origin (Appendix S3).

It was once thought that rainforest weeds were only an issue on edges and in severely damaged areas of rainforests (Murphy 2008), but many transforming rainforest weeds in our region can work from the inside out: starving mature rainforest of space, nutrients water and sunlight (see ***water hogging weeds***). Weed control and rainforest restoration go hand-in-hand because weeds are a major threat to rainforests and are one of the major ecological brakes operating on these ecosystems in south-eastern Australia. Weeds are also a major 'social brake' to rainforest restoration as well (Figure S248), although their distribution in the landscape is inextricably linked the human community, as discussed by Cameron (2008). For an excellent discussion on the ecological principles that underpin strategic weed management, consult Murphy (2008). Here is their opening statement:

> "Tactical approaches to manage and control invasive species, such as spraying, burning and hand-pulling local invasions, without regard to the regional populations and distributions of these species, are unlikely to be effective or efficient over large scales, nor in the long term (see ***landscape-scale weed control*** and ***knockdown weeding***). This is because factors contributing to regional-scale persistence and spread are not addressed. Prioritising control of invasive populations based on their position in a regional context is likely to be the most effective strategy for controlling multiple species over the long term. This is not to suggest that tactical approaches are not important as it is at this level that individual plants are killed. Although many elements of the management approach suggested here represent tactical actions, successful management will be most likely when these actions are conducted within a landscape-level and regional strategic framework".

A good example of this strategic regional approach is to undertake catchment-level control of water-dispersed weeds (such as Wandering Jew **Tradescantia fluminensis* or Blue Periwinkle **Vinca major*) by beginning at the top of the catchment where the first populations are found. This means that any control measures are not contaminated (and negated) with every flood event by the reinvasion should you have begun downstream.

There are many forms of weed control that operate at many scales and requires careful setting of priorities (DSE 2007d), ranging from biological control, physical removal and the use of herbicides. It is unlikely that you will succeed in the medium to long-term (Murphy 2008) unless you also intend to:

1. Reduce the threat of weeds to rainforest habitat (by controlling for other factors that weaken rainforest: e.g. fire, pest animal impacts, etc.)
2. Create resistant habitat (creating and maintaining large patches with small area to volume ratios, patches with sealed edges, edges free of invasive transforming weeds, patches that have their ecotones intact, patches that have repaired gaps dominated by native species, patches that are monitored for new weed invasions and well managed for existing invasions)
3. Manage for resilient landscapes that are connected, healthy and functional.

Together, these actions should result in healthier rainforest stands that are both more resilient and part of weed-resistant landscapes, but to do so your plan needs to be both strategic and always adaptable (Murphy 2008).

Remember as well, that if you are proactive, you will be more effective. This is particularly important following disturbance that you know (or suspect) will favour a particular weed species. For example, sites that are clean of Cape Ivy **Delairea odorata*, Wandering Jew **Tradescantia fluminensis* and Blue Periwinkle **Vinca major* will succumb at the rate of 25% of their area over a 15 year period as the result of flood deposition of fragments of these species. This means that if you wait for 12 months following a flood event, you will have a number of small infestations (easily dispatched) instead of 25% of your rainforest's stand area, should you be slack and wait 15 years before you intervene

As a part of this approach, you need to know your weed well and to be able to identify dispersal highways (often waterways and roads) that can transport transforming weeds over long distances. For example, consider Bitou **Chrysanthemum monilifera* ssp. *rotundata,* which is mostly spread by birds and its fruit (flesh intact) sinks when it falls into water. However, if the fruit dries or it is voided by a bird, it then is able to float. Removing infestations from floodplains and the edges of estuaries before tackling the whole infestation is a great way of deciding which part of the population to hit first whilst limiting its ability for long-distance dispersal via waterways (which would otherwise have made your problem larger, whilst you marshalled necessary resources).

The other aspect that you need to know well is the social milieu in which you operate: you are unlikely to succeed at the local and regional scale in weed control if you act alone. Develop networks contacts, shared goals and act in concert. Together, you can establish a level of landscape scale control of transforming weeds that you as an individual alone can never hope to achieve.

WEED CONTROL IS A SOCIAL CONTRACT AS WELL A RESTORATION IMPERATIVE!

Figure S248. Sinuous Reach of the Snowy River, Victoria. Weed control forms part of the social contract to operate in most areas. If you neglect it, you will lose the faith of your neighbours and the community at large, not to mention that it usually indicates that you have failed in your rainforest restoration objectives. Here, a past riparian and rainforest revegetation project has been effectively left unmanaged for more than 10 years. It was the major reason that the community got up in arms and, (through repeated representations to the East Gippsland Catchment Management Authority), helped us to see the threat that intermittent management could be to the riparian environment. The community's success in bringing this problem to our attention and the alignment of this issue with the objectives of the Save Our Snowy campaign, led directly to the rehabilitation of the Snowy River and the riparian and rainforest restoration component worth $7 million dollars in a an overall package exceeding $40 million! This amazing project also incorporates the restoration of 28% of the river's headwater flows through water savings elsewhere in the Murray-Darling system. This may be a fortunate example, but the lesson here is to recognise the social and ecological imperatives of restoration and to maintain the ecological management of restored areas of the landscape. Failure to do so, will lead to the wrath of your local community and the collapse of your past restoration effort.

The easiest way to comprehend integrated weed management is to conceptualise it as finding the weed's Achilles' heel; that is, at what stage is the problem plant at its most vulnerable to control or eradication? It can be as simple as:

- Using one weed against another by preventing germination through the use of herbicide-generated mulches (using Kikuyu **Pennisetum clandestinum* as a mulch)
- Accepting that one dominant weed (e.g. Bitou **Chrysanthemum monilifera* ssp. *rotundata*) is a an effective mechanism for shutting down other (or a more diverse) weed assemblies: the site is essentially 'on hold' until you are ready to deal with it
- Adding shade before annuals and biennials can germinate in the bared soil
- The use of competition from native species to occupy the problem plant's niche by planting or encouraging the full range of life-forms onto your site to occupy every vacant niche etc.
- Recharging the soil seed bank with natives in the knowledge that they will be there when the next disturbance occurs.

Integrated weed management also involves the dispassionate assessment of every weed at the time you see it, its life-cycle stage (germinating, maturing or dying), the progress of work at your restoration site, its ability to spread and its usefulness. The latter point is worth illustrating:

- The targeted use of the weed to your advantage before you control it:
    - As shelter in highly exposed situations (e. g. weedy grasses or annuals to provide shelter from salty winds in Littoral Rainforests)
    - As a guard against browsing (e. g. Lantana **L. camara*, Blackberry **Rubus anglocandicans,* etc.) or human access (to prevent worm diggers getting into your rainforest soil and turning the whole place up side down and thereby maintaining weed populations on the disturbed areas);
    - The provision of shade in *successional planting*
    - As food (e. g. Deadly Nightshade **Solanum nigrum spp. agg.*, Madeira Winter-cherry **S. pseudocapsicum* etc.) until your plantings can supply food to rainforest animals
    - As refuges (e. g. leaving African Boxthorn **Lycium ferocissimum* following herbicide control as a shelter from predators for roosting or breeding by species such as Red-browed Firetails *Neochmia temporalis*) until your plantings can provide equivalent niches (e. g. Sweet Bursaria *B. spinosa*).

Integrated weed management is also about biding your time. Even though you may have a transforming weed appear on your site from tidal movements (e.g. Mile-a-minute **Ipomea caraica*), you would wait a season or two until it is big enough to easily control (scraping and painting); otherwise your eradication techniques are ineffective. Weed control is a complex discipline and you will have to develop this art of integrated weed management (and this may involve seeing some native species as weeds) at certain stages during succession or after unusual or novel disturbances. Examples include: Seaberry Saltbush *Rhagodia candolleana*, following weed control in Littoral Rainforest, Black Wattle *Acacia mearnsii* in the early stages of restoration in Warm Temperate Rainforest etc.

Sound and intelligent weed control is greatly aided by an understanding of which infestations contribute most to the invasion of the weed, and that not all populations of a weed are equal in this regard (Murphy 2008). For example, Mickey Mouse Weed **Ochna serrulata* invades local bushland from urban gardens. The dilemma is to know the more important infestations to control first: the bushland population or the original (and usually more mature) garden plants that spawned the invasion. One way to determine this is to monitor the rate of visitation by frugivores that love this weed's fleshy-fruit. Just such a study has been done and the result was that the bushland populations were much more frequently visited and accounted for more of the spread than the garden populations (Gosper *et. al*. 2006). Both infestations need to be dealt with, but at least such information can underpin why you would choose to attack and remove the bush infestation first.

Logistically, unless you have a lot of time and labour available to you, you will probably have to use herbicides. The tool with the greatest finesse (but a very limited spectrum) is biological control, probably followed by Bradley Weeding, which has wide spectrum of use and is species-targeted. Many would say the most ham-fisted are chemicals, but with good adaptive management, the appropriate use of any of these tools can elicit great subtlety and fantastic results. Some of the benefits that will accrue may surprise you (Figures S248, S249 and S250).

Remember that no weed control is without impact. Integrated weed control has less of an impact because careful choices and the timing of the interventions made. The use of restoration following weed control is one of the ways of redressing the imbalance caused by transforming weed invasions (Mason *et. al*. 2008) and is fundamental to landscape-scale weed control and why we advocate the integration of both *knockdown weeding* and *bush regeneration*.

In Victoria, integrated weed control must be practised and demonstrated if a contractor is to apply herbicides to off-label species.

Biological control

One of the reasons weeds are weeds is that they have been transported from their indigenous habitat to a new area, minus their suite of natural biological control agents (insects, fungi, bacteria, etc.) or disturbance regimes (fire, frost, flood) that keep them in line in their home patch. These living natural checks are called *biological controls*. There are several relevant (and some) excellent examples of biological control of transforming weeds in the rainforests of south-eastern Australia.

A weed would not be a weed if it had reached equilibrium with the ecology of the site and its disturbance regime. There are some surprising allies in weed control that you may not see (Figures S251, S252 and S253). These pictures illustrate the principle of evolution and adaptation of the local fauna to a novel resource arriving on their doorstep: effectively home-grown biological control. Both examples have been noted in the Cann River valley in Far East Gippsland. Others are known from Sea Acres Nature Reserve at Port Macquarie in New South Wales involving Swamp Wallabies *Wallabia bicolor* and Bitou.

WEED CONTROL ENABLES RAINFOREST JEWELS LIKE THIS TO BREED

Figure S249. Tamboon Inlet, Victoria. Dense groundcover swards of transforming weeds such as Kikuyu **Pennisetum clandestinum* and Blue Periwinkle **Vinca major* reduce nest hole habitat availability and increase accessibility to the nests of both Azure Kingfishers *Alcedo azurea* (above) and Spotted Pardalote *Pardalotus punctatus* by predators such as Tiger Snake *Notechis scutatus*. Weed control increases optimum habitat for nest-hole construction. Photo: Sean Phillipson.

Figure S250. East Gippsland, Victoria. Weeds limit access (food and nest sites) for Gippsland Water Dragons *Physignathus leseuerii howittii*. The colouration differences are related to their differing rainforest habitats. The dark un-barred individual (left; (photo Sean Phillipson), is from Gallery Rainforest where basking occurs on dark rocky habitat at Nowa Nowa in Boggy Creek Gorge; whereas the one on the right is from restored Warm Temperate Rainforest 35km away on the lower Snowy River. It is boldly striped and coloured with greenish-yellow stripes and spots, which are better suited to its foraging and basking habitat which is the dappled shade beneath the canopy.

If these uses catch on, persist and spread, there may be a prospect in future that such horrendous transforming weeds (that can kill otherwise intact rainforest on their own), may eventually be brought to heel by nature itself. Other forms of biological control have to be imported from the weed's country or region of origin. This is a really serious business and a great deal of care needs to be exercised when vetting potential living control agents, lest we repeat the mistake of the Cane Toad **Bufo marinus'* introduction: a mistake for which the cost to our country is the inexorable extinction of its native animals.

Are we doing any better today? The unplanned introduction of Willow Sawfly *Nematis oligospilus* larvae (CSIRO 2006) is devastating Willows *Salix* spp.: a complex of species and hybrids that are a ***Weeds of National Significance*** (*WoNS*) (Figures S254, S255 and S256). It is proving beneficial, if a little risky because this control agent was not vetted prior to its introduction to ensure that it would not itself become a problem. Willows are transforming weeds of Gallery Rainforest, but the death of willows does not necessarily lead to a good outcome, especially where other transforming weeds on the same site are ignored. In contrast, the well researched, staged and planned release of three biological controls agents (a rust, a beetle and a leaf-hopper) for Bridal Creeper **Asparagus asparagoides* – a potent weed of Warm Temperate, Dry and Littoral Rainforests in our region – is a great success story (Figures S257, S258 and S259).

Just occasionally, we get a lucky break with biological control (as with the Willow Saw-fly), and our most recent example is the discovery at Pambula Beach of a rust infestation that is devastating Cape Ivy **Delairea odorata*. (Stewart Cameron pers. comm.). This rust has just recently been documented at Lakes Entrance in East Gippsland, Victoria (see Appendix S3 Weed ecology and management priorities: worksheet: Legend; Figure AS3-3), while a rust is on the move from the north that kills Bitou.

Herbicides

Herbicides are a double-edged sword: they kill unwanted weeds, but will also kill non-target species as well, if not thoughtfully selected and carefully applied. Care in herbicide use can range from using different application techniques, to knowing specificity for particular species, to regulation of strength of mix. It may come as a surprise that aerial applications of some herbicides have a place in rainforest restoration.

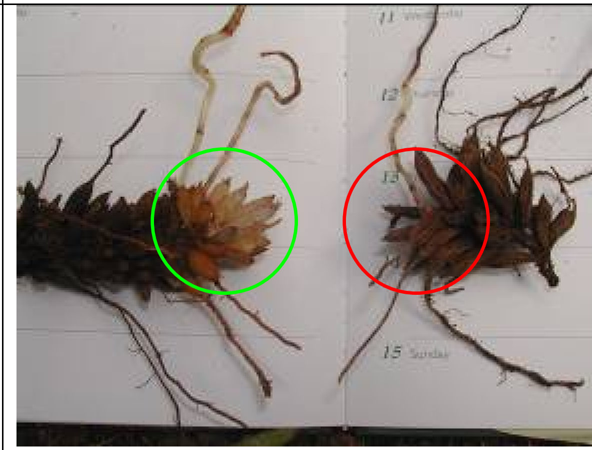
Experiments in New South Wales have shown that there is good control of Bitou **Chrysanthemoides monolifera* ssp. *rotundata* with a weak mixture of glyphosate applied over the cooler months (May and then again in August) to Littoral Rainforest. There are many Littoral Rainforest species adversely affected by Bitou invasion including: Beach Sow Thistle *Actites megalocarpa*, Kidney Weed *Dichondra repens*, Weeping grass *Microlaena stipoides*, Austral Stork's-bill *Pelergonium australe*, Rough-fruit Pittosporum *P. revolutum*, Bracken *Pteridium esculentum* and Prickly Couch *Zoysia macrantha* (French *et. al*. 2008; Hamilton *et. al*. 2008). Many more rainforest plants that are still hanging on, but are overtopped by the Bitou, can survive such applications and go onto repair the site. This may be because of one or a combination of the following: they have little exposed leaf area, are dormant, their waxy leaves resist herbicide entry or they may be able to survive such low doses. Even so, though this weed may cover extensive areas, intensive ground control of Bitou (as apposed to aerial non-targeted spraying) always results in fewer native species present after treatment (French *et. al*. 2008); in other words, there is always collateral damage. Such knockdown weeding may be acceptable where there is follow-up bush regeneration and the sites regenerative potential is maximised. Although losses of natives in the first year following aerial spraying are around 10%, losses continue in subsequent years (Estelle Gough pers. comm.). It not being clear whether this is due to herbicide impacts or the rapid exposure of overtopped plants once the structure of the Bitou infestation rots down. Observations by the author at Miners Beach (Port Macquarie) show a rapid colonisation by pioneer species following aerial weed control that rapidly closes down establishment opportunities for Bitou, particularly where on-ground manual follow-up spraying is conducted. Certainly, extensive aerial spraying on steep erosion prone landforms leads to landslips. For the pros and cons of various management regimes see Appendix S3: Worksheet: Example Bitou impacts.

Given the collateral damage, the caveat here then is that aerial spraying should not be used in isolation to maximise biodiversity outcomes because we cannot always depend on natural dispersal to restore missing species (French *et. al*. 2008). This is where ***integrated weed management*** is so important. French *et. al*. (2008) recommend (as we do) to improve outcomes following weed control in general, but Bitou control in particular, that you should subsequently apply restoration techniques and practices that maximise structural complexity: plant ground cover, shrubs, subshrubs and canopy cover. Species richness and functional richness (i.e. diversity of growth forms) are important in providing redundancy in the system; and do not forget to plant less conspicuous species (one reason why all species of rainforest in the region are listed in our planting appendices).

<table>
<tr><th colspan="3">THE BEGINNINGS OF HOME-GROWN BIOLOGICAL CONTROL FOR WANDERING JEW</th></tr>
<tr><th>SWAMP RATS TO THE RESCUE!</th><th colspan="2">NEW COTTAGE INDUSTRY: WOMBAT BEDDING FROM WANDERING JEW</th></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>Figure S251. Cann River upstream of the Princes Highway Bridge, Cann River Victoria. Swamp Rats Rattus lutreolus are the only species known to the author that consume Wandering Jew *Tradescantia fluminensis and this is the first example that the author has seen. Unfortunately, there are not enough Swamp Rats in the world for this method of control to be effective. This event, however, does mark the beginning of an exotic species being used by native fauna, in a way that may at some time in the distant future bring it into balance, instead of being the rampant weed that it is today. This photo was taken on river's left bank 200m upstream of the highway bridge in late winter (10 October 2005).</td><td>Figure S252. Cann River Bushland Reserve, Cann River Victoria. Common Wombat raking up several square meters of Wandering Jew *Tradescantia fluminensis : the area is many square meters in extent.</td><td>Figure S253. Cann River Bushland Reserve, Cann River Victoria. Common Wombat doing a great job on a Wandering Jew infestation and dragging it into its nearby burrow apparently for use as bedding.</td></tr>
</table>

THE ACCIDENTAL INTRODUCTION OF WILLOW SAW-FLY INTO AUSTRALIA		
HEALTHY WILLOWS: DEGRADED STREAMS	HEAVY SAWFLY INFESTATION	THE END RESULT…HMMM!
		
Figure S254. Buchan River, Victoria. Willows are nationally significant weed on our rivers in south-eastern Australia. In the lowlands of the region, when Gallery Rainforest was cleared from these streams, massive erosion occurred and the ill-considered response was to put in place a 'quick fix' using northern hemisphere trees. Each was a closely related taxon (often geographically separated, and not in breeding contact, in Europe and Asia]. However, once they were brought together in a new land without biological controls, novel genetic combinations began to emerge and a major new weed infestation took off. Photo: Tim East.	**Figure S255.** Since its unintended introduction, the Willow Sawfly *Nematus oligospilus* has spread rapidly in the south-east (Ede 2006). Originally from Mexico and North America, it defoliates the tree, and over time, this weakens the root structure and the tree begins to senesce (Ede 2006). Death usually occurs within 2 years of successive defoliations (Ede 2006). Photo: <www.hortnet.co.nz>	**Figure S256. Tambo River, Victoria.** A Blue Periwinkle **Vinca major* desert on the Tambo following willow weed control. The problem for river managers and rainforest restorers alike is that the rate of willow loss with the sawfly is rapid and extensive; and for a time, our rivers will be in the same vulnerable state to erosion as when the Gallery Rainforest was removed and willows had to be planted in the first place. As with the Bridal Creeper control, the removal of a rampant weed opens up a niche. If native species are the only candidates, then a transition back to the original ecosystem can begin. If other weeds are the only options, then one weedy landscape will replace another. The question is: which weed is worse? Another willow replacement candidate along much of our rivers is the berry-bearing Blackberry **Rubus anglocandicans*. From an ecological perspective, this is a much more desirable result (compared with periwinkle), because it has good habitat value, is a pioneer species in rainforest and is a useful interim restoration stepping stone back towards reinstating the original rainforest. From a regional weed perspective, it is not at all attractive! The answer is to use integrated weed control, which incorporates knockdown weed control with bush regeneration in order to avoid the results pictured here.

THE CONVERSION OF A WEED OF NATIONAL SIGNIFICANCE INTO A BACKGROUND WEED THROUGH THE INTELLIGENT APPLICATION OF BIOLOGICAL CONTROLS

ON THE WAY OUT	AFTER	HOW IT OCCURS
		
Figure S257. Entrance Walk, Lakes Entrance Victoria. Bridal Creeper **Asparagus asparagoides* is a rampant weed from South Africa. It is a transforming weed for two reasons: it smothers the understorey (cutting off light to native plants) and secondly it has a massive tuberous root system that sucks the ground dry and physically occupies nearly all of the soil space in which it grows. Few native plants are capable of competing with such an effective and invasive ***water hogging weed***. This is evident from this photograph of a young stand of Littoral Rainforest where the last of a previously 100% cover of Bridal Creeper is dying out: to reveal that there are no native species that have been able to establish. 12 months later: the competition from this weed has abated and the result at this spot is very different (see Figure S258).	**Figure S258. Entrance Walk, Lakes Entrance Victoria.** Where there are plenty of native species still present, the removal of Bridal Creeper produces a fantastic regeneration response of Littoral Rainforest species including: Sea Box *Alyxia buxifolia*, Coast Beard-heath *Leucopogon parviflorus*, Common Boobialla *Myoporum insulare* and Sweet Pittosporum *P. undulatum*. Where there are few native plants, but lots of weeds, sadly that is what will take over. In this case, the regeneration is native and comprised of many of the species already on site that pre-dated the infestation by Bridal Creeper. It was only when it was knocked down by the leaf-hopper infestation that they could reproduce once more and the ecology could be restored. The other advantage to this site is that Bridal Creeper is a water-hogging weed, and the condition of the rainforest canopy improved rapidly after the weed population crashed.	**Figure S259. Entrance Walk, Lakes Entrance Victoria.** Biological controls for Bridal Creeper were aimed at reducing the plant's vigour and its seed production (to slow its rate of spread). A year after leaf-hopper introduction at Lakes Entrance, the population of Bridal Creeper crashed because of defoliation. Why was this? The leaves serve two purposes: early in the season they supply the food for the vine's growth, flowering and fruiting. Later in the year, once that task has been achieved, the food production by the leaves is converted into starch and a new crop of tubers is produced (green circle on hopper-free plant on the left). These store energy and water for the long hot dry summer so the plant can re-emerge in autumn and grow once more. When the hopper defoliates the plant, the tubers cannot regrow (red circle on hopper-infested plant on the right). Next autumn, there is no food left to renew the aerial stem and leaves. Instead of just slowing seed production, a single biological control agent is killing the plant! All three agents (rust fungus, leaf-hopper and beetle) have (on early indications) an excellent chance of changing this previously transforming weed to a background one.

When it comes to herbicide use, most of what you will spray with broad-spectrum herbicides such as glyphosate will be off-label use. In other words you are using a chemical developed for agricultural purposes in a manner for which it is not licensed. This sounds crazy, but it's not really. Basically, the chemical companies that develop these very useful compounds, base their research effort on those weed species for which there will be the largest market (agricultural weeds) and consequently the best economic returns.

This leaves the rainforest restorer with a dilemma: these chemicals are very useful for knocking off a lot of ***environmental weed***s for which there are no licences to do so. Now things get complicated:

- In New South Wales: you must apply for an off-label use permit from the Australian Pesticides and Veterinary Medicines Authority by logging onto their website: <www.apvma.gov.au> and navigating your way to the pesticides section, which will give you the contact details of the relevant authority officer. Your application will require information on the chemicals you wish to use, the use to which it will be put (what weeds, what application methods and so on) and the situation in which it will be used (next to a river wetland or away from waterways, etc.)
- In Victoria: if you or the project manager can demonstrate that you are practicing integrated weed management then an annual dispensation can be obtained for "off-label use" of these chemicals in lieu of a permit. The procedure is as follows (Nigel Ainsworth pers. comm.):

"Victorian law allows certain off-label use of registered chemicals without the need for a permit (except for S7 class chemicals). All aspects of such off-label use are the user's responsibility including residue controls, environment safeguards, occupational health and safety and animal welfare. Chemicals used off-label are not necessarily covered by the manufacturer's warranty. Such use must not be in contravention of the Agricultural and Veterinary Chemicals (Control of Use) Act 1992. *The product used must not be a prescribed or restricted chemical, which are required under Victorian law to be used strictly in accordance with label directions, unless a permit is obtained for other use.*

An Agricultural Chemical User Permit (ACUP) is required to be held by any user of restricted chemicals in Victoria unless exempted. A person working under the direct supervision of an ACUP holder may also use restricted chemicals. The user must also make and keep for a period of two years certain prescribed records of use.

Restricted chemicals are Schedule 7 (S7) poisons that are agricultural chemicals:

- *Metham sodium*
- *Atrazine*
- *Ester formulations of triclopyr; MCPA; 2,4-D; and 2,4DB.*

The use of certain agricultural chemicals within Chemical Control Areas (CCAs) may be restricted when the CCA is in operation.

All chemical use should be in accordance with the Code of Practice for Farm Chemical Spray Application".

To summarise some of the key points for environmental weed control, off-label use is not illegal so long as:

- The product used is not a restricted chemical (see list above). Restricted chemicals are contained in some common products for environmental weeds such as Garlon and Grazon
- The user does not exceed the label rate or maximum frequency of application
- All label restraint statements are observed; i.e. all the 'do not instructions' on the label.

To obtain an off-label permit for rainforest restoration in Victoria, you must be able to demonstrate integrated weed management. But what does that term really mean and in practical terms, how can it be incorporated into daily rainforest restoration activities?

The short answer is that if you are not practising integrated weed management on your restoration site; then you are not practising ecological restoration, you are simply gardening and that is most definitely, not the aim. Integrated weed management as practised on the Snowy River may provide a suitable guide that can be regionally adapted to the conditions and needs of your restoration site.

Integrated weed management can be enacted using the following approaches:

- Minimisation of disturbance to prevent soil exposure, which prevents the emergence of light-stimulated annual and biennial weed species (sun weeds).
- Identification of colonial and other native species on the site prior to spraying to avoid killing these individuals and colonies so they can expand and fill weed niches.
- Timing of weed spraying (to coincide with dormancy of native species) to facilitate rapid colonisation in areas treated (these species out compete weeds and provide habitat for rainforest species regeneration). The target weed is usually extensive areas of Kikuyu, which can be sprayed in May just before frosts send it into winter-dormancy. At this time most of the following species are already dormant and therefore do not take up the herbicide. These species include Large Bindweed *Calystegia sepium*, Common Reed *Phragmites australis*, Scrub Nettle *Urtica incisa*, Bracken *Pteridium esculentum* and Downy Ground-fern *Hypolepis glandulifera*.
- Another (somewhat surprising) example is the application of Fusilade ® to kill Kikuyu amongst swards of Sword Tussock-grass *Poa ensiformis*; a species we would have assumed to be susceptible to this monocotyledon-specific herbicide. A trial by Snowy River Riparian P/L in 2006 in a dry autumn period when the tussock-grass is dormant (but still green-leaved), killed the Kikuyu but apparently left the native species largely intact. The technique used though is to be very specific in targeting the Kikuyu, with only minor spillage onto the tussock-grass.
- Herbicide knockdown of Kikuyu to produce durable mulch that lasts for 6-12 months preventing most weeds from regenerating whilst allowing rainforest plants to germinate.
- Think outside the square: prune fern colonies or rhizomatous ferns of their fronds where weeds have invaded the colony prior to treatment, waiting a week or so (for the cut wounds to be sealed) and then spraying e.g. Lacy Ground-fern *Dennstaedtia davallioides* (Figure S260) or give your graminoids a hair cut (Figure S261).
- Accepting that adult plants may be lost during the initial spraying but can be regained through seedling regeneration of the patch following spraying (e.g. Tall Sedge *Carex appressa* and Basket-grass *Oplismenus hirtellus*; Figures S262 and S263).
- Training your staff or volunteers to identify rainforest regeneration that occurs within the dead Kikuyu thatch and to avoid its destruction in following weed maintenance cycles.

THINKING OUTSIDE THE SQUARE CAN GIVE YOU GREAT WEED CONTROL WHILE SAVING NATIVES

Figure S260. Cann River upstream of Princes Highway, Cann River Victoria. Re-sprouted and healthy colonial Lacy Ground-fern *Dennstaedtia davallioides* several months after pruning (red arrows), prior to blanket spraying for Wandering Jew **Tradescantia fluminensis* (stem fragments encircled in red).

Figure S261. Cann River upstream of Princes Highway, Cann River Victoria. Bergalia Tussock *Carex longebrachiata* tied in a 'bun', to allow closer spraying to the tussock for transforming weeds while conserving this important rainforest graminoid.

To weed or not to weed: that is the ecological and logistical question?

Weed maintenance in rainforest restoration can be one of the most expensive and time-consuming tasks in your restoration project. The act of weeding should be preceded by very, very careful thought. Now is definitely the time to get out of gardening mode and into the ecological restoration mode. This conscious switch in attitude will save you a lot of time and money. Weed species and level of infestation are what dictates the action required as the following examples show.

Example 1: Site 29 lower Snowy River, Marlo Road Victoria (Figures S264 and S265).
The situation:

- Enrichment planting of 17 year-old former revegetation site and Framework Method on balance of site.
  Weed treatment:
- Enrichment planting and Framework areas: initial blanket spray Kikuyu and Blue Periwinkle to obtain mulch
- Respray for Wild Radish **Raphanus raphinastrum* and Cleavers **Galium aparine* as Kikuyu mulch breaks down
- Repeat for as long as is necessary (Figure S264) until canopy closure is achieved or regrow ***living mulch*** to prevent annual weed germination (Figure S265) including resowing the site with other grasses (Additional Reading: Carbon cycles and rainforest restoration: Figure AR30).

Basis for weeding decisions:

- Sprayed Kikuyu (is a good mulch); and controlling sun weeds ensures successful establishment.

Example 2: Willows to Natives Trial, Val and Biddy Russell's property: Bete Belong, Victoria (Figure S266).
The situation:

- Following planting and willow culling: the bulk of the weed biomass is Deadly Nightshade *Solanum nigrum* ssp. agg. and Prairie Brome-grass **Bromus catharticus* (Figure S266). Both species are annuals
- There has been a small germination and low biomass of Blackberry **Rubus anglocandicans*, Tree Tobacco **Solanum mauritianum* and a minor re-establishment of Wandering Jew **Tradescantia fluminensis* and Blue Periwinkle **Vinca major* following floods
- There has been a lot of Kangaroo Apple regeneration.
  Weed treatment:
- Leave the largest biomass of annual species (Brome-grass and Nightshade)
- Remove Tree Tobacco, Wandering Jew and Periwinkle.
  Basis for weeding decisions:
- Leaving annuals because they will be overtopped by Kangaroo Apple and its shade causes them to die
- Existing plantings are already several years old and will not be out-competed
- New weeds such as Tree Tobacco should be removed because it is a new weed on the Snowy (although not a serious weed; Big Scrub Landcare Group 2005): landscape context demands its removal
- Remove transforming weeds because of the threat they pose to the riparian ecosystem in general and rainforest restoration site in particular.

The integrated weed management process is finalised by mass planting of these sites with over 70 species of rainforest plants of all life-forms, life cycles and reproductive strategies to:

- Fill vacant or weed-occupied niches
- Shade the site within 8 months to prevent light-dependent weed germination
- Recharge soil seed banks with the seed of native species (graminoids, daisies, wattles and peas)
- Encourage natural seed dispersal by frugivores and the natural regeneration of rainforest plants.

For integrated weed management to work well, it requires that you as the rainforest restorer look at each weed species with a dispassionate eye and this should include native species as well (Figure S267). What use can it be to you? What is its life-cycle? Should it always be controlled or eliminated? Does it need to be controlled every time it appears or only some times? Does it have affects that are deleterious to the ecology of the site or neighbouring areas? Figure S268 illustrates this issue very well: to remove the weed would be to destroy the very remnant you are working to save –.so take a moment!

In answering these questions, the rainforest restorer needs to stay abreast of the latest information on the weeds that occupy your restoration site. Two examples come to mind.

The first is with regard to Camphor Laurel **Cinnamomun camphora* where research by the Rainforest CRC in the Big Scrub sought to investigate whether this widespread and rampant woody weed was a "Scourge or Saviour" (Neilan *et. al*. 2005). They found that three ecological features of this species facilitated rainforest regrowth in abandoned grazing land:

1. This species attracts frugivorous birds that disperse the seeds of other rainforest plants (more than 30 recorded in their study)
2. The dense canopy of Camphor Laurel shades out the sun weeds (grasses and herbs) that would otherwise outcompete rainforest seedlings
3. The leaf litter and the canopy shade may further combine by creating a microclimate suitable for the germination and establishment of rainforest plants (such as providing cool soil temperatures).

CONSERVING GRAMINOID (GRASS AND SEDGE) COLONIES THROUGH SOIL SEED BANK REGENERATION.	
	
Figure S262. Second Island, Marlo Estuary Victoria. Tall Sedge *Carex appressa* seedling regeneration following spraying of Wandering Jew. **FC and EVC**: *East Gippsland Deltaic* Littoral Rainforest **Treatment**: double strength glyphosate+pulse; treated early October. Five weeks after herbicide treatment for Wandering Jew the treatment has also killed adult plants of Tall Sedge *Carex appressa* (despite adequate site preparation) because of overzealous spraying. The population will recover with the natural soil seed bank regeneration that is being pointed out (encircled area in red).	**Figure S263. Second Island, Marlo Estuary Victoria.** Basket Grass *Oplismenus hirtellus* seedling regeneration following spraying. **FC and EVC**: *East Gippsland Deltaic* Littoral Rainforest **Treatment**: double strength glyphosate+pulse; treated early October. Elsewhere on the site, Bradley Weeding was employed to conserve larger patches of Basket Grass *Oplismenus hirtellus*. In this spot, though, it was intertwined amongst the target weed (Wandering Jew) and was unavoidably killed in the herbicide application. The population will recover with the natural soil seed bank regeneration that is being pointed out (encircled area in red).

TIMELY AND APPROPRIATE WEED CONTROL CAN SAVE THOUSANDS OF DOLLARS

Figure S264. Site 29, lower Snowy River Victoria. Weed control is a case-by-case decision-making process. In full sun, Wild Radish *Raphanus raphinastrum* (left) and Cleavers or Sticky-weed *Galium aparine* (right) are both transforming weeds that definitely require control. In deep shade, Cleavers will germinate, but is a background weed and does not require further action. Wild Radish does not germinate in full shade. Weeds here will be controlled by planted canopy species, by using either the method shown in Figure S265 or the technique illustrated in Additional Reading: Figure AR30.

Figure S265. Site 30, lower Snowy River Victoria. Our beautiful Kikuyu *Pennesetum clandestinum* mulch has done the job for 8-12 months, and has allowed establishment of plantings (left) including species that will shade the site. However, failed plantings on the right would have led to the situation in Figure S264 if we had not regrown our Kikuyu mulch. This regrown mulch (right), is the sign of good site management in this case because it has prevented most regeneration of annual and biennial sun weeds, the hint of this potential is given by the single Sow Thistle *Sonchus oleraceus* that has come up (red arrow).

WEEDING CAN BE A SCARY THING THAT REQUIRES A LOT OF NERVE AND SOMETIMES INVOLVES LEAVING EXOTIC SPECIES AND PULLING OUT NATIVES!

Figure S266. Site 42, Bete Belong, lower Snowy River, Victoria. This is the Willows to Natives Trial. Holding your nerve with weed control in rainforest restoration is a very important principle. Management of this site to date has been to treat shade weeds and then under-plant shade and inundation-tolerant species beneath the living willows. When these established, the willows were culled (12 months ago). Over late summer, this weed colony appeared. Here, Ned Rickard is inspecting the site and deciding what weed control is necessary. From a gardening perspective, the answer would be: remove everything. But rainforest restoration is about ecology, minimum effort for maximum restoration gain and the action on this site was to leave the obvious weeds (all annuals) and to tackle the less obvious ones (resprouting shade weed and Blackberry **Rubus anglocandicans* seedlings) through Bradley weeding (see text).

Figure S267. Site 32 Marlo Road, lower Snowy River Victoria. Natural regeneration sometimes leads to some difficult choices: here, Black Wattle *A. mearnsii* has been “weeded because their natural regeneration is so abundant on this site. As mentioned elsewhere, high densities of this species can out-compete other species for periods of up to 15-20 years. This is a classic example of ***flipping the paradigm***: “it is a native so we must conserve it on every occasion”. In reality, you must consider each species native or exotic on its merit when weeding: what is the site’s trajectory, and how do you intend to manage it so that it gets there quickly, with minimum damage and maximum native species diversity? Another example (but not recommended in south-eastern Australia) is practiced in logging or road-damaged Subtropical Rainforest in northern New South Wales. Here restoration ecologists cull rampant (native) canopy vines to allow a forest canopy to recover.

WIND IS OFTEN THE FOE IN LITTORAL RAINFOREST RESTORATION: AND SO ACCEPT A WEED AS AN ALLY

Figure S268. Middle Rock, Lake Cathie New South Wales. Impatient or ill-considered removal of this patch of Bitou *Chrysanthemoides monolifera* ssp. *rotundata* (red ellipse) in this situation would cause the canopy decapitation and destruction of the leeward side of this Littoral Rainforest remnant (red arrow) that you may otherwise think you are restoring. Your actions would remove the first (and most important) slat in your storm shutter (*sensu* Land and Water (2001) (yellow arrow). The obvious alternative is growing before your very eyes: Blady Grass *Imperata cylindrica* (blue ellipse). By establishing small patches of this species on the windward side of the Bitou (blue arrow) thereby gradually trading the native storm shutter for the weedy one. This patient and staged approach kills the weed but keeps the fig intact.

This pioneer role (in particular its ability to come up in abandoned pasture and on rocky sites as oldfield regrowth), has led these workers to suggest that large landscape scale areas may be colonised by native rainforest species if Camphor Laurel thickets are allowed to persist. Once there is closed canopy and a sufficiently large pool of native recruits established beneath them, **you can then cull** the mature Camphor Laurels and removing their seedlings to allow the more rapid maturation of the native rainforest species establishing beneath (Neilan *et al.* 2005; Neilan *et al*. 2006).

Caution and much careful observation is required here before embracing transforming weeds as an acceptable alternative to restoration using native species in the landscape. The following protocol is suggested:

A. **Is the weed a noxious or listed species?** The debate about leaving it in the landscape to act as a rainforest progenitor ends here: **you are legally required to control it!**
B. **What is your site context?** If the species is new to your area **don't chance it; eradicate it immediately**: you are not doing permaculture here;
C. **What is the colonising behaviour of the candidate weed species?** It should only be a weed of derelict or grossly disturbed land such as abandoned farmland and otherwise destroyed rivers and not intact bushland. If it invades intact bush, **eradicate it immediately**
D. **Satisfy yourself that the nursery crop weed species is not the final product of succession**; i.e. that rainforest succession is occurring and that the weed is controlled as a result of the developing rainforest's structure (shading etc.) or ecology (competition etc.) Cotoneaster and Blackberry are two examples known to fit this bill in the south-east (see below)

E. **If you wish to control the landscape scale weed infestation on your site**, are there sufficient resources to both suppress the weed (and any other transforming weeds that may arise following your initial control of the target weed)?
F. **That the control of these species will end up in rainforest succession** and the colonisation of the site by a functioning rainforest and not a more diverse and bigger weed problem
G. **If all of these considerations are met** then you may wish to consider the candidate weeds listed below.

There are six landscape-scale examples of fruit-bearing weed invaders in our region which could be candidates that may act as progenitors for rainforest succession in a similar fashion to that ascribed to Camphor Laurel by Neilan *et. al*. (2006). Each is discussed in turn and conclusions are drawn about its suitability for this role based on the previously enunciated protocol:

1. **Blackberry ****Rubus anglocandicans***: in former rainforest habitat** largely in East Gippsland (Warm Temperate and Littoral Rainforest); Strzeleckis and Otway Ranges (Cool Temperate Rainforest). Studies of Blackberry groves in East Gippsland do show colonisation by secondary species such as Blackwood *Acacia melanoxylon*, whose light to deep shade (Chapter S4: Table S8) is sufficient to shade out the Blackberries and begin the rainforest succession process (e.g. Frenchmans Creek and Kinkuna at Lakes Entrance). In addition, killing blackberry thickets in the same region produces abundant regeneration of other rainforest species (both bird-dispersed fruiting species and wind-dispersed species); that together indicate the type of rainforest succession observed by Neilan *et. al*. (2006) in the Big Scrub. This is a candidate species wherever it is not listed as a ***noxious weed***;
2. **Bridal Creeper ****Asparagus asparagoides* **in former Littoral Rainforest habitat** along Entrance Walk and North Arm Lakes Entrance, where biological control has led to a marked reduction in its cover and a proliferation of other fruit-bearing bird-dispersed Littoral Rainforest species (Figure S257). This species is not a candidate for this process because it is a transforming weed: a water-hogging weed that actually kills mature rainforest as a result. Other members of the Asparagus weed brigade should be seen in a similar light and should not be used under any circumstances in this manner.
3. **Large-leaf Cotoneaster ****C. glaucophyllus* **var.** *serotinus* **and Velvet Cotoneaster ****C. pannosus* **infestations (that are to date uncontrolled) and on former Littoral Rainforest sites** along the North Arm at Lakes Entrance, which have led to subsequent colonisation of a plethora of Littoral Rainforest species on this oldfield regrowth site. Careful note of the progress of this combination needs to be done because these species are of sufficient stature to be maintained in the mature canopy of the emerging Littoral Rainforest where they may eventually over time take over. In addition, these species have taken over the threatened EVC Limestone Pomaderris Shrubland nearby at John Street.
4. **Bitou ****Chrysanthemoides monilifera* **ssp.** *rotundata* **along the south coast of** New South Wales (particularly north of Moruya River) that has not resulted in regeneration until weed control was undertaken (e.g. South Head). Be especially careful here of control of this species within the dispersal-reach of ***peri-urban*** areas where there are likely to be a significant transforming weed flora ready to rise and take the Bitou's place once you kill it. This requires the advice provided under ***Landscape-scale weed control*** to be carefully followed. If this is likely (e.g. Tathra), take all necessary steps to control the other transforming weeds first. In so doing, you will eliminate the Bitou and its likely weed successors in favour of local rainforest native species, thereby ensuring rainforest succession rather than ***weed succession***. This species is not a candidate because it is a transforming weed that kills mature Littoral Rainforest and many of the species associated with it, as well as other coastal vegetation (French *et. al*. 2008; Hamilton *et. al*. 2008).
5. **Lantana ****Lantana camara* **infestations in Subtropical Rainforest and Dry Rainforest habitat** around the footslopes of Gulaga (Mt. Dromedary) in the Tilba Tilba district. These infestations are currently being controlled and careful note should be taken of the rainforest regeneration response. Experience elsewhere shows that Lantana is an effective edge seal (against cattle and deer browsing) as well as reducing the impact of edge effects such as light and wind penetration, but that rainforest succession in such situations may be slow or non-existent and as such it may be a poor candidate for this approach and a locality-based decision should be made based on what you observe.
6. **A range of fruit-bearing woody weed species on the Bega River in former** ***Sands Rivers*** **Warm Temperate Rainforest habitat** (including Privets and Cherry Plums etc. (see below). Unfortunately, there are insufficient native rainforest food sources near enough to these infestations around Bega itself for rainforest colonisation to have already begun. However, these species will be useful as shade and frost protection for rainforest restoration in the short-term (if and until, local seed sources can be re-established).

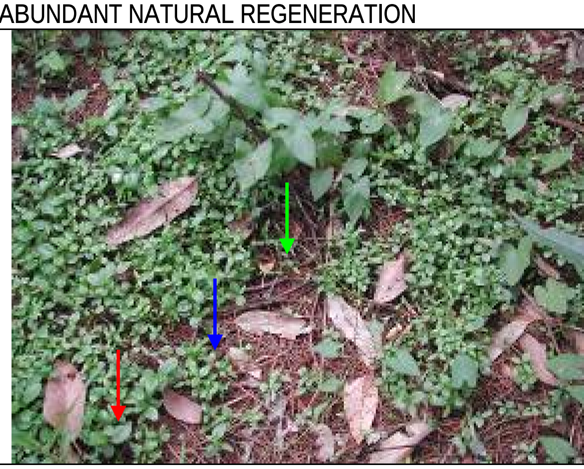
Another example of following the logic train of transforming weeds as rainforest progenitors is that of Tree Tobacco **Solanum mauritanianum*, but more is known in this case. This example is presented as a caution to us all. Although this exotic weed species (like its native equivalents: Kangaroo Apple), has become a food item for rainforest pigeons and flying foxes, it has become so at a cost. Choosing to retain a 'useful weed' can have unforeseen consequences. CSIRO researchers on the Atherton Tablelands in Queensland have discovered that the nationally threatened Spectacled Flying Fox *Pteropus conspicillatus* is coming into contact with Paralysis Tick *Ixodes holocyclus* because it is feeding on Tree Tobacco. The fruiting season of Tree Tobacco (October-December) coincides with lactation in this species and affected flying fox mothers (up to 10%) of the colony, become paralysed and fall from their roosts, with obvious consequences for the suckled young. This is especially concerning because Spectacled Flying Foxes are long-lived and have low rates of reproduction. This combination of factors may further threaten the species' survival.

In south-eastern Australia, we are fortunate that the equivalent native species (Kangaroo Apple *Solanum aviculare* and Large Kangaroo Apple *S. laciniatum*) to the exotic Tree Tobacco, which fulfil similar roles. The other consideration is the landscape context of restoration in our region. We live in a largely intact landscape with few weeds. Why would you encourage or maintain a weed that has the potential through animal dispersal to appear in remote rainforest stands, when it may actually impact on one of your local native threatened species (the Grey-headed Flying Fox *Pteropus poliocephalus* that also feeds upon its fruits)? As such, we do not advocate the retention of Tree Tobacco on restoration sites in south-eastern Australia, though this is regularly done on rainforest restoration in the Big Scrub region of northern New South Wales.

Make no mistake: the issue of a threatened species adapting to and using a weed can be critical for a species that is already nationally vulnerable (the use by rainforest pigeons of Camphor Laurel and Privets is legendary: saving these animals from extinction during the early to mid 1900s). Integrated weed management is an important technique, but, as you can see, the decisions that you make at the restoration scale, and for land managers at the landscape scale, can have profound impacts. In some cases it may mean the survival of a species. So, think very, very carefully, watch the results of all of your integrated weed management decisions and adjust your actions according to the results that you observe.

Weed control and natural regeneration

A great deal of natural regeneration (free plants) can be obtained by the judicious and timely application of weed control, be that through herbicide (Figures S269 and S270), use of the dominant weeds themselves (Figure S271), hand-weeding techniques or a combination of several techniques (Figure S272).

<table>
<tr><th colspan="2">CAREFUL WEED CONTROL PROVIDES ABUNDANT NATURAL REGENERATION</th></tr>
<tr><td></td><td></td></tr>
<tr><td>Figure S269. Site 70b, Marlo Road lower Snowy River Victoria. This Maximum Diversity Restoration shows abundant and diverse natural regeneration due to careful weed control. Species regenerating here include: Bergalia Tussock Carex longebrachiata, Downy Ground-fern Hyoplepis glandulifera, Cockspur Flower Plectranthus parviflorus, Sweet Pittosporum P. undulatum and Lilly Pilly Syzygium smithii.</td><td>Figure S270. Site 70a Marlo Road lower Snowy River Victoria. Three regeneration cohorts of natural germination of Sweet Pittosporum P. undulatum (red, blue and green arrows) beneath the senescing late secondary species: Black Wattle A. mearnsii.</td></tr>
</table>

NATURAL REGENERATION: SHOWING THE WAY FORWARD OR CONFIRMING SUCCESS	
	
Figure S271. Site 41 Bete Belong, lower Snowy River Victoria. This high-erosion-risk bank was planted out with willows in the 1970s and shows signs of natural regeneration. This provided important clues and directions for the restoration task ahead: • Despite heavy root competition and dense shade natural regeneration was possible • Regeneration in this photo: Snowy Daisy-bush *Olearia lirata* and Mountain Burgan *Kunzea peduncularis* as well as many others on the site • This showed us the range of species that could be established beneath the willows prior to them being culled. This provided a basis for trials that then allowed for a seamless transition to native species without risking the security of the bank (See also Figure S266).	**Figure S272. Site 70f Marlo Road, lower Snowy River Victoria.** Just 3 of more than 100 native species recorded naturally regenerating on the lower Snowy. All of the species pictured require bare soil to germinate and establish. Such niches only began to appear two years after works on the site began because of repeated Wild Radish **Raphanus raphinastrum* germination (we stopped counting at 25 soil seed bank germination events!). Site preparation was blanket spraying followed by Bradley Weeding, when the abundance of natural regeneration became apparent. Native species pictured regenerating include: Black Wattle *Acacia mearnsii*, Southern Mahogany *Eucalyptus botryoides,* Fireweed Groundsel *Senecio linearifolius*, Shrubby Fireweed *S. minimus* and Golden Everlasting *Xerochrysum bracteatum*. Seed sources for this natural regeneration were pleasingly varied and included: • Seedlings from seed set of previous plantings (Everlastings) • Pre-existing trees (Mahoganies) • The soil seed bank (Fireweeds).

Table S24 provides a guide to rainforest species that commonly regenerate on restoration sites in East Gippsland and the timing of spraying that will ensure their establishment by killing the weeds that overtop them before they germinate. If you have effective weed control then these species will establish at their appointed time of germination (Appendix S15). Those that are listed and bolded in Table S24 are the most abundant germinations of pioneer and early secondary species that would be most useful on Framework and Maximum Diversity Method sites. Spraying the over-topping thatch during your native species' dormancy with glyphosate will ensure almost miraculous transformations to native species cover where these species are present. Appendix S15 provides a guide as to when to expect germination on Maximum Diversity or Natural Regeneration sites from the broader suite of rainforest species in south-eastern Australia.

Over-spraying to conserve indigenous species populations

This technique is used where there are massive infestations of transforming weeds and a significant prospect of abundant or diverse natural regeneration or conservation of existing native plants that are over-topped by these weeds. Where they have a large mass (Bitou **Chrysanthemoides monolifera* ssp. *rotundata*, Lantana **Lantana camara,* Kikuyu **Pennisetum clandestinum* or Blackberry **Rubus fruiticosus* spp. agg.) and are highly susceptible to specialised herbicides or specialist herbicide applications, then substantial areas of native species can sometimes be salvaged. Applications can involve a variety of techniques that include: low volumes, light applications, spot spraying small areas to kill large spreading and susceptible plants (e.g. Lantana **L camara*), using narrow spectrum herbicides or timing applications to periods when non-target species are dormant. These specialist situations are listed in Appendix S3 and techniques are detailed in Chapter 8: Herbicide use on restoration sites.

Table S24. Native species that commonly germinate, resprout or colonise following herbicide treatment on rainforest restoration sites in East Gippsland.

Germination time or time of active growth	Species*	Timing of spraying
Pioneer species		
Autumn-winter	**Shrubby Fireweed *Senecio minimus*** and **Fireweed Groundsel *S. linearifolius***,	Late February-March
Late autumn	**Common Reed *Phragmites australis***	May (but closely observe and spray whilst dormant)
Winter	Bidgee Widgee *Acaena novae-zelandiae* and Northern Geranium *G. homeanum.*	June-July-August
Late winter	Tree Violet *Melicytus dentata*	August
Early spring	**Large Bindweed *Calystegia sepium***	Late September, early October when Kikuyu is actively growing, but the bindweed is still dormant
Mid spring	Tall Sedge *Carex appressa*, **Bergalia Tussock *C. longebrachiata***, **Shiny Flat-sedge *Cyperus lucidus***, Basket Grass *Oplismenus hirtellus*	August-September
Summer	**Kangaroo Apples *Solanum* spp.**, Green-berry Nightshade *Solanum opacum*, Forest Nightshade *S. prinophyllum*, Eastern Nightshade *S. pungetium*, Slender Dock *Rumex brownii*, Weeping Grass *Microlaena stipoides*	September
Drought	**Scrub Nettle *Urtica incisa***	Based on drought-induced dormancy
Any time	**Black Wattle *Acacia mearnsii***	Not important, because germination is not seasonal.
Colonial early secondary species		
Usually spring	**Downy Ground-fern *Hypolepis glandulifera***, **Bracken *Pteridium esculentum***, **Scrub Nettle *Urtica incisa***.	Spray edges where roots extend but no aerial foliage is yet present or use grass-specific herbicides.

*Species in **bold** are the most abundant and therefore important to conserve in rainforest restoration.

The Splatter-gun (large droplet size application) Method

This is a recently developed method that has been used with great success in New South Wales rainforest restoration (Andrew Paget pers. comm.). The technique involves using small burst of herbicide delivered over longish distances in a tight target pattern: a blob causing a localised splat. It works if there are large infestations of sprawling weeds (e.g. Lantana **L. camara* and perhaps Bitou **Chrysanthemoides monilifera* ssp. *rotundata)* that are highly susceptible to the herbicides being used. Treating Lantana is especially important because it can facilitate hot fires on remnant margins and in gaps (Miles and Kendall 2006); and in a drying climate its removal from remnants may prove to be the remnant's salvation if a fire comes by. This technique sprays a blob of herbicide, which hits the weed and is translocated to the whole plant, killing a larger area than the small and tightly delivered herbicide blob. This then releases any native plants that have established in the infestation and allows greater access to clean up any straggler weeds. It does not work for species that have a sprawling habit, but do not readily translocate the poison e.g. Seaberry Saltbush *Rhagodia candolleana*, which, though a native species, does sometimes require control in damaged Littoral Rainforest stands where it can be a gap-maintaining species (see: Chapter S8: Paths and roads).

Weed replacement plants for use by fruit eaters (replacing take-away with eat-at-home locals)

Weeds are generally considered to be a threat to the natural environment and nationally they directly threaten 16 bird species, though the true impact is likely to be greater (25 bird species in New South Wales alone are reported to be threatened by weeds; CRCfAW 2007a). Although weed invasion has a negative impact on ecosystems and individual species, there are examples where weeds benefit native species providing support to fruit-eating species in fragmented and damaged landscapes (CRCfAW 2007a). Local observations suggest that the fruits of weeds also augment their diets in largely natural areas as well, while their structure also provides habitat and protection for nesting of birds in particular (e.g. Lantana **L. camara*, Blackberries **Rubus anglocandicans,* etc.).

Unfortunately, this relationship leads to the spread of these alien plants, many of which are transforming weeds that go on to do untold damage to natural and fragmented rainforest ecosystems. If you undertake broad-scale weed control programs on weeds that have buffered populations of native fruit-eating birds from the consequences of broad-scale destruction of their natural habitats in the past (CRCfAW 2007a), (without providing replacement food resources), you could potentially threaten these local populations of the fruit-dependent species.

In some cases, where the local rainforest has been wiped out, the framework and composition of your restoration site's weed infestations may be a *de facto* 'pseudo-rainforest' of fruit-bearing species from other countries that have been brought there by fruit-dependent animals (Figure S273). It is important to work with this structure and these food resources when undertaking your restoration works. So what can be done?

RESPECT EXISTING HABITAT AND ITS FAUNA VALUES: WORK CAREFULLY WITH WHAT YOU HAVE

Figure S273. Buckland Road Bega River, Bega New South Wales. This former habitat of *Sand Rivers* Warm Temperate Rainforest (Figures S16 and S17) is now almost entirely composed of weeds. However, it is a fantastic starting point for restoration because it already has abundant and diverse fruiting food resources and a rainforest structure derived from these species. At this site they include: Cotoneasters *Cotoneaster* spp., Cherry Plum *Prunus cerasifera*, Large-leaved Privet **Ligustrum lucidum* and Small-leaved (Chinese) Privet **Ligustrum sinense*. It is very important to conserve these weeds as much as is practical during your restoration, but this will take patience and careful planning. You can work with this 'pseudo-rainforest' by doing supplementary and successional planting of indigenous native fruiting species while keeping the weedy rainforest structure as the framework for your restoration. Over time (as you provide alternative native species fruit resources), you can gradually cull the non-indigenous weeds and effect a seamless transition from an entirely weedy landscape: into a restored rainforest that conserves your native fruit-dependent and seed-dispersing fauna at the same time!

One way to minimise this impact, is to provide alternative native fruit resources (CRCfAW 2007a) by buffering your intended restoration works (using the weeds) until native alternatives can be established. This approach aims to:

- Conserve fruit-eating animal populations that may be threatened by your weed control
- Enhance the seed dispersal and recruitment of native species
- Reduce weed seed dispersal by your fruiting species plantings: effectively acting as competitors for seed dispersal services (CRCfAW 2007a).

To do this well, a logical and scientific basis for the substitution of weed fruits with native fruits should be followed. The Cooperative Centre for Australian Weeds has done this successfully. This is how it was done: substitutes were selected using an extensive body of ecological knowledge gathered in eastern Australia on the relationships between native plants and their fruit-eating bird-dispersal agents (CRCfAW 2007a). Characteristics known to affect food choices by birds that have been used in this approach include: fruiting timing and duration (phenology), fruit colour, fruit size and structure (CRCfAW 2007a). This then enables you as the restorer to have some security when planning the recovery of your highly degraded and heavily weed-infested restoration site. Using this system of Gosper and Vivian-Smith (2007), you will be able to determine which of the native plants you intend to reinstate will be the best substitutes available to support your local fruit-eating bird populations while your rainforest is being recovered. This system is presented in more detail in Gosper and Vivian-Smith (2006). **Remember your ecological restoration principles though by using only those species that are indigenous to: your area, the specific rainforest type that you are restoring and the habitat context in which you are working.**

The weed species that produce the largest infestations in south-eastern Australia – those for which it is probably critical to follow the advice provided in CRCfAW (2007b) – are largely the Weeds of National Significance (WoNS): Bridal Creeper **Asparagus asparagoides*, Bitou **Chrysanthemoides monolifera* ssp. *rotundata*, Lantana **L. camara* and Blackberry **Rubus fruiticosus* spp. agg. The Cooperative Research Centre for Weeds has provided the following lists of native species fruiting substitutes for those transforming species that grow in south-eastern Australia (CRCfAW 2007b) Species that have been missed in this compendium have been added by the author (and these are underlined):

> **Bitou **Chrysanthemoides monolifera* ssp. *rotundata***: Boobialla *Myoporum boninense* ssp. *australe*, Muttonwood *Myrsine howittiana*, Hairy Psychotria *Chelicanthes loniceriodes*, Seaberry Saltbush *Rhagodia candolleana*, Pearl Vine *Sarcopetalum harveyanum*, <u>Austral Sarsaparilla *Smilax australis*</u>, Sweet Sarsaparilla *Smilax glyciphylla*, Poison Peach *Trema tomentosa* var. *viridis* and Tree Heath *Trochocarpa laurina*

> **Lantana **L. camara***: Red Ash *Alphitonia excelsa*, Jungle Grape *Cissus hypoglauca*, Ruby Saltbush *Enchylaena tomentosa*, Giant Pepper Vine *Piper hederaceum* var. *hederaceum*, White Supplejack *Ripogonum album*, Poison Peach *Trema tomentosa* var. *viridis* and Tree Heath *Trochocarpa laurina*

> **Blackberry **Rubus fruiticosus* spp. agg**: Sea Box *Alyxia buxifolia,* Hairy Appleberry *Billardiera mutabilis*, Scrambling Lily *Geitonoplesium cymosum,* Tree Violet *Melicytus dentatus,* Queensland Bramble *Rubus moluccanus* var. *trilobus*, Small-leaved Bramble *Rubus parvifolius* Rose-leaf Bramble *Rubus rosifolius*, Kangaroo Apple *Solanum aviculare* and <u>Snake Vine *Stephania japonica* ssp. *discolor*</u>.

The other WoNS species that has yet to have the same process applied to it for our region, as has been done for South Australia CRCfAW (2007a), is Bridal Creeper **Asparagus asparagoides*. To overcome this geographic deficiency, the replacement species list was begun by using the example provided for north-east New South Wales and South-East Queensland: Ground Asparagus **A. aethiopicus* (which is an ecologically equivalent weed) as the starting point (CRCfAW 2007c).

This starting list of native species replacements (in bold) have been augmented by the author by selecting candidate replacement rainforest species for Bridal Creeper for south-eastern Australia. Note that species from montane and sub-alpine ecological vegetation classes (e.g. Sub-alpine Beard-heath *Leucopogon macraei*), have not been included because Bridal Creeper does not grow in these habitats. The **full potential list** of candidate fruiting species that may be suited for use on your rainforest restoration site in south-eastern Australia is:

> **Bridal Creeper **Asparagus asparagoides***: Native Quince *Alectryon subcinereus*, Sea Box *Alyxia buxifolia*, Bangalow Palm *Archontophoenix cunninghamii*, Berry Saltbush *Atriplex semibaccata*, Coffee Bush *Breynia oblongifolia*, Staff Climber *Celastrus australis*, Brittlewood *Claoxylon australe*, Prickly Currant-bush *Coprosma quadrifida*, Shrubby Deeringia *D. amaranthoides*, Giant Stinging Tree *Dendrochnide excelsa*, Small-flower Flax-lily *Dianella brevicaulis*, Paroo Lily *Dianella caerulea* s.l., Pale Flax-lily *Dianella longifolia s.l*., Black-anther Flax-lily *Dianella revoluta* ssp. *revoluta*, Tasman Flax-lily *Dianella tasmanica*, Myrtle (Black) Ebony *Diospyros pentamera*, Turquoise Berry *Drymophila cyanocarpa*, Corkwood *Dubosia myoporioides*, Koda *Ehretia acuminata* var. *acuminata*, Nodding Saltbush *Einadia nutans*, **Saloop *Einadia hastata***, Red Olive Plum *Elaeodendron* var. *australe*, Yellow Ash *Emmenosperma aliphitonioides*, Ruby Saltbush *Enchylaena tomentosa*, Rough Saw-sedge *Gahnia aspera*, Tall Saw-sedge *Gahnia clarkii*, Brickmaker's Saw-sedge *Gahnia grandis*, Scrambling Lily *Geitonoplesium cymosum*, Wombat Berry *Eustrephus latifolius*, Cheese Tree *Glochidion ferdinandii* var. *ferdinandii*, Guioa *G. semiglauca*, Trailing Guinea-flower *Hibbertia dentata*, Climbing Guinea-flower *Hibbertia scandens*, Lance Beard-heath *Leucopogon lanceolatus* var. *lanceolatus*, Coast Beard-heath *Leucopogon parviflorus*, Cabbage Fan-palm *Livistona australis*, Narrow-leaved Orangebark *Maytenus silvestris*, Tree Violet *Melicytus dentatus* s.l., Tree Broom-heath *Monotoca elliptica*, Bushy Broom-heath *Monotoca glauca*, Jasmine Morinda *M. jasminoides*, Climbing Lignum *Muehlenbeckia australis*, Slender Lignum *Muehlenbeckia gracillima*, Mangrove Boobialla *Myoporum acuminatum*, **Boobialla *Myoporum boninense* ssp. *australe***, Common Boobialla *Myoporum insulare*, Muttonwood *Myrsine howittiana*, Variable Muttonwood *Myrsine variabilis*, Large Mock-olive *Notelaea*

longifolia forma *longifolia*, Large Mock-olive *Notelaea venosa*, Bleeding Heart *Omolanthus populifolius*, *Omolanthus stirlingifolius*, Anchor Vine *Palmeria scandens*, Orange Thorn *Pittosporum pauciflorus*, Rough-fruit Pittosporum *P. revoluta*, Sweet Pittosporum *P. undulatum*, Pencil Cedar *Polyscias murrayi*, Broad-leaf Panax *Polyscias sambucifolia* ssp. 1, Ferny Panax *Polyscias sambucifolia* ssp. 2, Hairy Psychotria *Chelicanthes loniceriodes*, Seaberry Saltbush *Rhagodia candolleana*, Brush Turpentine *Rhodamnia rubescens*, White Supplejack *Ripogonum album*, Queensland Bramble *Rubus moluccanus* var. *trilobus*, Small-leaved Bramble *Rubus parvifolius* Rose-leaf Bramble *Rubus rosifolius*, Yellow Elderberry *Sambucus australasica*, White Elderberry *Sambucus gaudichaudiana*, Blunt Sandalwood *Santalum obtusifolium*, Yellowwood *Sarcomelicope simplicifolia*, Pearl Vine *Sarcopetalum harveyanum*, Austral Sarsaparilla *Smilax australis*, Sweet Sarsaparilla *Smilax glyciphylla*, Kangaroo Apple *Solanum aviculare*, Large Kangaroo Apple *Solanum laciniatum*, Green-berry Nightshade *Solanum opacum*, Violet Nightshade *Solanum silvestre*, Devil Thorn *Solanum stelligerum*, Gunyang *Solanum vescum*, Snake Vine *Stephania japonica* ssp. *discolor*, Buff Hazelwood *Symplocus thwaitesii*, Scentless Rosewood *Synoum glandulosum* ssp. *glandulosum*, Brush Cherry *Syzygium australe*, Lilly Pilly *Syzygium smithii*, Brush Pepperbush *Tasmannia insipida*, Mountain Pepper *Tasmannia lanceolata*, Bower Spinach *Tetragonia implexicoma*, Poison Peach *Trema tomentosa* var. *viridis* Tree Heath *Trochocarpa laurina*; Burny Vine *Trophis scandens* ssp. *scandens* and Veiny Wilkea *W. heugeliana*.

To work out which of the potential list of species for Bridal Creeper (or any other species that you need to deal with) are the most suitable for substitution on your restoration site, you will need to apply the following filters:

1. Are the infestations of Bridal Creeper on your restoration site at a level that would require a staged and considered substitution by local native fruiting species? We suggest that any site that has more than 1/3 of its area and/or an area of greater than 1ha covered by the weed should require you to follow the next steps.
2. Apply the methodology outlined in CRCfAW (2007a) – i.e. (Phenology + Morphology+ (Conspicuousness + Accessibility) = score – for each candidate substitute fruiting species (see the Method worksheet in Appendix S3 and use the Vic fruiting plant substitute and NSW fruiting plant substitute worksheets to obtain the necessary data you need to do the scoring) and use the weed seeding and flowering calendar (also in Appendix S3)
3. Only apply the scoring to substitutes that would have naturally occurred on your site in the past (in the rainforest type that you are restoring)
4. Use the substituted species that you choose within the context of the restoration method that the site dictates that you need to use. Do not deviate from your chosen method for restoration. That is: other factors (such as money, site conditions and other limitations) should determine your choice of Restoration Method, rather than the single consideration of accommodating local fruit-eating species
5. Continue to apply the Guidelines for Developing and Managing Ecological Restoration Projects (SER 2004; Clewell et. al. 2005) as these apply to your site.

If the weed infestation you wish to replace is not one of the WoNS for which the replacements have already been listed, then use their methodology (CRCfAW 2007a; Gosper and Vivian-Smith 2007) and the extensive fruit data base that they have provided at the CRC's website <www.weeds.crc.org.au> to determine the right substitute native fruiting species for incorporation into your site's restoration schedule. Because the CRC is to be closed down in 2008, we have negotiated the inclusion of this data base in the Restoration Manual (compiled as two worksheets in Appendix S3: Vic. fruiting plant substitutes or NSW fruiting plant substitutes. Rainforest habitat weed species in south-eastern Australia that have been observed to require the same analysis include: Hawthorn **Crataegus monogyna*, English Ivy **Hedera helix* and Large-leaf Privet **Ligustrum lucidum*.

Strangler figs as weed control agents

The innovative people in the Big Scrub have come up with a novel and deliciously ironic way of dealing with tree weeds of rainforests. The technique requires the placement of one or more strangler fig seedlings onto the trunks of weed trees. Over a 10-15 year period the fig's roots ***anastomose*** around the host's trunk and strangle it to death. Thus the weed is replaced by a keystone species without further expensive intervention, while smaller saplings and seedlings are controlled by other methods. This technique is now a standard suggestion for dealing with Camphor Laurel **Cinnamom camphora* in that region. For us (in the sub-tropics): use Small-leaved Fig *Ficus obliqua* within its range or ***banyan forms*** of Rusty Fig *F. rubiginosa*. Banyan forms can be grown by selecting seedlings from the nursery with an abundance of aerial roots, or by collecting cuttings from mature trees that display the banyan habit.

It is important to note that this process can be applied because the suggested replacement fig species for dispatching the Camphor Laurels also produce abundant fruit crops over winter, at the same time as that of the host (Appendix S : worksheet: All spp+FCs). This is important because oldfield regrowth of Camphor Laurels are a very important food resource in the landscape (Neilan *et. al*. 2005) and are actually initiating landscape-scale reforestation of native rainforests in some regions such as the Big Scrub in northern New South Wales (Neilan *et. al*. 2006).

Soil seed banks: free seed in your soil

Introduction

Most of the pioneer, many of the secondary and some of the primary rainforest species plants have seed that remains viable in the soil for decades or even centuries. These plants are said to store their seed in the soil seed bank. If conditions are right, germination and establishment will occur. Luckily you can manage your restoration site in a way that will encourage natural regeneration from this soil seed bank, as well as providing conditions suitable for dispersal and germination of short-lived seed.

Some of these species are called paddock rainforest starters and if your restoration site is a grazed paddock, then the first thing you can do to encourage their germination is to take out the stock. These species will come up and all you need to do is manage the transforming weeds that will follow. If there is a rainforest remnant nearby, then you may need to consider planting your regenerating trees with mistletoes (if they are not arriving of their own accord). This will encourage honeyeaters to use your site for the mistletoes, fruit and nectar and they will deposit any seed from the rainforest fruits that they have just consumed and brought from the nearby rainforest remnant. See Additional Reading: Mistletoes and rainforest regeneration: vital in a fragmented landscape. Mistletoe planting guidelines are provided in Additional Reading: Restoration, mistletoe planting and mistletoe colonisation.

Through integrated weed management, you can create niches (and consequently the right germination conditions) that will release some of the seed from the soil seed bank (Figures S271 and S272). For the vast majority of pioneer and secondary species (if they are not paddock rainforest starters), the ‘right condition’ or niche is bare soil (free of weeds). In contrast, for the primary species, the right niche is in leaf litter, but, once more, the caveat on good weed control still applies. Plant families, genera and species noted to germinate from the soil seed bank (but not listed in Table S24) include: Eucalypts, Tea trees, Kunzeas, Common Tussock-grass *Poa labillardierei*, Saltbushes: Berry Saltbush *Atriplex semibaccata*, Saloop *Einadia hastata*, Nodding Saltbush *E. nutans*, Lax Goosefoot *E. trigonos* and Seaberry Saltbush *Rhagodia candolleana*.

Understanding this phenomenon, and harnessing it, is a very important rainforest restoration principle that is intimately tied to integrated weed management. The role of the soil seed bank in rainforest restoration and recovery following disturbance is encapsulated in ***Successional Planting*** (Appendix S16).

Successional Planting

Successional planting is a process used in rainforest restoration that seeks to mimic the natural regeneration sequences of the particular rainforest type upon which you are working (Appendix S16). In south-eastern Australia, it begins with planting sun and frost-hardy pioneers. Once this group of species is established, the planting may end at this point if there are insufficient funds to continue and there is an intact rainforest stand within 500m (Chapter 5: Choosing restoration methods: matching your site with your budget and resources). This is the Framework Method and it relies on the next two successional stages happening naturally through dispersal of seed and establishment of the late secondary and primary mature phase species on your restoration sites. Nature will, over time (provided weeds are controlled), do the rest.

If there are no rainforest remnants within a kilometre then wind, water and animal species’ dispersal of rainforest seed to your restoration site will be so random and at such low levels, that the latter successional stages are likely to fail (in the lifetime of your pioneer and early secondary species: a period of 5-20 years or so). This is because the level of recruitment of late secondary and primary rainforest species will be too slow to alter the sites characteristics (increase shade and shelter, improve weed control, establish fruit/seed production and establish rainforest niches etc. before your plantings die). Consequently, once your nursery crop of pioneer species plantings come to the end of their lives (Table S25), the site will show little or no regeneration of these or other rainforest species from the latter stages of succession, and your restoration will sink back into a sea of weeds.

It is therefore important to plant a variety of pioneer and secondary species with differing life-spans so that your site does not end up with large areas dying out at one time and nothing to fill the gaps (Figures S274, S275 and S276).

Table S25. Examples of nursery crop species and the time until their maturation/senescence in south-eastern Australia, which allows establishment of primary mature phase species through natural regeneration.

Nursery crop (pioneer and secondary species) by rainforest ecological vegetation class	Senescence time (years)	Primary species colonisation time (begins at nursery crop maturity) (years)
Cool Temperate Rainforest		
Silver Wattle Acacia dealbata	20*-40*+	10*-20*
Frosted Wattle *Acacia frigescens*	60*+	20*-20*
Blackwood *Acacia melanoxylon*	40-60+	10-20
Blanket-leaf *Bedfordia arborescens*	40*-60*	10-20
Common Cassinia *C. aculeata*	10*-15*	2*-3*
Mountain Tea-tree *Leptospermum grandifolium*	60*-80*	20*-30*
Satinwood *Nematolepis squamea* ssp. *squamea*	20*-40*	15*-30*
Dusty Daisy-bush *Olearia phlogopappa*	5-10	2-3
Hazel Pomaderris *P. aspera*	20-30	20
Victorian Christmas Bush *Prostanthera lasianthos*	20*-30*	5*-10*
Fireweed Groundsel *Senecio linearifolius*	8-12	1-3
Warm Temperate Rainforest		
Black Wattle *Acacia mearnsii*	20-23	15-20
Blackwood *Acacia melanoxylon*	40-60+	10-20
Bower Wattle *Acacia subporosa*	25-30	15-20
Varnish Wattle *Acacia verniciflua*	10*	5*-8*
Hazel Pomaderris *P. aspera*	20-30	20
Subtropical Rainforest		
Maidens Wattle *Acacia maidenii*	40*-60*+	10*-20*
Southern Kurrajong *Commersonia rossii*	15*-20*	10*-15*
Giant Stinging *Tree Dendrochnide excelsa*	Multiple decades*	Decades*
Littoral Rainforest		
Coast Sallow Wattles *Acacia longifolia* ssp. *sophorae*	10-15	5*-10
Boobiallas *Myoporum acuminatum*/insulare*	15-20	8-12
Coast Tea-tree *Leptospermum laevigatum*	100-120	50*-100
Giant Honey-myrtle *Melaleuca armillaris*	120*+	50*-100
Warm Temperate Rainforest/Littoral Rainforest		
Gunyang *Solanum vescum*	1-3	2
Fireweed Groundsel *Senecio linearifolius*	8-12	1-3
Kangaroo Apple *Solanum aviculare*	7-10	2-3
Tree Everlasting *Ozothamnus ferrugineus*	10*	5*-8*
Sallow Wattle *Acacia longifolia* ssp. *longifolia*	10-15	5-10
Southern Kurrajong *Commersonia rossii*	15*-20*	10*-15*
Black Wattle *Acacia mearnsii*	20-23	15-20
Gallery Rainforest		
Silver Wattle *Acacia dealbata*	20*-25*	15*-20*
White Sallow Wattle *Acacia floribunda*	15*-20*	10*-15*
River Oak *Casuarina cunninghmiana*	Multiple decades*	Decades*
Dry Rainforest		
Limestone Pomaderris *P. oraria* ssp. *calcicola*	15*-25*	10*-15*
Limestone Wattle *Acacia caerulescens*	25*-30**	15-25
Gully Dry Rainforest		
Green Wattle *A. irrorata*	20*-23	15*-20
Black Wattle *Acacia mearnsii*	20-23	15-20
Bower Wattle *Acacia subporosa*	20-30	15-20

*Not fully known: estimated by author; **Dot Rule (pers. comm.).

THREE DIFFERENT RAINFOREST SUCCESSIONAL OUTCOMES IN THE SAME STAND OF SENESCING SILVER WATTLE: UNDERSTOREY REALLY COUNTS!

Figure S274. Goldsmith's Colquhoun Forest, Victoria. A senescent stand of Silver Wattle *Acacia dealbata* (middle ground) that regenerated when vegetable growing ceased some twenty years ago. This was then replaced by Snowy Daisy-bush *Olearia lirata*, with rainforest species regenerating beneath. In the background, a new wave of Silver Wattle is maturing (marked by the wattle blossom). Effectively, the first nursery crop has passed without rainforest regeneration and has (in the absence of fire) been replaced by another nursery crop of shrubs. This latter regeneration event may produce a better mature rainforest regeneration result as it is more dense at ground-level and likely to inhibit browsing. This was in stark contrast to the preceding Weeping Grass *Microlaena stipoides* sward that dominated the groundlayer beneath the previous Silver Wattle nursery crop. This observation is backed up by Figure $276 where groundlayer species have obscured and protected the regeneration.

Figure S275. Goldsmith's Colquhoun Forest, Victoria. This shows the importance of more than one nursery crop species. The Silver Wattle (foreground and middle ground) has senesced and produced a healthy Lilly Pilly *Syzygium smithii* (right middle ground). In the background, Blackwood *Acacia melanoxylon* regenerated at the same time but is still in reasonable (though declining) health. Nevertheless it will continue to act as a perch for defecation of rainforest fruit that may well find a site free of browsing either in the fallen timber and/or the copse of Scrub Nettle *Urtica incisa* (red arrow).

Figure S276. Goldsmith's Colquhoun Forest, Victoria. This is the best mature rainforest regeneration event in this senescing stand of Silver Wattle. This is likely to be the result of the camouflaging effect of the groundlayer of Bracken *Pteridium esculentum*. The major species to regenerate here include the mature phase canopy species: Muttonwood *Myrsine howittiana*, Sweet Pittosporum *P. undulatum*, Lilly Pilly *Syzygium smithii* and the vines: Forest Clematis *C. glycinoides*, White Milkvine *Marsdenia rostrata*, Jasmine Morinda *M. jasminoides* and Austral Sarsaparilla *Smilax australis*. The regenerative process is further protected from browsing on this edge by Bracken (foreground) and Snowy Daisy-bush *Olearia lirata* (middle ground). Unfortunately, the same protection does not exist behind the rainforest regeneration in this photograph where Sambar are pushing in and destroying the regeneration. Sadly this scenario is now widespread across East Gippsland and in southern New South Wales rainforests where previously intact rainforests are being destroyed by this pest.

DIVERSE SPECIES PLANTINGS ENSURES CONTINUITY THROUGH MULTIPLE REGENERATION CYCLES

Figure S277. Site 41 Bete Belong, lower Snowy River Victoria. This restoration site is about 15 years old. A White Sallow Wattle *A. floribunda* (part of the original planting) has senesced and fallen. In its wake Kangaroo Apple *Solanum aviculare* has regenerated abundantly. Note the variety of secondary species that date from the initial planting that still remain: Blackwood *Acacia melanoxylon* (left) and Common Boobialla *Myoporum insulare* (right). Subsequent enrichment plantings have also added other pioneer species such as: Varnish Wattle *A. vernicaflua* (red arrow). The primary species Lilly Pilly *Syzygium smithii* has also been planted (green arrow) because this site is too remote from any existing stand for any of its seed to reach this locality through animal dispersal.

Use the data in Table S25 to determine your pioneer and secondary species mix (with reference to the relevant floristic community planting list) for your site (start with Appendix S6). It is very important to note, however, that these do vary regionally, and if you are suspicious of the accuracy of the data for species growing in your area that are listed in Table S25, or the relevant species for your site are not listed, take steps to determine their life-expectancies for yourselves. This is done by observing the state of the relevant species knowing the date of the previous disturbance event that produced the regeneration (fire, flood, land clearing, etc.).

So, for a site that has to date only had the Framework Method restoration applied, and which is not likely to have rainforest succession continue through offsite recruitment, the next two stages of Successional Planting will need to be undertaken (Appendix S16). This will ensure that a larger diversity of late secondary and primary mature phase rainforest species are added to the site through your planting efforts. This is what constitutes the Maximum Diversity Method, which aims to restore around 50% or more of the original rainforest stand's plant species diversity through planting. This produces a much more self-sustaining natural regeneration system (Figure S277). The initial species composition is determined by consulting the floristic community's characteristic species lists for the rainforest type that would have been expected for that site (Appendix S17), while the planting sequence is guided by the Successional Planting technique (Appendix S16). The primary species are chose from the relevant EVC worksheet in Appendix S6. Remember, if the site's physical characteristics have been radically altered since historic times: then choose the floristic community or ecological vegetation class that best suits the conditions that exist on your site today (Chapter 3: Setting your *restoration trajectory* and goals: what rainforest was it and should this be the one to be put back?).

It is very important to note that even if you are able to do the Maximum Diversity Method over your entire site, to do so will be very expensive (Restoration Manual Framework Method). A much cheaper option is to apply the Maximum Diversity Method on the most benign (easiest) spots and plan to apply the Framework Method to the majority of your restoration area and let nature (and natural regeneration) take its course. Essentially your Maximum Diversity plantings will become the remnant from which recruitment will kick-start the successional process throughout the balance of your Framework Method plantings. In time, primary mature phase rainforest species will spread across the rest of the site for you free of charge (except for the cost of weed maintenance).

Caveat

Natural systems are difficult to compartmentalise, model and predict. The stages described and illustrated in Successional Planting (Appendix S16) represent clearly identifiable phases in rainforest restoration. Whether these stages can be established in one year or many is season and site dependent. The stages that are illustrated in Appendix S16 are on average sites with poor seasonal factors taken into account.

Companion planting

Introduction

In the context of rainforest restoration, companion planting is used as one of the tools available in our tool box of adaptive management to combat a particular problem. For example:

- Sun intolerance (Lilly Pilly *Syzygium smithii* when young being planted beneath pioneer nursery crop species such as Fireweed Groundsel or Kangaroo Apple)
- Outright shade-dependence (Austral Lady Fern *Diplazium australe* at all life stages being planted underneath Lilly Pilly);
- Frost sensitivity (White Milk-vine *Marsdenia rostrata*) requires protection from a frost-hardy ***cover crop***, such as Black Wattle *Acacia mearnsii*, to which it is especially suited because of its drought tolerance.

There are three methods for companion planting:

1. Planting both species at the same time. This method allows for the benefits of the companion relationship to accrue immediately, but species should be well matched. So for the palatable species/ camouflage species mix to work, both species need to be well calibrated for their growth rate in the first year: one should not overtop the other (Figure S247). In the second year (provided they two have reached a height that will exclude your browsing problem species), it does not matter that the palatable species exceeds the height of the camouflage species (Figure S245). Another good example is the planting of Kangaroo Apple *Solanum* spp. with Sword Tussock Grass *Poa ensiformis*. The former suffers from exotic grass (e.g. Yorkshire Fog **Holchus lanatus*) infestation at their bases, especially in the second and third years where frosts can prune back the crown of the Kangaroo Apples. To overcome this problem the planting of the sward-forming native grass can out-compete the exotic species. This removes the need for problematic and costly herbicide control of weeds near the bases of the herbicide-sensitive Kangaroo Apples.
2. Staggered planting in the same season. This is most often used where camouflage or unpalatable species are employed to hide wattles (Figure S245) or the tougher primary canopy species such as Muttonwood or Sweet Pittosporum. The camouflage species are planted first and once established (6-8 weeks), then the palatable species are planted close-up to those individuals that have abundant growth that can obscure them. As the camouflage species grow, the palatable species grow up within their crowns and within a year emerge out of the top of them (attaining a height that is beyond the reach of the browsing animals on the restoration site) (Figure S245)
3. Planting beneath or amongst already established plants. This is particularly useful where an extensive niche is required, such as shade or frost shelter (Restoration Manual: Tubestock). Depending on the service provided by the companion plant, the crown may need to be well developed (for frost protection) and the companion planting may take place one to several years or decades after the original planting (e.g. deep shade and high humidity required by some epiphytes) such as for Fragrant Fern *Microsorum scandens* (Figure S152). Somewhat surprisingly, in the case of browsing, the companion plant need not obscure the palatable plant, but may simple deter the browser by being prickly (Chapter 5: Use of deterrent weed species in the Clumped Mixed Canopy Method) or providing a bare framework of branches that breaks up the picture for the browsing animal (Chapter 8: Camouflage species).

Browsing management using companion planting

The use of companion planting can mean not having to use artificial tree guards. Where browsing or grazing is a problem, this can be done by planting unpalatable, camouflage or deterrent species next to palatable species to give them protection. Most browsing species (Sambar are an exception: everything to them is palatable!) will pass over a palatable plant if it is obscured by the inedible or unfavoured plant. This technique has been very successfully used to establish Black Wattle *Acacia mearnsii*, Varnish Wattle *A. verniciflua* and Blackwood *A. melanoxylon* on rainforest restoration sites in areas with significant populations of Hog Deer and Black Wallabies. Useful unpalatable species are listed, and the process is illustrated, in Appendix S11: Figures AS11-1 to AS11-5.

SUMMARY	
COMPREHENSION: STOP	Rainforest restoration is not a simple process in most cases. It requires an extensive kit of knowledge and tools in order to be able to meet any of the challenges that you could face during the process.
KNOWLEDGE: THINK	Understanding what knowledge and tools you may need is the first step in equipping yourself for rainforest restoration. Mastering these skills will allow you to become an ecological healer that can move seamlessly around your restoration site and repair whatever damage you may find. Rainforest restoration in particular, and ecological restoration in general, are acts of goodwill and kindness towards the Planet, as much as they are the application of a series of technical methods and approaches. As such, you are part of a global effort to reverse the damage caused by modern humanity to our only life-support system.
WHAT TO DO?: ACTION	Get geared up and get out there. Be an advocate for the bigger picture. Become an example to others, teach whatever you know and spreading the knowledge.
WHAT NEXT?	You now have to look from the site-specific to the landscape and learn about the big picture influences that will act on your rainforest restoration site over time.