# Chapter S1 Scope and history

AN ABANDONED DAIRY FARM, AN EXPANDED NATIONAL PARK: A RAINFOREST RESTORATION OPPORTUNITY!

Durras Mountain, Murramarang National Park New South Wales. A Large Mock Olive *Notelaea longifolia* at (what was once) the front door to the old dairy farmhouse beside the disused Coast Road between Kioloa and Pebbly Beach illustrates the pendulum swings of history. The abandoned farm returned to the public land estate when it was purchased in 1973 and added to the Murramarang National Park. The *NPWS* has used the *Natural Regeneration Method* (simply by controlling *transforming weeds*) and this is showing fantastic results, with Subtropical Rainforest gradually recolonising the old paddocks of the dairy farm (below middle). The rate is dependent on the time since stock were removed and the presence of permanent water (bottom left) that sustains higher populations of Eastern Grey Kangaroo and Swamp Wallaby (bottom right). NOTE: the *transforming weeds* controlled here do not include pasture grasses. This method works because the *seed rain* from adjacent intact rainforest gullies includes *paddock rainforest starters* which germinate in such pastures when stock are removed. Rainforest is returning, with the copse of Brittlewood *Claoxylon australe* (top background). History has many phases, and your use of this book will ensure that your efforts can turn the destructive elements of our past into a restoration future.

South end: permanent stock water sustains native *browsers*, slows rainforest regeneration: large mob = 120 pellets $m^{-2}$

South end: macropod grazing refuges: fallen tree head and native brambles. In contrast, deer would overrun these rendering them useless.

North end: no stock water: reduced kangaroo numbers (grazers that eat young wattle), in time rainforest reduces *habitat*: to single males = 31 pellets $m^{-2}$.

HISTORY COMES IN MANY FORMS: OPEN YOUR EYES AND MIND TO SEE THESE LANDSCAPE CLUES

Figure S1. Site 20, lower Snowy River Orbost Victoria. Historic survey maps record the passing of the rainforest and its veteran Mahoganies. The burnt *stag*: alludes to annual burning of frost killed Kikuyu for spring green pick; the willow stump is mute testament to past river management that saw rainforest cleared and *snags* removed, river velocity increase and the river widen by 50%. *Fungi* rot the stump ushering in a new era of *rainforest* and *riparian restoration*.

## What is ecological restoration?

This Manual and its contents have been derived from local experience that has been developed from ***ecological first principles***. As such, it has largely evolved in isolation from the international discussion on ecological restoration *de novo* (from the beginning). Doing things that way (remaining ignorant of existing restoration ***paradigms***) leaves you wired for what is going on: super aware of the site's prospects, pitfalls and your restoration results. It is therefore pleasing to observe (at the end of writing about our experiences) that there is a significant international body of work that defines ***ecological restoration*** and largely concurs with our local approach and methods.

The Society for Ecological Restoration International has produced two excellent publications on the subject of ***ecological restoration***: the 'SER International Primer on Ecological Restoration' (SER 2004) and 'Guidelines for Developing and Managing Ecological Restoration Projects' (Clewell *et al*. 2005). The former outlines the principles behind ecological restoration and the latter teases these out into a series of guidelines. From the latter, the following definition of ecological restoration neatly circumscribes the ecological restoration approach that we have applied to recovering rainforests in south-eastern Australia (our notes are in parentheses):

> Ecological restoration is: "the process of assisting the ***recovery*** of an ***ecosystem*** that has been ***degraded***, ***damaged***, or ***destroyed***. It is an intentional activity that initiates or accelerates ecosystem recovery with respect to its health (***functional processes***), integrity (species composition and community structure), and sustainability (***resilience***: ability to resist disturbance and recover from it). Restoration ensures ***abiotic*** support from the physical environment, suitable flows and exchanges of organisms and materials with the surrounding landscape, and the reestablishment of cultural interactions upon which the integrity of some ecosystems depends. Restoration attempts to return an ecosystem to its historic trajectory, i.e., to a state that resembles a known prior state (we call them reference sites from which we derive ***benchmarks***) or to another state that could be expected to develop naturally within the bounds of the historic trajectory (where the historic condition of the site and its condition today are profoundly different). The restored ecosystem may not necessarily recover its former state, since contemporary constraints and conditions can cause it to develop along an ***altered trajectory***."

The Guidelines (Clewell *et al*. 2005) in accord with SER (2004) assume that ecological restoration is accomplished once:

> "the assistance of the restoration practitioner is no longer needed to ensure long-term ecosystem sustainability. However, ***ecosystem management*** may be required to prevent recurrent degradation of restored ecosystems on account of alterations in the environment or anthropogenic changes. Such activities are considered management rather than restoration. In other words, ecological restoration makes ecosystems whole again and ***ecological management*** keeps them whole. Correspondingly, some restored ecosystems will require management in the form of traditional cultural practices (e.g. as used to occur with the targeted-burning of vegetation adjacent to rainforest by the ***Kooris*** to conserve the cultural significance of such sites and the resources restricted to them). This distinction between restoration and management (including cultural practices) facilitates resource planning and budgeting, and it protects ecological restoration efforts from being held liable for subsequent inconsistencies or misjudgement in ecosystem management."

To ecologically restore rainforest then is to see such bush as a complex and interdependent system, which is nonetheless a divisible whole, whose parts or components can be understood and then creatively and flexibly employed to recover it using ***adaptive management***. Put simply, let us help you to: observe, act, watch, react and try again – and over time you too will succeed in restoring rainforest! For a detailed treatise on ecological restoration see Definitions and synonymy.

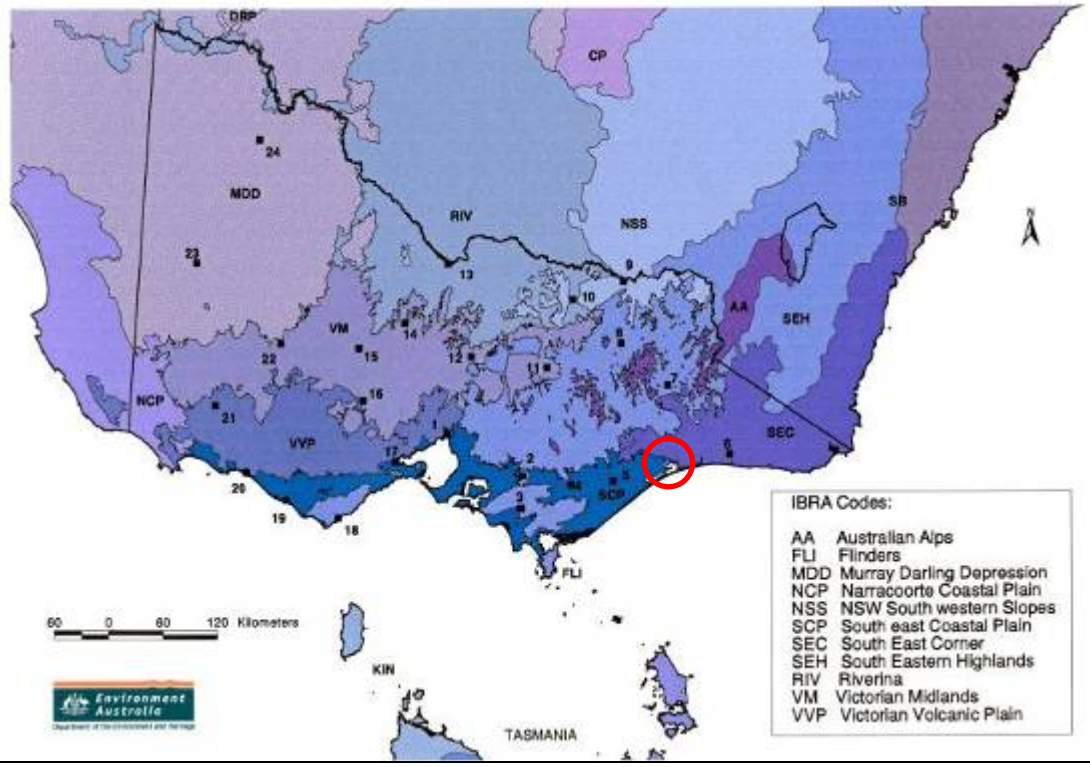
## Scope

Geographically, this Manual deals with all of the rainforests of mainland south-eastern Australia; that is south of Pebbly Beach and the Clyde River valley north of Batemans Bay to the Otway Ranges in Victoria. This encompasses five of Australia's national ***Biogeographical Regions*** [IBRA Version 5.1 (DEH 2007)] derived from Thackway and Cresswell's original 1995 work. Map S1 illustrates the geographic scope of the Manual described below:

- South East Corner Bioregion (SEC: Map S1): from just north of Bateman's Bay (Kioloa) to the lowland reaches of the Mitchell River northwest of Bairnsdale in the south, ranging from the coast up to the Monaro escarpment's edge
- South Eastern Highlands Bioregion (SEH: Map S1): that includes the Errinundra Plateau, Murrungowar Range, the Central Highlands, Strzelecki Ranges and Otway Ranges
- Australian Alps Bioregion (AA: Map S1): only in Victoria and then principally in association with the Baw Baw Plateau and other smaller massifs (Lake Mountain and Mt Donna Buang) in the Central Highlands

- South east Coastal Plain Bioregion (SCP: Map S1): in a small area between the Mitchell River and Metung in Victoria (red circle on Map S1
- Flinders Bioregion (FLI: Map S1): encompassing the mountainous non-isthmus areas of Wilsons Promontory.

This Manual provides restoration information for seven rainforest *ecological vegetation classes* (*EVCs*), 57 ***floristic communities*** (FCs) (or equivalent entities) and 735 species using general principles developed through extensive restoration experience with Warm Temperate Rainforest (the previously most extensive, the most depleted by clearing) and to a lesser degree Gallery and ***Littoral Rainforests***. The author has spent considerable field research time gathering information on Subtropical, Dry and Littoral Rainforest restoration from northern New South Wales to broaden the scope of this Manual.




Map S1. Interim Bioregionalisation of south-eastern Australia Version 5.1 (DEH 2007). The red circle indicates the part of the South-east Coastal Plain with rainforest.

## Threats to rainforest

*Habitat loss*

In general, the rainforests of south-eastern Australia are ***threatened*** because they have been, or are being, cleared, fragmented, grazed/browsed, affected by disease, burnt or invaded by weeds (Figure S1). New threats such as deer are already having a significant impact (Peel *et al*. 2005), while ***climate change*** is looming as an overriding and significant threat to all of the ***rainforest types*** found across south-eastern Australia. All of these threats act to reduce the area of rainforest and, in some cases, its habitats are still being lost to other uses such as agriculture, urbanisation or coastal development (Appendix S1: worksheet: Rainforest depletion; worksheet: Nomination status or potential; worksheet: Threatening Processes). Many of the rainforest of our region are entirely restricted to it or are at their edge of range. With climate change being so rapid, the future of many rainforests that are at the edge of their range (Appendix S2: worksheet: Rainforest edge of range) and which face impenetrable ***migration barriers*** is at best uncertain and at worst they face extinction. How then do these threats play out for each rainforest type in an historic context?

Rainforests within south-eastern Australia at the time of the arrival of Europeans were always in relatively small and often scattered stands (though some of the Cool Temperate Rainforest stands of the Otways, Strzeleckis and Central Highlands were large and many of the Gallery and Warm Temperate Rainforest stands along the lowland rivers of East Gippsland were more or less continuous for many kilometres). This generally scattered and restricted 'island

archipelago' disposition across the landscape reflected the prevalence of fire in the landscape of the region and its deleterious impact on rainforests. South-eastern Australia remains one of the most fire-prone regions of the continent. Rainforests have consequently been restricted to relatively small fire-protected ***refuges*** in areas of the landscape with reliable rainfall and moderate temperatures. Most types occurred on inherently fertile habitats (***Subtropical Rainforest, Warm Temperate Rainforest, Dry Rainforest, Gallery Rainforest and Cool Temperate Rainforest***) or literally made their habitat fertile by enrichment of soils due to their long-term occupation of particular sites (Dry Rainforest, ***Dry Gully Rainforests*** and ***Littoral Rainforests***). One type, Littoral Rainforest has its nutrient capital supplemented by salt haze.

The earliest stages of European land use in the south-eastern Australia involved squatting that was associated with grazing in grasslands and grassy woodlands. This type of land use involved herding grazing animals into areas of the landscape that could be immediately used without the need for back-breaking land clearing. The first rainforests to be affected by European land use in that case would almost certainly have been the Dry Rainforests of the Bega-Candello-Quamma-Cobargo districts and the Subtropical and Warm Temperate Rainforests of the Tanja area.

As the volume and value of produce from the regions outside the major settlements of Sydney and Melbourne began to grow, a coastal shipping trade sprang up to transport these goods to their major markets. This process too had its impacts on rainforests. The first was on Littoral Rainforest stands that had the misfortune to be located on coastal sites with the features of good natural ports because these localities needed land to support urban and industrial development associated with shipping. These included: Bairnsdale, Cunninghame (later to become Lakes Entrance), Eden, Tathra, Bermagui, Narooma and Batemans Bay. Today you have to look hard to find evidence of the past presence of such stands, but these can be uncovered using techniques discussed in Chapter 3: Was it ever rainforest?

As the population and the wealth of the early colony grew, fertile land became the focus for European activity. Sites that combined fertility with relatively flat and well-watered areas were sought out and preferentially cleared for agriculture. This has had a disproportionately large impact on Subtropical and Warm Temperate Rainforests in the region. Other types, such as Dry Rainforest (of gorges and rocky escarpments) and Cool Temperate Rainforest (at least in the early days of settlement), were largely unaffected because they were generally on steeper, inaccessible country unsuited to clearing , except perhaps for those that were unlucky enough to be associated with gold-bearing country. One such example were the rainforests on and around Gulaga (Mount Dromedary) that were extensively cleared during mining and sluicing for gold and later agricultural development around the footslopes (Pacey and Hoyer 1995). Types affected included Subtropical Rainforest and Dry Rainforest on the footslopes, through to Warm Temperate Rainforest in the mid-elevation gully reaches to the Cool Temperate Rainforests of the upper slopes and mountain ridges. In the Otway and Strzelecki Ranges, relatively flat ridge country that hosted Cool Temperate Rainforest was cleared (in the Otways) and many of the steep gullies also went (more so in the Strzelecki Ranges).

*Squatting and early grazing*

The primary impact of this type of land use was likely to have been the loss of ***understorey*** in Subtropical, Warm Temperate and Dry Rainforests in the Bega-Candello-Quamma-Cobargo and Tanja districts. As time went on, clearing for more intensive grazing probably also included these areas as well. Although today we view Dry rainforests primarily as a feature of rock outcrops and steep country (not suited to grazing), there is strong contemporary evidence – in the form of Dry Rainforest remnants still present e.g. Buckajo Road, Araluen Valley, or recently lost (near Candelo) – to suggest that it developed beyond the small tor fields that we largely see it on today. This was possible because of the resilience of the dominant canopy species, Rusty Fig *Ficus rubiginosa* to fire (Additional Reading: Ignition times), which easily withstands the usual fires that occur in the Grassy Woodlands of the region (Cameron 2006). These areas beyond the rock tors would have been the first to have been lost to grazing and clearing because of the accessibility of the gently undulating fertile ground upon which they grew.

*Land clearing*

The land clearing that has most greatly affected rainforests in south-eastern Australia is that which has occurred on fertile alluviums of the lowland river valleys and their nearby gullies. Detailed studies have shown that significant tracts of Warm Temperate and Gallery Rainforests have been lost from the Mitchell, Tambo, Nicholson, Snowy, Brodribb, Bemm, Combienbar, Cann, Genoa and Wallagaraugh Rivers. As evidenced by the contemporary 'discovery' of '*Sand Rivers'* Warm Temperate Rainforest on the Murrah and Brogo Rivers, rainforest of the lowland floodplains was probably once widespread in southern New South Wales. Though detailed and targeted studies have not been conducted for all of the lowland floodplains of rivers in southern New South Wales, it seems highly likely that areas of rainforest were also lost from the Wallagaraugh north to the Murrah River (Warm Temperate and Gallery Rainforests), while north of the Tuross River to the Clyde River (Subtropical, Warm Temperate and Gallery Rainforests) are the candidates.

*Timber harvesting*
Prior to the development of specific ***prescriptions*** for the protection of rainforest in timber harvesting areas (e.g. *DSE* 2004c; DSE 2007a), many rainforest stands and their ***ecotones*** as well as areas of ***Cool Temperate Mixed Forest*** were lost to timber harvesting (Peel 1999). The aerial extent and number of stands lost to this form of land management has certainly decreased as a result of these prescriptions. However, there are still likely to be increased fire risks and other deleterious impacts to the remaining 'protected' rainforest stands from extensive timber harvesting that changes the old growth structure of the adjacent eucalypt forest to even-aged regrowth and the ***edge effects*** (Additional Reading: Edge effects) of logging to the boundary of currently inadequate buffers based on stand significance, rather than the presence of rainforest.

*Myrtle Wilt*
Myrtle Wilt is a fatal fungal disease of the ***canopy tree*** Myrtle Beech *Nothofagus cunninghamii,* which is the ***dominant species*** of Cool Temperate Rainforests in all rainforest regions of Victoria (i.e. Central Highlands, South Gippsland and Otways except East Gippsland where this tree is absent and Wilsons Promontory where all stands are remote from disturbance). It is most common in older trees and its spread is exacerbated by disturbance (Peel 1999). Timber harvesting in or near Myrtle Beech and road infrastructure that damage these trees allows the disease to spread and rise above natural levels. As a consequence, these activities have caused significant damage to Cool Temperate Rainforests in Victoria that are dominated by Myrtle Beech *Nothofagus cunninghamii* (Peel 1999) due to the association between forest disturbance and this fatal fungal disease (Packham *et. al*. 1992; Cameron and Turner 1996). The threat is so great, and the link to human disturbance elevating the disease to epidemic levels in these forests so strong, that disturbance forms one of the major threats to Cool Temperate Rainforest. So vulnerable are these Cool Temperate Rainforests to this disease, that they are listed under Victoria's *Flora and Fauna Guarantee (FFG) Act* (1988) as is Myrtle Wilt which is listed under the same Act as the ***Potentially Threatening Process*** "Human activity which results in artificially elevated or epidemic levels of Myrtle Wilt within Nothofagus-dominated Cool Temperate Rainforest" (Appendix S1: worksheet: Threatening processes).

*Burning and paddock rainforest starters*
Frequent and/or intense wildfire is a significant threat to rainforests. In the forested landscape, the major threat from fire arises from wildfires that may increase in frequency as a result of human activity such as accidental or intentional ignition and climate change. An additional, but less obvious, threat is from fuel reduction burning, which uses the moisture differentials associated with rainforest ecotones and the rainforests themselves. Frequent burning of the ecotone simplifies its structure and composition and removes rainforest secondary and ecotone species: reducing stand ***diversity***, integrity and extent. The removal of these secondary species has a very profound impact on the resilience of the adjacent rainforest stand to wildfire, because these ***secondary species*** that dominate the ecotone often have low volatile oil contents and other adaptive mechanisms to slow fire, thereby protecting the nearby rainforests. This is seen in the long ignition times or low potential for ignition of their foliage (Additional Reading: Ignition times). Such species include: Blackwood *Acacia melanoxylon*, Blanket-leaf *Bedfordia arborescens*, Southern Brush Kurrajong *Commersonia rossii* and Hazel Pomaderris *P. aspera* to name a few that have been tested. These modified ecotones are then less able to protect the rainforest in the event of a wildfire event. Over time such burning can encroach on the rainforest itself.

Similar results occur when the margins of remnant rainforests in agricultural areas are repeatedly burnt. The ecotones shrink and the self-repairing ecotone and margin of the remnant rainforest stand retreats in the face of the recurrent burning. The process of burning to maintain green-pick for domestic stock in cleared rainforest habitat will kill paddock rainforest starter species and prevent rainforest regeneration for as long as the practice is maintained (Additional Reading: Mistletoes and rainforest regeneration: vital in fragmented landscapes).

*Weed invasion*
Weeds are insidious in their action on rainforests. Often they infiltrate otherwise healthy rainforest stands, gain a toe-hold and take over. Weeds degrade and destroy rainforests in one or a number of ways: they occupy the ***niches*** or sites that rainforest species would occupy; they prevent regeneration or they kill adult rainforest plants outright because they are ***water-hogging weeds***. This threat is still very much active and expanding in south-eastern Australia and the number of weeds that affect rainforests increase each year (Appendix S3: Weed ecology and management priorities). With global warming, species that are currently held in check by your current ***climate***, will over time extend or change their range and come to a rainforest near you (Appendix S3: worksheet: Climate change alert weeds).

Not all ***exotic species*** threaten rainforest (indeed some may actually either be of neutral consequence or marginally beneficial); the trick is to know which ones are the greatest threat and therefore should command your limited budget

and attention. You will come to know that transforming weeds are the most serious. Transforming weeds have arisen from a surprisingly wide range of sources including: horticultural (e.g. Lantana *Lantana camara*, Wandering Jew **Tradescantia fluminensis*), herbalism (e.g. Madeira Vine **Anredera cordifolia*), agricultural (Kikuyu **Pennesetum clandestinum*), mining and erosion control (e.g. Bitou **Chrysanthemoides monilifera* ***ssp.*** *rotundata*) and river management (willows *Salix* ***spp.***). New weeds emerge every year: Common Pampas Grass **Cortaderia sellonica* from 1970s gardens and Agapanthus **Agapanthus praecox*: the latest trend-setting 'architectural and water-wise plant' option for the ecologically ignorant.

*Deer*

The threat that deer pose to rainforest has only slowly been dawning on land managers in south-eastern Australia. A study put together to nominate deer as a threatening process under the *Flora and Fauna Guarantee Act 1988* (Peel *et al*. 2005) lists some of the early findings for the region. The major impacts (by Sambar) are currently seen on the lowland rainforests of the region (Warm Temperate, Gallery and Littoral Rainforests). Littoral Rainforests in Victoria are also being affected by Hog Deer. In a study of New South Wales pest species, the Invasive Animals Cooperative Research Centre (2007) lists more than 350 threatened species at risk from ***pest animals***, which is only marginally behind the number threatened by weeds (others are at risk from both groups combined). They note nine threatened species at risk from deer in the Southern Rivers Catchment Management Authority region and found that the number threatened did not appear to be related to animal density (a finding with which we would concur). A more recent analysis of the conservation status of a portion the Victorian Rainforest flora by David Cameron (DSE) and the author (Appendix S1: Worksheets: IUCN Flora determination status) shows that 50 of the 134 taxa assessed (or 37%) are impacted by a single deer species: Sambar. The major impacts of deer on biodiversity are related to their trampling (rutting in particular), grazing/browsing pressure, destruction of habitats through accelerated erosion, ***dispersal*** of weed species (SAC 2007) and antler rubbing of trees and shrubs.

One of the major looming threats for the Cool Temperate Rainforests of the region is the damage wrought on them by deer. Significant damage to specific rainforests at specific sites has already been documented, but the landscape scale extent and intensity of damage is yet to be fully realised. This is because the full ecological potential of deer to occupy niches across the landscape in our region is yet to occur with undamaged examples of rainforest becoming rarer all the time (Figure S2). Given this seemingly early stage of colonisation, it is very worrying to see the level of impact from deer in Cool Temperate Rainforests that is also already apparent. Figures S3, S4 and S5 illustrate some early impacts, and on this site (based on distribution), there are at least four species of deer that could be causing this impact: Rusa, Fallow, Red and/or Sambar. The feeding ***ecology*** of these deer varies, but experience in rainforests elsewhere in New South Wales suggests Sambar or Rusa are likely candidates for the damage shown in Figures S3, S4 and S5.

To date the impact is more concentrated in the rainforest than it is in the surrounding eucalypt dominated Wet Forest (as is the case for other rainforest types elsewhere in south-eastern Australia). Sambar are noted to have had significant impacts on Cool Temperate Rainforests in the Central Highlands, where they consume regeneration and through their habit of knocking down tree-ferns for forage (SAC 2007). In this rainforest ecological vegetation class, they are also a threat to some species such as the *Environment Protection and Biodiversity Conservation Act (EPBC Act)* and FFG-*Act* listed: Shiny Nematolepis *N. wilsoni* (Murphy *et. al*. 2006; ***personal observation***).

Sites inspected to date in East Gippsland that do not yet show the impacts of deer include: the Errinundra Rainforest Walk in the Errinundra National Park and Betts Creek in the Snowy River National Park. An inspection at Murrungowar showed that significant deer impacts in rainforests are present near to Cool Temperate Rainforest at this site. The suspected impacts of deer on Cool Temperate Rainforests observed by the author in southern New South Wales at localities such as Clyde Mountain near to Batemans Bay that are known to carry Sambar (Mason 2006) are very concerning. This is one reason for including Cool Temperate Rainforests in the Manual (climate change is the other). Restoration is likely to be necessary in Cool Temperate Rainforests before these pests are effectively managed and brought under control at a landscape scale because the political and management response (has to date) been woefully inadequate.

*Goats*

Feral goats are present in Victoria, sometimes as the result of domestic herds that have escaped where they are often used to control large Blackberry **Rubus anglocandicans* infestations. Severe damage from feral goats has been done to Dry Rainforests in the Mitchell River National Park (in the recent past) and perhaps elsewhere in New South Wales to other rainforest types.

COOL TEMPERATE RAINFORESTS UNDER THREAT FROM DEER

Figure S2. All sites are at Poo's Corner, Clyde Mountain Kings Highway west of Batemans Bay. Here un-browsed Eastern Leatherwood *Eucryphia moorei* foliage reaches down to knee height (***c.f.*** with Figure S3) beside the busy highway. Browsing is restricted here due to difficult access, human traffic and high visitor use.

Figure S3. Deer-browsed Eastern Leatherwood *Eucryphia moorei* suckers up to 2m high within the stand above Poo's Corner in the steep gully just metres away from Figure S2. These suckers become new crown units when the tree's mature crown is lost. Without them, it will not survive in the long term.

THE SIGNS OF DEER IMPACT ARE THERE: YOU JUST HAVE TO KNOW WHAT TO LOOK FOR

Figure S4. Damage from browsing of tree-ferns is typical of deer impacts elsewhere in south-eastern Australia. Although this damage is low enough to have been caused by Swamp Wallabies *Wallabia bicolor*, it provides circumstantial evidence of deer when viewed in concert with the other deer damage in this Cool Temperate Rainforest stand.

Figure S5. Sassafras *Doryphora sassafras* basal coppice is severely browsed by deer a vital regeneration path when the crown is damaged. Without it, individual trees are killed.

*Climate change and global warming*

With the projected and actual impacts of global warming becoming clearer in south-eastern Australia, it is apparent that all of the rainforest ecological vegetation classes of the region will be significantly affected in the coming decades. The problem for rainforests does not lie in the magnitude of the change (all life has had to deal with this in the past), but instead it is the rate of change (Lindenmayer and Burgman 2005). Depending on the relative impacts of climatic change (the elements comprising the change and whether or not they are linked): one or a combination of the following elements will impact a rainforest stand near you: rising sea levels, increased rainfall variability and rising temperatures (especially in spring) (DSE 2004a), increased storm events and as a result: increased coastal inundation and coastal erosion (Victorian Coastal Council 2007). Changing rainfall patterns increased temperatures and increased evaporation are changing wildfire frequency, intensity and extent. These together are causing the fire season to be extended as well and *mega-fires* are emerging as a major threat to rainforests across south-eastern Australia. Climate change is with us, and it is clear that the region's rainforests are entering a whole new phase of their evolution. These threats and the management considerations needed to deal with them individually are explored in Chapter 4 Climate change: multiple threats, magnitudes and synergies. Given the complexity of the issues involved (even at the EVC level), we have produced ***climate change bump-along-tables*** to help conceptualise these impacts. For south-eastern Australia – based on DSE (2004a); CSIRO (2007) –, these impacts are likely to include:

- More variable rainfall and increased intensity and duration of droughts: rainfall could be higher or lower on average or just plain variable (all types may be affected), while droughts are likely to be more frequent, more severe and longer lasting (Figure 4.13)
- Rising temperatures, shifting climatic envelopes (Cool and Warm temperate and Subtropical Rainforests with shifting zones)
- Extreme temperature events (whereby populations and species are put at risk)
- The forecast rapidity of changes may overrun the ability or capacity for the migration of species/floristic communities and/or ecological vegetation classes to suitable habitat in time to avoid potentially lethal changes to sea levels, increased erosion rates along the coast, increased temperatures, changes to fire regimes and frost regimes (all types of rainforest) given the patchy and isolated nature of rainforest stands in south-eastern Australia and the relatively slow rate of recruitment by plants from neighbouring stands
- The loss of the cool temperate *climate envelope* in some areas (Cool Temperate Rainforest)
- Increased frequency and intensity of wildfires may cause the loss of individual stands or complete suites of stands of some types (Subtropical, Warm Temperate, Cool Temperate Gallery and Littoral Rainforests)
- Rising sea levels (7-55cm by 2100): accelerated coastal erosion of dunes, sea cliffs; the re-activation of marginal bluff habitats (Subtropical, Warm Temperate and Littoral Rainforests on river flats)
- Increased frequency and severity of storm systems that leads to major coastal erosion events, storm surges and saline inundation (Subtropical and Warm Temperate Rainforests on river flats and Littoral Rainforest)
- *Rainforest-dependent species* potentially face a reduction or complete loss of habitat: e.g. Sooty Owl from 972,000km$^2$ of habitat currently to 30,400 km$^2$ under the worst case scenario; Giant Gippsland Earth Worm 4,300 km$^2$ currently down to 0 km$^2$ [after Brereton *et. al*. 1995 cited in Lindenmayer and Burgman 2005).

Rainforest types covered by the Manual

Although there are broad guiding principles in ***rainforest restoration*** techniques across rainforest types (only plant when soil moisture is adequate, etc.), there are particular species combinations, techniques and considerations that are specific to each type. It is important to know what type or types of rainforest are present, or used to be present, on your restoration site in order to understand their specific restoration requirements and the species of plants to return to the site. Without such knowledge, and close adherence to the relevant species lists, you would not be conserving rainforest, you would just be gardening (to put it bluntly).

Each rainforest type has its own special habitat requirements and peculiarities. It is this reality that requires that you, the rainforest restorer, to understand the basic differences between the major types recognised nationally, which are called Ecological Vegetation Classes (EVCs) and their regional sub-types: Floristic Communities (FCs) (see Definitions and synonymy: Differential rainforest definitions for south-eastern Australia).

The rainforest descriptions that follow are derived from Peel (1999), Beukers and Miles (in prep.) and Tindall *et al*. (undated). A brief description of each is provided below. If you wish to know more about these rainforest types (than is briefly provided below); consult Peel (1999) for Victorian Warm Temperate Rainforest, Gallery Rainforest and Dry Rainforest descriptions. The Littoral Rainforests of south-eastern Australia are described here for the first time. For full descriptions of the currently described rainforest ecological vegetation classes for New South Wales (Subtropical-

Warm Temperate Rainforest, Warm Temperate Rainforest, Dry Gully Rainforest, Gallery Rainforest and Dry Rainforest) consult Beukers and Miles (in prep.) and Tindall et al. (undated).

### Rainforest types restricted to New South Wales

*Subtropical Rainforest* (*sensu* Floyd 1990) *Subtropical Warm Temperate Rainforest* (*sensu* Beukers and Miles in prep.)

Climate: Based on Moruya (in the subtropics) the average maximum is 20.4°C with the average minimum 11.3°C. Rainfall is 957mm and has a summer maximum. The east coast ***subtropical climate zone*** (Moruya Heads: Bureau of Meteorology 2003b) has a wetter summer and a drier winter (winter rainfall is 50% of that in summer but still more than 30mm in any one month c.f. to the ***warm temperate climate zone*** south of Bunga Head. Seasons are less distinct (average maximum temperature range of 7°C), with milder drier winters (with only 3.3 days <2°C), milder summers (on average only 6.5 days over 30°C) that are wetter with a more humid summer-autumn.

Habitat: Warm coastal and lowland slopes (west and east aspect) or ridges with a high degree of topographic or vegetation protection from fire and also in topographically fire sheltered localities (north- or east-facing gullies). All sites have fertile geologies: rhyolite (Tanja), dolerite at Goalen Head, monzonite-derived soils on Gulaga (Mount Dromedary), basalts at Durras Mountain, and the alluvial flats derived from these geologies. Coast and Hinterland Wet Fern Forest [Map Unit 33 *sensu* Beukers and Miles (in prep.)] or Bega Dry Grass Forest provide vegetation-based fire protection ensuring either infrequent (the former) or moderate to low intensity fires (the latter).

Appearance: Usually a two-tiered tree canopy appearing 'lumpy' and composed of scattered emergents over a dense low canopy (to around 15m). Leaf sizes are large: ***notophyll*** to ***mesophyll*** (7.5-12.5 to >12.5cm). The understorey is rich in ***ferns*** (with an average of eight species and up to 19). In the old and protected sites there are three ***epiphytes*** but as many as nine. Some of these epiphytes (ferns) may be large.

Dominant species: Emergents include: Giant Stinging Tree *Dendrochnide excelsa*, Small-leaved Fig *Ficus obliqua* and Rusty Fig *F. rubiginosa*. Canopy trees that are usual in this rainforest include: Wild Quince *Alectryon subcinereus*, Brush Bloodwood *Baloghia inophylla*, Sassafras *Doryphora sassafras*, Koda *Ehretia acuminata*, Sandpaper Fig *Ficus coronata,* Muttonwood *Myrsine howittiana* and Lilly Pilly *Syzygium smithii*. On wetter sites, palms are usual: Bangalow Palm *Archontophoenix cunninghamiana* (north of Durras Lake) while Cabbage Fan Palm *Livistona australis* is more widespread. Understorey trees and shrubs such as Hairy Psychotria *Chelicanthes loniceriodes*, Brittlewood *Claoxylon australe*, Bolwarra *Eupomatia laurina*, Scentless Rosewood *Synoum glandulosum* and Bleeding Heart *Omolanthus populifolius* are sparse unless on margins or in regenerating gaps or areas (see Opener). The canopy is often festooned with large woody vines such as Gum Vine *Aphanopetalum resinosum*, Kangaroo Vine *Cissus antarctica*, ***Jungle*** Grape *C. hypoglauca*, the massive Giant Wonga Vine *Pandorea* sp. (Ipswich) and White Milk-vine *Marsdenia rostrata*. Large epiphytes such as Elkhorn Fern *Platycerium bifurcatum* and Birds Nest Fern *Asplenium australasicum* grow on rocks and tree-trunks (if not poached); tree-ferns in this region are rare.

Places to see it: Known from handful of localities: Hidden Valley between Bunga Head and Goalen Head Fig Valley at Goalen Head (where largely cleared), the foot slopes of Gulaga (Mt. Dromedary) and Nachanuka (Little Dromedary) (Figure S6) both near Tilba Tilba (Figures S7, S8, and S9); and regenerating on a former farm along the summit ridge of Durras Mountain north of Pebbly Beach.

| LANDSCAPE CONTEXT AND CLEARED HABITAT | |
|---|---|
|  |  |
| Figure S6. Nachinuka (Little Dromedary), New South Wales. Subtropical Rainforest ***landscape context***. | Figure S7. Tilba Tilba, New South Wales. Subtropical Rainforest cleared habitat. |

Figure S8. Gulaga National Park, New South Wales. A small Subtropical Rainforest stand in a south-east facing gully. Note the 'lumpy' canopy with: emergent subtropical species pictured that include: Giant Stinging Tree *Dendrochnide excelsa* (green arrow) and Cabbage Fan-palm *Livistona australis* (red arrow). Dominant Canopy species in this stand are: Maidens Wattle *A. maidenii*, Sandpaper Fig *Ficus coronata*, Sassafras *Doryphora sassafras* and Koda *Ehretia acuminata* and Lilly Pilly *Syzygium smithii*.

Figure S9. Nachanuka, New South Wales. Buttressing and epiphytes are classic features of Subtropical Rainforest as illustrated here. The massive tree with spur buttressing in the foreground is Small-leaved Fig *Ficus obliqua* (one of the species that produce the classical emergent broad-spreading crowns of this rainforest EVC: Chapter S2: Figure S50) with Climbing Fishbone Fern *Arthropteris tenella* the epiphyte growing up the right hand buttress of the fig and the trunk in the background. The fluted buttress in the background belongs to the Giant Stinging Tree *Dendrochnide excelsa,* which is indicative of a canopy gap, some time in the long-distant past.

*Dry Gully Rainforest (rainforest of dry gullies)*

Habitat: Gullies (often, but not always, in deeply dissected terrain) at low elevations from sea level to 600m on moderate fertility soils derived mostly from Ordovician metasediments. Rainfall ranges from 750 to 1200mm annually. Stands can occur in exposed aspect gullies (unusually for rainforest) where there is a lesser degree of topographic protection than is the case for other rainforests of south-eastern Australia. However, this is compensated for by the deep dissection of the gully-systems in which it grows and/or the adjacent vegetation's low fuel loads (Cameron ***pers. comm.***). It also occurs on this geology in more gentle terrain, in south-, east- or north-facing gully systems (Figure S10), which, for the north aspect, requires fire protection from grassy woodlands adjacent to the stands (Figure S11). This rainforest type occurs north from Bega.

Appearance: Usually a dense low canopy (around 15m) with emergents (eucalypts). The understorey shrub layer is sparse, with ferns being the dominant though patchy ground layer. Vines are not as prominent as in other rainforest types of the region. Typically for drier rainforest types: tree-ferns are rare (confined to moist niches).

Dominant species: The usual emergent tree species are Coast Grey Box *Eucalyptus bosistoana* and Woolybut *E. longifolia* on the margins and Mountain Grey Gum *E. cypellocarpa* on the gully floor or nearby sheltered aspect slopes. Further north in the Clyde River valley the adjacent slope eucalypts include: Spotted Gum *Corymbia maculata*. The dominant canopy tree is Grey Myrtle *Backhousia myrtifolia* with Sweet Pittosporum *P. undulatum* also usually present. Sandpaper Fig *Ficus coronata,* Muttonwood *Myrsine howittiana* and Lilly Pilly *Syzygium smithii* are less common, but usually represented in most stands. Understorey trees and shrubs are sparse but may include Hairy Psychotria *Chelicanthes loniceriodes*, Coffee Bush *Breynia oblongifolia*, Large Mock-olive *Notelaea venosa*, Rough-fruit Pittosporum *P. revolutum*, Tree Violet *Melicytus dentatus s. l.* or Orange-thorn *Pittosporum pauciflorus*. Ground layer ferns are sparse and drought-tolerant and include: Necklace Fern *Asplenium flabellifolium,* Rasp Fern *Doodia aspera*, Sickle Fern *Pellaea falcata* and shield-ferns *Lastreopsis* spp. There are also a range of drought-tolerant ***graminoids*** regularly encountered: *Gahnia aspera*, Variable Sword-sedge *Lepidosperma laterale*, Tailed Rapier-sedge *L. urophorum*, and Spiny-headed Mat-rush *Lomandra longifolia*. Vines are less prominent in this rainforest type but include: Gum Vine *Aphanopetalum resinosum*, Jungle Grape *Cissus hypoglauca*, White Milk-vine *Marsdenia rostrata,* Jasmine Morinda *Morinda jasminoides*, Wonga Vine *Pandorea pandorana* s.s*,* and Common Silkpod *Parsonsia straminea*; the smaller wiry species: Austral Sarsaparilla *Smilax australis*, Wombat Berry *Eustrephus latifolius* and Scrambling Lily *Geitonoplesium cymosum*. Small epiphytes are sparsely distributed on rocks and tree-trunks (particularly Grey Myrtle) with ferns such as Rock Felt-fern *Pyrrosia rupestris*, Filmy-fern *Hymenophyllum cupressiforme* and orchids such as *Dockrilla* spp., Tangle Orchid *Plectorrhiza tridentata* and *Sarcochilus* spp. usually present.

Places to see it: Coolagolite (Figure S10), Myrtle Gully Araleun-Moruya (Figure S11), Runnyford-Nelligen Road between Runnyford and Nelligen (Figure S12), Boggy Creek off Head of Cuttagee Road in Biamanga National Park (Figure S13). Although not described as such from Victoria (where the species composition is different), the ecological equivalent is probably *Ephemeral Streams* Gallery Rainforest (*sensu* Peel 1999) which is dominated by Kanooka *Tristaniopsis laurina* (David Cameron pers. comm.).

LANDSCAPE CONTEXT AND CLEARED HABITAT

Figure S10. Coolagolite, New South Wales. Dry Gully Rainforest landscape context.

Figure S11. Myrtle Gully, Araleun-Moruya Road. Dry Gully Rainforest and cleared habitat.

Figure S12. Runnyford-Nelligen Road, New South Wales. Dry Gully Rainforest stand showing the emergent Spotted Gums *Corymbia maculata*, common in the Clyde River Valley.

Figure S13. Boggy Creek Biamanga National Park, New South Wales. Understorey of Dry Gully Rainforest. Note the dominance of Grey Myrtle *Backhousia myrtifolia* in the canopy and the sparsity of ground-ferns, (which with the exception of drought-hardy colonial species such as Prickly Rasp-fern *Doodia aspera*) is typical of this rainforest type. The very old sunlit Grey Myrtle (Background Right) illustrates fluted buttressing.

*Unquadratted floristic community: Sand Rivers Warm Temperate (on sandy alluvial terraces)*

Habitat: This type has only recently been discovered and is so rare that it has yet to be added to the New South Wales vegetation typology. It occupies alluvial terraces of sand rivers in southern New South Wales at low elevations from near sea level. Currently known from small areas on the Murrah and Brogo Rivers, but was probably quite extensive on the cleared sections of the Murrah, Brogo and Bega River their larger tributaries and further north.

Appearance: Usually a dense low canopy (around 15m) with emergents (various eucalypts and River Oak *Casuarina cunninghamiana*). Beneath the canopy the understorey shrub layer is sparse, with ferns the dominant but patchy cover. Light-dependent fern species dominate the ***rainforest gaps***. Vines are not as prominent as in other rainforest types in the region, perhaps because of the frequency of flooding.

Dominant species: The emergent overstorey includes Blackwood *Acacia melanoxylon*, River Oak *Casuarina cunninghamiana* and/or: Southern Mahogany *Eucalyptus botryoides*, Mountain Grey Gum *E. cypellocarpa*, River Peppermint *E. elata* and Manna Gum *E. viminalis*. Black Wattle *A. mearnsii* and White Sallow Wattle *A. floribunda* are present in rainforest gaps that develop following flooding or fire. The canopy is low and dominated by Sandpaper Fig *Ficus coronata*, Koda *Ehretia acuminata* and Muttonwood *Myrsine howittiana,* with Kanooka *Tristaniopsis laurina* less common (restricted to the stream margin) where this community borders Gallery Rainforest (e.g. Murrah River and Brogo Gorge). It is notable that there is an absence of other Warm Temperate Rainforest canopy species that are abundant in the rainforest gullies that abut these alluvial terraces and these include: Yellowwood *Acronychia oblongifolia*, Sassafras *Doryphora sassafras*, Cabbage Tree Palm *Livistona australis*, Sweet Pittosporum *P. undulatum,* Scentless Rosewood *Synoum glandulosum* and Lilly Pilly *Syzygium smithii*. Understorey trees and shrubs are sparse but include: Tree Violet *Melicytus dentatus s. l.*, Rough-fruit Pittosporum *Pittosporum revolutum*, Hazel Pomaderris *P. aspera* and Poison Peach *Trema aspera*. **Herbs** such as Spiny-headed Mat-rush *Lomandra longifolia*, Weeping Grass *Microlaena stipoides*, Australian Basket Grass *Oplismenus hirtellus* and Basket Grass *O. aemulus*, Sword Tussock-grass *Poa ensiformis*, White-root Pratia *Lobelia purpuresens*, Indian Weed *Sigesbeckia orientalis*, Forest Starwort *Stellaria flaccida* and Scrub Nettle *Urtica incisa* are abundant. Tree-ferns are absent (in contrast to adjacent Warm Temperate Rainforest gullies). However, ground-ferns are diverse and moisture-dependent and include: Austral Lady-fern *Diplazium australe*, Lacy Ground-fern *Dennstaedtia davallioides*, Downy Ground-fern *Hypolepis glandulifera*, Harsh Ground-fern *Hypolepis muelleri* and Shiny Shield-fern *Lastreopsis acuminata*. The drought-tolerant species include: Common Ground-fern *Calochlaena dubia*, Sickle-fern *Pellaea falcata*, Bracken *Pteridium esculentum* and these are more prominent in brighter gaps. Vines are relatively diverse though generally not visually dominant and include: Jungle Grape *Cissus hypoglauca*, Forest Clematis *C. glycinoides*, White Milk Vine *Marsdenia rostrata*, Jasmine Morinda *M. jasminoides*, Queensland Bramble *Rubus moluccanus*, Austral Sarsaparilla *Smilax australis* and Snake Vine *Stephania japonica*. Epiphytic fern species include: Kangaroo Fern *Microsorum scandens* and Rock Felt-tern *Pyrrosia rupestris*.

Places to see it: Former habitat: Bega River (Figures S14, S15). Extant example: the Murrah River upstream of Benny Gowings Rd. bridge (Figures S16, S17). Glossary: opener.

LANDSCAPE CONTEXT AND CLEARED HABITAT

Figure S14. Bega River, Bega New South Wales. Landscape context: the willow zone on the banks.

Figure S15. Bega River Bega, New South Wales. Cleared rainforest and degraded habitat, once estuarine: now freshwater (when its there)!

Figure S16. Murrah River, upstream of Benny Gowings Rd bridge New South Wales. Stuart Cameron is standing in front of a ***gap*** in *Sand Rivers* Warm Temperate Rainforest dominated by White Sallow Wattle *A. floribunda* that is partly obscuring the mature rainforest on either side (upstream and downstream). Here it is dominated by Koda *Ehretia acuminata*, Sandpaper Fig *Ficus coronata* and Muttonwood *Myrsine howittiana*.

Figure S17. Murrah River, upstream of Benny Gowings Rd bridge New South Wales. Understorey of *Sand Rivers* Warm Temperate Rainforest, note the ***abundance*** of moisture-dependent ground-ferns and the absence of tree ferns that is typical of this rainforest type with the emergent River Oak *Casuarina cunninghamiana*. See also Figure 8.7) and Glossary opener.

*Unquadratted floristic community: "Grassy" Dry Rainforest (from the Bega and Brogo Valleys)*

Habitat: This Dry Rainforest type is found along the eastern margin of the Bega Valley where the Warm Temperate Rainforests stands of the steep metamorphosed escarpment spill out into broader shallower gullies of rolling granitic hills in the valley. Fire protection was primarily provided by the grassy ecosystems of the surrounding hills, including Brogo Wet Vine Forest and Bega Dry Grass Forest. Known localities include the gullies along steeper gully systems associated with the more pronounced granitic hills around the Brogo-Warragul Range area north west of Bega and the steeper hills (e.g. McLeod's Hill north east of Warragul Range Road) located between Quaama and the Brogo River on the Princes Highway.

Appearance: The rainforest has an uneven canopy with a variety of canopy species. Rainforest gaps are grassy. As far as is known, Rusty Figs are not the dominant species, but may have once been present on associated granite tors or as stranglers figs that began life in the dead spouts or the crook of branches in large old eucalypts. The most striking feature of those remnants examined is the grassy and herbaceous understorey.

Dominant species: Only three sites are known at the present (all being on private land) and, to date, only one has been sampled. The following species list is based on that site only. The exact composition of this Dry Rainforest type is yet to be determined. Emergents are Kurrajong *Brachychiton populneus* and would probably have also have included: Rough-barked Apple *Angophora floribunda*, Blue Box *Eucalyptus baueriana*, Forest Red Gum *E. tereticornis* on the margins and Rusty Fig *Ficus rubiginosa*. Rusty Fig may establish on the ground or rock outcrops as well as in the older eucalypts. It establishes on emergent trees internally (in hollows) of gum-barked species (e.g. Forest Red Gum), but externally as a strangler on rough-barked species such as Blue Box and Rough-barked Apple. The canopy is dominated by: Wild Quince *Alectryon subcinerus*, Sassafras *Doryphora sassafras*, Koda *Ehretia acuminata*, Sandpaper Fig *Ficus coronata* and Muttonwood *Myrsine howittiana*. After disturbance, the gaps are occupied by Lightwood *Acacia implexa*, Black Wattle *A. mearnsii*, Maidens Wattle *A. maidenii*, Three-nerved Cassinia *C. trinerva*, Hazel Pomaderris *P. aspera,* Kangaroo Apple *Solanum aviculare* and Poison Peach *Trema aspera*. The usual understorey shrubs are Coffee Bush *Breynia oblongifolia*, Tree Violet *Melicytus dentatus s. l.* Vines are not all that common (perhaps because of stock grazing): Forest Clematis *C. glycinoides*, Wombat Berry *Eustrephus latifolius*, Scrambling Lily *Geitonoplesium cymosum*, Twining Glycine *G. clandestina*, White Milkvine *Marsdenia* □*alcate*□, Wonga Vine *Pandorea pandorana* s.s., Small-leaved Bramble *Rubus parvifolius*, Star Cucumber *Sicyos australis*, Snake Vine *Stephania japonica* and Bearded Tylophora *T. barbata.* Forbs may be present such as: Bidgee-widgee *Acaena novaezelandiea*, Scurvy Weed *Commelina diffusa*, Kidney Weed *Dichondra repens*, Northern Cranesbill *Geranium homeanum*, Stinking Pennywort *Hydrocotyle laxiflora*, Slender Pennywort *H. tripartita*, Slender Dock *Rumex brownii*, Fireweed Groundsel *Senecio linearifolius*, Indianweed *Sigesbeckia orientalis*, Forest Starwort *Stellaria flaccida* and Scrub Nettle *Urtica incisa*. Graminoids are visually abundant and these are the species observed to date: Bergalia Tussock *Carex longebrachiata*, *Cyperus imbecillus*, Common Hedge-hog Grass *Echinopogon ovatus*, Margined Panic *Entolasia marginata*, Blady Grass *Imperata cylindrica*, Weeping Grass *Microlaena stipoides*, Australian Basket Grass *Oplismenus hirtellus*, Tall Mountain-tussock *Poa helmsii*, Common Tussock-grass *Poa labillardierii.* Ferns are not dominant and those that are recorded are all drought-tolerant: Necklace Fern *Asplenium flabellifolium*, Rasp Fern *Doodia aspera*, Sickle Fern *Pellaea falcata* and Tender Brake *Pteris tremula*.

Places to see it: Only several localities are known at present, most are on private land and public access is not available (Figure S18) as well as Bush Heritage Australia's Brogo Reserve <www.bushheritage.org.au>.

Figure S18. Bega Valley, New South Wales. This habitat photo of this undescribed Dry Rainforest type has been taken from a public road. The site is private land and no access to the site is available.

*Unquadratted floristic community: Estuary Berm Littoral Rainforest (on low wave-generated beach ridges)*

Note: species in bold are postulated to have once been present, but are yet to return. These species are sourced from the nearest sand-based Littoral Rainforest quadrat (of *South Coast Sands* Littoral Rainforest at Richmond Beach).

Habitat: This type has only recently been discovered and is so rare that it has yet to be added to the New South Wales vegetation typology. It is only known as small regenerating patches on its former and very restricted habitat (*estuary berms* that form beach ridges) inside the entrance of Batemans Bay (Figures S19 and S20).

Appearance: Colonising the margins of Coastal Sheoak Swamp Forest, but gradually colonising the higher adjacent beach ridges of its former habitat that was cleared for agriculture. Canopy species present include: Brittlewood *Claoxylon australe*, Sandpaper Fig *Ficus coronata* and Mangrove Boobialla *Myoporum acuminatum*, Sweet Pittosporum *P. undulatum*. The understorey is dominated by graminoids including large tussock-forming species such as Tall Saw-sedge *Gahnia alcate*, Black-fruit Saw-sedge *Gahnia melanocarpa*, Spiny-headed Mat-rush *Lomandra longifolia*, Basket Grasses *Oplismenus* spp. and Weeping Grass *Microlaena stipoides*.

Dominant species: Emergent species would have included: Coast Banksia *B. integrifolia*, Swamp Oak *Casuarina glauca* and Forest Red Gum *Eucalyptus tereticornis*. The canopy is currently low and of low diversity, being dominated by Brittlewood *Claoxylon australe*, Sandpaper Fig *Ficus coronata,* Mangrove Boobialla *Myoporum acuminatum*, and may have included: Muttonwood *Myrsine howittiana*, Large Mock-olive *Notelaea longifolia*, Scentless Rosewood *Synoum glandulosum* and Lilly Pilly *Syzygium smithii*,. Understorey trees and shrubs are sparse but include: Coffee Bush *Breynia oblongifolia*, Hairy Psychotria *Chelicanthes loniceriodes*, Tree Violet *Melicytus dentatus* s. l., Rough-fruit Pittosporum *Pittosporum revolutum*, Kangaroo Apple *Solanum aviculare* and Poison Peach *Trema aspera*. It may once have included: Bolwarra *Eupomatia laurina*, Hops Goodenia *G. ovata*, Austral Mulberry *Hedycarya angustifolia*, Tall Everlasting *Helichrysum elatum*, Coast Beard-heath *Leucopogon parviflorus* and Bleeding Heart *Omolanthus populifolius*. Vines include: Forest Clematis *C. glycinoides*, Common Silkpod *Parsonsia straminea*, Seaberry Saltbush *Rhagodia candolleana* and Snake Vine *Stephania japonica*, but may once have included: Kangaroo Vine *Cissus antarctica*, Nodding Salt-bush *Einadia nutans*, Twining Glycine *G. clandestina*, Trailing Guinea-flower *Hibbertia dentata*, Climbing Guinea-flower *Hibbertia scandens*, Dusky Coral-pea *Kennedia rubicunda*, Jasmine Morinda *M. jasminoides*, Small-leaved Bramble *Rubus parvifolius* and Bearded Tylophora *T. barbata*. The groundlayer is dominated by graminoids that include: Short-stem Sedge *Carex breviculmis*, Knobby Club-rush *Ficinia nodosa*, Spiny-headed Mat-rush *Lomandra longifolia,* Weeping Grass *Microlaena stipoides* and Basket-grass *Oplismenus aemulus*, Australian Basket-grass *Oplismenus hirtellus* and Common Tussock-grass *Poa labillardierei*. Graminoids that may once have been present include: Paroo Lily *Dianella caerulea*. Forbs present or may have been present include: Scurvy Weed *Commelina diffusa*, Kidney Weed *Dichondra repens*, Lax Goose-foot *Einadia trigonos*, Yellow Pennywort *Hydrocotyl foveolata*, Angled Lobelia *L. anceps*, Whiteroot *Lobelia purpurescens*, Grassland Wood-sorrel *Oxalis perennans*, Cockspur Flower *Plectranthus parviflorus*, Slender Dock *Rumex brownii*, Shrubby Fireweed *Senecio minimus*, Indianweed *Sigesbeckia orientalis*, Forest Nightshade *Solanum prinophyllum*, Eastern Nightshade *Solanum pungetium*, Devil Thorn *Solanum stelligerum*, New Zealand Spinach *Tetragonia tetragonioides*, Scrub Nettle *Urtica incisa*, Trailing Speedwell *Veronica plebia* and Ivy-leaf Violet *Viola hederacea*. Ferns are depauperate with Sickle Fern *Pellaea alcate*, Bracken *Pteridium esculentum*, but could include: Necklace Fern *Asplenium flabellifolium*, Elkhorn *Platycerium bifurcatum* and Tender Brake *Pteris tremula.*

Places to see it: Calendula Nature Reserve, New South Wales (Figures S19, S20, S21 and S22) and east shore (where more intact).

LANDSCAPE CONTEXT AND CLEARED HABITAT

Figure S19. Calendula Reserve, New South Wales. Cleared berm and swale habitat.

Figure S20. Calendula Reserve, New South Wales. Cleared and fire-degraded habitat.

Figure S21. Calendula Nature Reserve, New South Wales. Regenerating, but weed invaded habitat of *Estuary Berm* Littoral Rainforest. National Parks and Wildlife Service are doing a fine job combating the weedy Sharp Rush *Juncus acutus*. That is invading the former habitat of this Littoral Rainforest floristic community. The original clearing is assumed to have been for market gardens to supply nearby Bateman's Bay. The *landforms* on which it grows are very special and consist of a series of small dunes that have developed since the last Ice Age as the result of storm events when the sandy shore is eroded and redeposited by the wave action to form a berm, the sequential arrangement of which are called beach ridges.

Figure S22. Calendula Nature Reserve, New South Wales. Regenerating understorey of *Estuary Berm* Littoral Rainforest in the margins of Swamp Oak Floodplain Forest (which was not cleared for agriculture). Note the grassy nature of the understorey and the absence of ferns: both features of Littoral Rainforests on sands. This landform (and the rainforest that is now regenerating upon are unique to this locality, and were missed by the author in a regional survey that spanned Durras New South Wales to the Gippsland Lakes in Victoria. A more intact site on the east shore of the creek was visited during the South Coast Rainforest Restoration workshops and (thankfully) has an active Landcare group under the auspices of Eurobodalla Shire looking after it.

Rainforest types found in both New South Wales and Victoria

*Cool Temperate Rainforest (of the cool wet mountains and plateaus)*

Climate: Based on the Weeaproinah station (Otways), temperatures of the ***cool temperate climate zone*** have average maximum 14.4ºC and cool winters with the average minimum being 7.8ºC. Snowfall may be an irregular event over the cooler months. Rainfall is 1932mm with a winter maximum; the driest months are Jan-Feb with a minimum of 87mm.

Habitat: ***Montane*** plateaus and higher mountain gullies (>650m elevation). Occurs in high rainfall zones where cloud cover is frequent. Most stands are restricted to steep south- or east-facing gullies and occasionally broad ridges on fertile soils in the highest rainfall areas.

Appearance: A forest of small-leaved trees moss festooned over a ferny understorey, rarely with emergent eucalypts. The understorey is dominated by ferns (with tree-ferns dominant if deer are not present), while vines are rare. Epiphytes are common and abundant, with ferns and ***non-vascular epiphytes:*** mosses and ***liverworts*** being dominant in both Victoria and New South Wales. In New South Wales, these rainforest also have epiphytic orchids.

Dominant species: This ecological vegetation class is usually dominated by one or a combination of Southern Sassafras *Atherosperma moschatum*, Black Oliveberry *Elaeocarpus holopetalus* and Myrtile Beech *Nothofagus cunninghamii*. In Victoria, other species can include Gippsland Waratah *Telopea oreades* and, after disturbance: Silver Wattle *Acacia dealbata*, Frosted Wattle *Acacia frigescens* and Blackwood *Acacia melanoxylon*. In addition to Southern Sassafras and Black Oliveberry, the New South Wales Cool Temperate Rainforest stands also have Sassafras *Doryphora sassafras* and Eastern Leatherwood *Eucryphia moorei* as co-dominant species. Some of the highest elevation stands in New South Wales are surrounded by a type of ***cloud forest*** dominated by Hill Kanooka *Tristaniopsis collina*. Blackwood and Black Wattle *Callicoma serratifolia* are the most common trees that indicate disturbance. Although vines are rare, Mountain Clematis *C. aristata* is usual as is Twining Silkpod *Parsonsia brownii* and Austral Sarsaparilla *Smilax australis* may also be present. In Victoria, the understorey may have shrubs such as Mountain Pepper *Tasmannia lanceolata* and Errinundra Pepper *Tasmannia xerophylla ssp. robusta*.

Places to see it: In New South Wales at Poo's Corner Kings Highway at Clyde Mountain (Figures S23, S24). In Victoria at Errinundra Saddle Rainforest Walk and along Coast Range Road at the Coast Range Rainforest, both of which are in the Errinundra National Park, as well as many sites in the Central Highlands and Otways in Victoria; in the Strzeleckis: Tara Bulga National Park.

COOL TEMPERATE RAINFOREST AND ASSOCIATED CLOUD FOREST

Figure S23. Poo's Corner, Kings Highway Clyde Mountain New South Wales. Cool Temperate Rainforest dominated by Sassafras *Doryphora sassafras* and Eastern Leatherwood *Eucryphia moorei*.

Figure S24. Poo's Corner, Kings Highway Clyde Mountain New South Wales. Fringing Cloud Forest dominated by Hill Kanooka *Tristaniopsis collina* surrounding the upper rocky margins of the Cool Temperate Rainforest stand pictured in the (Figure S23). The Cloud Forest extended up to the saddle at the head of the gully but was restricted to the rocky outcrops.

*Warm Temperate Rainforest (in the lowlands)*

Climate: Based on the Lakes Entrance station temperatures of the warm temperate climate zone, the average maximum is 19.1°C and the minimum is 10.3 °C. Rainfall is 711mm and evenly distributed throughout the year (though higher elsewhere). The climate south of Bunga Head and based on Lakes Entrance data shows four distinct seasons (average maximum temperature range of 8.2°C), cool humid winters (on average 6.5 days <2°C), a seasonally more even rainfall distribution with a tendency toward drier summers with more days of extreme summer temperatures (on average 14 days over 30°C).

Habitat: Lowlands below 700m in moist sheltered sites (south- or east-facing gullies) and on river flats remote from the high flood energy zones of rivers, which are occupied by Gallery Rainforest (see below). In the subtropical climate zone it occurs on cooler (southerly aspects) and less fertile geologies than Subtropical Rainforests.

Appearance: Usually has a dense canopy, often with emergent eucalypts (especially in gullies and on river flats). These species include Blue Gums *E. globulus*, Southern Mahogany *E. botryoides* and several others. The canopy is often densely festooned with large woody vines such as Jungle Grape *Cissus hypoglauca*, Forest Clematis *C. glycinoides*, Wonga Vine *Pandorea pandorana* s.s. and White Milk-vine *Marsdenia rostrata*. The understorey is usually dominated by a diverse array of ferns that include tree-ferns *Cyathea* spp. and Soft Tree-fern *Dicksonia antarctica*, ground-ferns (water-ferns *Blechnum* spp., shield-ferns *Lastreopsis* spp. and Brakes *Pteris* spp.); small herbs and grasses are also diverse but lower in cover. Sedges can be common and large, with species from the genera *Carex*, *Gahnia* and *Lepidosperma* often present. In the old and well-protected sites where fire feral deer have yet to penetrate, there may also be small epiphytes including ferns (Filmy-ferns: *Hymenophyllum*, *Microsorum* spp., *Pyrrosia* etc.) and orchids (*Sarchochilus* and *Plectorrhiza*).

Dominant species: This ecological vegetation class is usually dominated by Lilly Pilly *Syzygium smithii* and, after disturbance, Blackwood *Acacia melanoxylon*. On drier slopes, Sweet Pittosporum *P. undulatum* may be more common. Other usual species include and Blue Olive-berry *Elaeocarpus reticulatus* (more usual in the foothills) and Muttonwood *Myrsine howittiana.* Other rainforest trees are locally dominant and these include: Yellowwood *Acronychia oblongifolia* (Mitchell River National Park to Cabbage Tree Creek in Victoria); Cabbage Tree Palms *Livistona australis* (Cabbage Tree area, then in southern New South Wales) and Leatherwood *Eucryphia moorei* around the Howe Range. Occurrences of rainforest dominated by Leatherwood in southern New South Wales occur at higher elevations and are classified as Cool Temperate Rainforest (Beukers and Miles in prep.). A broader range of species become more common in southern New South Wales and these can include: Brittlewood *Claoxylon australe* and Sassafras *Doryphora sassafras*. Koda *Ehretia acuminata*, Sandpaper Fig *Ficus coronata* and Scentless Rosewood *Synoum glandulosum* become the dominant species on alluvial flats north of Bega on major sand rivers (see *Sand Rivers* Warm Temperate Rainforest previously described). The understoreys and vine flora of this widespread ecological vegetation class vary across the South East Corner and South east Coastal Plain ***Bioregions*** according to the position of the site along the ***latitudinal gradient***. The detailed floristic compositions for Warm Temperate Rainforests are compiled for Victoria in Peel (1999) and for New South Wales in Beukers and Miles (in prep.) (see Appendices).

Places to see it: This rainforest EVC used to be widespread in the lowlands (Figures S25, S26). Lonely Bay Rainforest Walk in Lake Tyers State Park (Figures S27, S28), Bemm River Scenic Reserve on the Princes Highway, Drummer Rainforest Walk on the Thurra River, Mount Drummer and Bellbird Creek on the Princes Highway just north of Eden.

LANDSCAPE CONTEXT AND CLEARED HABITAT

Figure S25. Arandene Gully, Kalimna Victoria.

Figure S26. The Mitchell River flats, Victoria.

| WARM TEMPERATE RAINFOREST | |
|---|---|
|  |  |
| Figure S27. Warm Temperate Rainforest stand at Dowell Creek Croajingalong National Park, Victoria. Canopy and rainforest gap with Jungle Grape *Cissus hypoglauca* in *Coastal Ranges Overlap* Warm Temperate Rainforest. | Figure S28. Warm Temperate Rainforest stand at Lonely Bay, Lake Tyers Victoria. Understorey of *Alluvial Terraces* Warm Temperate Rainforest. |

*Gallery Rainforest (a rainforest tunnel over a river)*

Habitat: The overriding factors governing the distribution of Gallery Rainforest in the lowlands of south-eastern Australia and remain consistent throughout its range: even in the Wet Tropics of northern Queensland. These include: the presence of a high flood energy zone along a stream and if the stream is ephemeral, it requires topographic fire protection. Perennial streams, and the humid atmosphere they generate, provide fire protection even in the absence of topographic protection from fire. In south-eastern Australia, Gallery Rainforests are restricted to the banks of swift-flowing, flood-prone rivers and streams of the lowlands below 560m. In higher rainfall areas of the region, the moderate fire protection is afforded by moist forests nearby and, on occasion's by Warm Temperate Rainforest on the floodplain. On rivers such as the Bemm, Combienbar, McKenzie, Thurra, Mueller, Wallagaraugh and the upper Clyde River's tributaries, Gallery Rainforest develops its classical canopy to form a tunnel (the "gallery") through which the river flows (Figure S29). On the Snowy, Genoa and Bega Rivers that are larger, or where their floodplain is constrained (some sections of the Bemm, Brogo and Murrah Rivers), the classic gallery-form cannot establish and the rainforest is restricted to one or both banks (Figure S30). In theses situations open water or other vegetation that includes Riparian Shrublands in Victoria and Riparian Forest of River Oak in southern New South Wales: physically separates the stands of each bank. Gallery Rainforest can also develop in drier areas in gorges that provide the necessary fire protection (e.g. Iguana Creek, Mitchell River, Boggy Creek at Nowa Nowa and the Brogo River). In these situations (often on ephemeral streams), flood intensity is concentrated by the narrowness of the gorges in which the stands occur.

Appearance: Gallery Rainforest can be variable in canopy height depending on the frequency and height of floods and frequency of fire. Long undisturbed sites have magnificent overstoreys of Kanooka compared with flood-beaten canopies on very flood-prone and gorge-constrained reaches of major rivers such as the Mitchell and Genoa rivers.

Dominant species: This ecological vegetation class is usually dominated by Kanooka (Water Gum) *Tristaniopsis laurina*. North of Bermagui, Grey Myrtle *Backhousia myrtifolia* and Sandpaper Fig *Ficus coronata* may also be present. North from, and including, the Clyde catchment: additional dominants include Black Wattle *Callicoma serratifolia* and Coachwood *Ceratopetalum apetalum*. Flood-tolerant ferns adorn the understorey, but mature tree ferns and large vines are usually absent (being regularly removed by flood events). Common ground-ferns include: Common Maidenhair *Adiantum aethiopicum*, Gristle-fern *Blechnum cartilagineum*, Fishbone Water-fern *B. nudum*, Strap Water-fern *B. patersonii* and Common Ground-fern *Calochlaena dubia*. The most abundant herbs are the large graminoids: Tasman Flax Lily *Dianella tasmanica*, Spiny-headed Mat-rush *Lomandra longifolia* and various pennyworts *Hydrocotyl* spp. Vines are not visually abundant: the most common species are wiry species such as Forest Bindweed *Calystegia marginata* and Austral Sarsaparilla *Smilax australis* that resprout after floods, while woody vines are rare for the same reason (with Jungle Grape *Cissus hypoglauca,* also called Water Vine, an exception).

Places to see it: At Bemm River, McKenzie River Rainforest Walk (Figures S29, S30) and Brodribb River (Figure S31, S32). In New South Wales: the Brogo Gorge on the Princes Highway north of Bega, the Wallagaraugh River Princes Highway, on the Clyde River in the vicinity of Brooman and downstream on its tributaries such as Drapis Creek and Monga National Park (Figures S33, S34).

CONTRASTING FORMS OF GALLERY RAINFOREST

Figure S29. Bemm River, Victoria. Gallery Rainforest without ***valley constraint***: forming the classic tunnel or gallery, after which the rainforest is named. Photo: Graeme Dear.

Figure S30. Brodribb River, Victoria Gallery Rainforest with valley constraint: higher flood energy causes the rainforest to be relegated to each bank.

Figure S31. Mackenzie River Rainforest Walk, Mackenzie River Victoria. Understorey of Gallery Rainforest on the McKenzie River upstream of the first pedestrian suspension bridge on the McKenzie River Rainforest Walk in Victoria. Note the abundance of ground-fens but the absence of vines and tree-ferns.

Figure S32. Brodribb River, upstream of Sardine Creek Road bridge Victoria. Gallery Rainforest stand on the Brodribb River immediately upstream of the Sardine Road bridge. Note its position on each bank as the result of the site being *valley-constrained* (rather than forming the tunnel or Gallery for which the EVC is named). Compare with Figure S29.

Figure S33. Sugarloaf Creek, Misty Mountain Road Monga National Park New South Wales. This log jam and the boulders both illustrate the flood energy and force of streams typical of many of those in the foothills of south-eastern Australia that carry Gallery Rainforest. This site is dominated by Coachwood *Ceratopetalum apetalum* in the less frequently disturbed margins of the stream (right) and Black Wattle *Callicoma serratifolia* downstream of the log jam (Centre). Other tree species at this site included Grey Myrtle *Backhousia myrtifolia*, Sandpaper Fig *Ficus coronata* and the shrubs Hairy Psychotria *Chelicanthes lonicerioides* and Brush Pepperbush *Tasmannia insipida* (left).

Figure S34. Sugarloaf Creek, Misty Mountain Road Monga National Park New South Wales. The ferny understorey of Gallery Rainforest (without tree-ferns) and the lack of vines are the vegetation's ***life-form*** testament to the frequency and force of floods that operate in these narrow valley-constrained foothill habitats of Gallery Rainforest. The steep valley sides, along with the perennial nature of stream both contribute to the fire-protection that allows these rainforests to establish and persist.

*Dry Rainforest (an apparent contradiction in terms)*

Habitat: Yes, the name of this rainforest is a contradiction in terms, but fire is the real foe of rainforests. Dry Rainforests generally grow on cliffs and rock scree (occasionally in ***dolines***) in rain shadow valleys where there is reliable rainfall including the Mitchell River, Genoa Rivers in Victoria, north to the Towamba, Bega and Brogo River valleys. These cliffs are often associated with river gorges, but not exclusively. Dry Rainforest also occurs in tor fields and on rocky ridges. In these habitats fire is largely excluded (or reduced in intensity by adjacent grassy ecosystems) or the low combustibility of the dominant canopy species (Additional Reading: Ignition times). This rainforest type is most unusual in that it usually occurs on north or west aspects. The other major habitat is in grassy woodlands (Bega Valley). The fire protection in this habitat is derived from the low ground fuels of the adjacent grassy ecosystems (Figure S18). Annual rainfall is as low 750mm.

Appearance: The canopy height is low (to 10m) and the canopy may on occasions be scattered or broken. There are usually emergent Kurrajongs. Eucalypts are generally absent. During severe drought, ***rain green*** canopy species (Muttonwood, Sandpaper Figs, Kurrajongs and Staff Vine) drop their leaves, but resprout after rain.

Dominant species: Kurrajong *Brachychiton populneus* is the emergent tree. In Victoria, the dominant canopy species are Muttonwood *Myrsine howittiana* and usually Sweet Pittosporum *Pittosporum undulatum*. Vines are conspicuous except where feral deer have destroyed them such as in the Mitchell River National Park. In Victoria, prickly shrubs dominate the understorey and many of the herbs are annuals or exceedingly drought tolerant (and fire retardant): briefly becoming active after rainfall before lapsing back into dormancy (Peel 1999). A broader range of species become more common in southern New South Wales and these rainforests are typically dominated by Port Jackson Fig *Ficus rubiginosa* with subsidiary species that include: Wild Quince *Alectryon subcinereus* and Kurrajong *Brachychiton populneus,* with both Snake Vine *Stephania japonica* and Rock Orchid *Dockrilla speciosum* usually prominent. In addition, Dry Rainforests in New South Wales are often associated with rocky ridges, particularly on rhyolite and in granite tor fields and grassy woodlands. A rarer Dry Rainforest habitat is that of shallow open gullies that flow down from the western escarpment of the Mumbla Range into the Bega Valley. Here the Brogo Moist Vine Forest (Map Unit 13 sensu Beukers and Miles in prep.) that used to be dominant before clearing would have in the past, afforded the fire protection. The shrub layer of the New South Wales form is sparse and includes Coffee Bush *Breynia oblongifolia,* Tree Violet *Melicytus dentatus s. l.* and the regionally rare *Deeringia amaranthoides*. Drought-tolerant ferns are usual including: Necklace Fern *Asplenium flabellifolium* Common Rasp Fern *Doodia aspera* and Sickle Fern *Pellaea falcata*. Vines entanglements in the fig canopy include: Staff Creeper *Celastrus australis,* White Milk Vine *Marsdenia rostrata,* Wonga Vine *Pandorea pandorana s.s.* along with the smaller twiners: Snake Vine*,* Star Cucumber *Sicyos australis,* Wombat Berry *Eustrephus latifolius* and Scrambling Lily *Geitonoplesium cymosum*. Grasses and forbs can be abundant (especially on deeper soils). Note the erratum in this regard in Peel (1999). Basket Grass *Oplismenus imbecillis*, Kidney Weed *Dichondra repens* and Scrub Nettle *Urtica incisa* are usual. Epiphytes are sparsely present on tree trunks and rocks: Rock Felt-fern *Pyrrosia rupestris*, Hare's-foot Fern *Davallia solida* var. *pyxidata* and Rock Orchid *Thelichiton speciosus*.

Places to see it: primarily on granitoids of the Bega Valley (Figures S35, S36); the Brogo-Warragul Range area north of Bega (Figures S37, S38) Verona, Candelo districts, Tilba district, Upper Deua River (south west of Araluen) and Clyde River Valley on granitoids. In Victoria (various geologies): Amphitheatre from Lookout Point (Mitchell River National Park), Anticline (Murrindal River) best viewed from the Pioneer Memorial on the Gelantipy Road.

LANDSCAPE CONTEXT AND CLEARED HABITAT

Figure S35. Buckajo Road, New South Wales. Landscape context of rolling hills in Grassy Woodland.

Figure S36. Buckajo Road, New South Wales. Fire protected by grassy woodland and rock outcrops.

Figure S37. Bush Heritage Trust property west of Brogo in the Bega Valley, New South Wales. Dry Rainforest dominated by Port Jackson Figs *Ficus rubiginosa* on a steep northern aspect. Such sites are protected by a combination of bare rock and/or grassy woodland ecosystems that (in general) only propagate low intensity ground fires and the fire suppressant crowns of the Rusty Figs (Additional Reading: Ignition times).

Figure S38. Bush Heritage Trust property west of Brogo in the Bega Valley, New South Wales. Understorey of Dry Rainforest, note the lack of ground-ferns (and understorey in general: another fire-reduction adaptation). Lithophytic ferns and orchids may be common where they occur on tors (but beyond the reach of Swamp Wallabies and deer).

*Littoral Rainforest (on the coast: literally)*

Habitat: Coastal landforms (dunes, sand flats, barrier islands); estuaries: ***lacustrine*** deposits such as berms, ***cheniers*** and estuary islands; riverine deltaic deposits in estuarine reaches; headlands; and marginal bluffs. The prevalence of salt (as ***connate salts*** and/or from wind, or water) is universal and fire protection is paramount. Host geologies are diverse, and these can dictate which floristic community is present on a particular site.

Appearance: in exposed positions the canopy is dense and wind-sheared and in the most exposed localities it may be no more than knee high (Additional Reading: Figure AR16). Conversely, in sheltered spots, it may resemble the uneven canopy of Warm Temperate Rainforest. Throughout its range in south-eastern Australia, Littoral Rainforests are composed of a range of the exposure-hardy and salt-tolerant rainforest species (or their ***ecotypes***) that found in ***hinterland*** rainforests as well as around 50 coastal rainforest-adapted species such as Boobialla *Myoporum* spp., Coast Banksia *B. integrifolia* and Seaberry Saltbush *Rhagodia candolleana*.

Dominant species: The only regular emergent tree in the most exposed sites is Coast Banksia *B. integrifolia*. A range of eucalypts including Coast Grey Box *E. bosistoana*, Southern Mahogany *E. botryoides*, Red Ironbark *E. tricarpa*, Woollybutt *E. longifolia* can be emergent species in localities with less coastal exposure around estuaries. The dominant canopy species vary according to the landform and climatic zone in which the stand occurs. Canopy species usually include: Sweet Pittosporum *P. undulatum* and Common Boobialla *Myoporum insulare*/Mangrove Boobialla *M. acuminatum,* while Muttonwood *Myrsine howittiana* and boobiallas are more common on sites subject to estuarine inundation. North of Tathra on rocky headlands and seacliffs, Rusty Fig *Ficus rubiginosa* can become prominent. In wetter or older (the least fire-prone sites) Lilly Pilly *Syzygium smithii* may be dominant. Southern Mahogany *Eucalyptus botryoides* is the most common and widespread eucalypt in Littoral Rainforest. The canopy is generally festooned with vines, typical of the hinterland rainforests, as well as dodder-laurels *Cassytha* spp. and coastal species such as Climbing Lignum *Muehlenbeckia australis*, Seaberry Saltbush *Rhagodia candolleana* and, in Victoria only, Bower Spinach *Tetragonia implexicoma*. The understorey is generally rich in shrub species (especially in gaps), with Coast Sallow Wattle *Acacia longifolia* ssp. *sophorae* and Sallow Wattle *A. longifolia* ssp. *longifolia*, Tall Everlasting *Helichrysum elatum* and Snowy Daisy-bush *Olearia lirata* are widespread. The ground layer in contrast to the moisture-dependent rainforests of the hinterland is dominated by graminoids and forbs instead of ferns. By far the most common and diverse coastal species occur in this group with Sandhill Sword-sedge *Lepidosperma concavum* being widespread, but Coast Sword-sedge *L. gladiatum* being restricted to Victorian stands. Other common herbs include: Scurvy Weed *Commelina diffusa*, Kidney Weed *Dichondra repens*, Hedge-hog Grass *Echinopogon ovatus*, Weeping Grass *Microlaena stipoides,* Basket Grass *Oplismenus hirtellus* and Scrub Nettle *Urtica incisa*. The ferns are universally characterised by drought tolerant species such as Necklace Fern *Asplenium flabellifolium*, Sickle Fern *Pellaea falcata*, Bracken *Pteridium esculentum* and Tender Brake *Pteris tremula*. Epiphytes are rare except in the subtropical climate zone north of Aragunnu Beach (New South Wales) where large epiphytic/lithophytic species such as Elkhorn *Platycerium bifurcatum*, Bird's-nest Fern *Asplenium australasicum* may be abundant if the stands are old and poaching has not occurred (sadly a rare situation, these days).

Places to see it: In Victoria: on marginal bluffs from Lakes Entrance (Figures S39, S40, S41, S42) to Tambo Bay, First and Second Island (Marlo Estuary), Point Hicks, Devlin's Inlet at Mallacoota; NSW: the northern shore of Saltwater Creek, Leatherjacket Bay (Figures S43, S44), Mogareeka estuary, Bithry Inlet and Aragunnu Beach.

LANDSCAPE CONTEXT AND CLEARED HABITAT

Figure S39. Kalimna, Victoria Littoral Rainforest landscape context: marginal bluff on an estuary.

Figure S40. North Arm, Lakes Entrance Victoria. Littoral Rainforest cleared habitat.

Figure S41. Jemmy's Point, Lakes Entrance Victoria. Marginal bluff stand.

Figure S42. Jemmy's Point, Victoria. Understorey of stand in Figure S41.

Figure S43. Leatherjacket Bay, New South Wales. Boulder berm stand.

Figure S44. Leatherjacket, Bay New South Wales. Understorey of Figure S43.

## What role can rainforest restoration play?

Given the grim reading on the threats to rainforest, let's look at what we can do as rainforest restorers. Given the current losses of rainforest and the threats that continue to operate on them what can be done to conserve them? Threats operate at different scales and over different time periods. The responses that we undertake to conserve rainforests must take account of these. Management of rainforests therefore ranges from: landscape responses such as: reservation of large areas (this allows for the evolution and migration of rainforests under different climate regimes); managing threats at a regional scale (for example identifying and eliminating weeds that are known to be a serious problem nearby but just entering your district); and local actions such as managing fire in the vicinity of rainforests.

Rainforest restoration aims to deal with as many of the threats that are acting on your rainforest site as you can give your time and resources. Some threats such as global warming can be anticipated, and we are still coming to terms with them (because our regional responses may be constrained by the magnitude of the problem or limited resources), while others such as habitat loss, fragmentation, weed invasion or pest animals can be managed or eliminated at the local scale, or on your restoration site. Consequently, rainforest restoration tries to repair, retain and reinstate rainforests in areas where they were once present, but are today damaged, depleted, in decline or entirely eliminated. In most cases, this is not going to involve the complete reinstatement of the original rainforest extent, so why bother at all? The answer is that given the extent of loss and the continuing threats to rainforest, rainforest restoration is an indispensable tool for the conservation of this vegetation in the region – and even small isolated restoration sites have habitat value for ***rainforest-dependent animals*** and plants (Chapter 9). Getting involved will be both rewarding and satisfying, while your efforts can be pivotal in the preservation and maintenance of our natural heritage.

## Rainforest restoration and conservation

Conservation of rainforests has and always will require a range of management responses to a series of threats at different scales. Rainforest restoration can play an important and essential part in this conservation process and the development of a Comprehensive Adequate and Representative Reserve System (*CARS*) by:

- Repairing largely functional stands to allow them to return to their normal and important function and role in the landscape: particularly for migration and refuges during climate change
- Degraded stands can be revived and play a major role in species conservation, both for species restricted to these stands and for migratory species
- Threatened rainforest species will require this habitat for their ongoing recovery, survival and evolution (the systems approach to conservation)
- Action now to conserve rare species can prevent them from slipping into threatened categories that will require larger resources to conserve or recover them
- The repair and reinstatement of rainforests in strategic parts of the landscape (rivers, lakeshores and in urban areas) is especially important for CARS and can have local, district and even regional benefits through the provision of clean water, shelter, amenity and recreation for both locals and tourists alike.

## History

*Introduction*

In Victoria, rainforests as a whole account for 0.14% of the state's vegetation and 4% of its plant biodiversity (Peel 1999). In addition, there are a significant number of animals that are partially or wholly dependent on the resources provided by the rainforests of the region. Some of these species are themselves rare or threatened. Although the figures for southern New South Wales differ in the exact detail, the quantum is similar.

In Australia, restoration of rainforests has been underway for more than 30 years and a great body of information and knowledge has been accrued in that time (see Additional Reading). Over the same period, rainforest restoration (Warm Temperate, Gallery and Littoral) has been undertaken in Victoria. At both the national and regional level, these early attempts have had startling success given the dearth of local information on the subject to date. Practitioners have relied on their own talent in applying ecological first principles to the science and art of rainforest restoration. Our knowledge has improved greatly in recent times; largely through the financial support of Federal National Heritage Trust and Victorian State Government funding. Now it's time to share!

The following text provides the history of the development of the different ***rainforest restoration methods*** and the background that underpins the rainforest Restoration Method selection key that will help you choose the right method for your site.

The first of these sources is from the Big Scrub [well it used to be Big: but less than 1% remains of the original 75 000 hectares of Subtropical Rainforest that was cleared for agriculture (Big Scrub Rainforest Landcare Group 2005)]. These people have been experimenting with different rainforest restoration techniques for the last 25 years. Kooyman (1996) has compiled the results of six trials from across the region, which was based on former Subtropical Rainforest

sites that have highly fertile basalt soils, reliable rainfall and they used advanced plants only. These have been divided into three models:

- Model 1: *Late succession planting - mixed species*. This model is for use on most of the ex-agricultural cleared rainforest sites in the Lismore-Byron Bay area
- Model 2: Early succession planting – mixed species. This model is used for sites adjacent to larger seed sources (remnants) of >200 ha
- Model 3: Pioneer plantings. This model is used for sites which are totally surrounded or largely bounded by seed sources (rainforest remnants) of >200 ha.

These models and the methods espoused in them (Kooyman 1996) do provide some very useful information, which has been liberally incorporated into this Manual. However, Kooyman's tree-based restoration models relate to a landscape, climate and site quality that is rarely encountered in south-eastern Australia. Consequently, growth rates and levels of recruitment from offsite rainforest remnants are all higher than could reasonably be expected in our region. The other problem is that unlike the south-east of Australia, a large proportion of the plant diversity of the Big Scrub comprises tree species (35–60 species is common in these Subtropical Rainforests), which in part explains the reliance by some practitioners from the Big Scrub region on models reliant on tree planting alone.

This, however, could not be further from the reality in south-eastern Australia, where the overall diversity of rainforests is lower and is more equally shared across the life-form spectrum (Peel 1999). Other site factors operating in south-eastern Australia that also mean the use of tree-only planting models do not suit the region include:

- Frosts are both more prevalent and severe in south-eastern Australia (the range of tree species available for a trees-only approach is therefore further limited to the selection of hardy *late secondary species* only) even for sites in the southern-most end of the subtropical climate zone [Bega: 68 total frost days (<2.2$^{o}$C) year$^{-1}$ and 33.9 severe frost days (<0.0$^{o}$C) year$^{-1}$ (Bureau of Meteorology undated a) c.f. Lismore: 1.5 total frost days (<2.2$^{o}$C) year$^{-1}$ and no severe frost days (<0.0$^{o}$C) year$^{-1}$ (Bureau of Meteorology undated b)]
- Reliable long-distance rainforest seed dispersal to our sites is limited because the major agent for this dispersal (fruit bats and/or fruit pigeons and figbirds), are not resident in the south-eastern Australia, but are irregular or seasonal migrants.

The concepts espoused in Kooyman's models are incorporated into the restoration methods adapted to south-eastern Australia. For example, Kooyman's Model 2 can use a range of the hardy secondary species available in the region. This equates to the standard revegetation technique widely used in riparian plantings. However, the dispersal limitation still remains: as exemplified by the technique being applied early on in areas of south-eastern Australia with much smaller remnant seed sources than Kooyman (1996) recommends (and often on sites more remote from seed sources). As a consequence, the rates of natural colonisation by rainforest plants have been very slow over the 15 years of observation (Peel unpublished 2002). If the works are within 500 m of a remnant, then natural recruitment is acceptable, with the distance for dispersal probably reaching as far as 15 km, but takes many decades to become evident. As Josephs (1999) says, don't stop thinking and adapting: good advice and we took her up on it.
As a result of a study tour undertaken by the author and Matt Kennedy (then the East Gippsland Catchment Management Authority's Biodiversity Facilitator) to investigate rainforest restoration methods across New South Wales, the techniques applied in south-eastern Australia more recently are sourced from a broader base than those suggested by Kooyman alone. A publication on the Wet Tropics (Goosem and Tucker 1995), for instance, provided more holistic models for rainforest restoration that allowed for the establishment of a broader suite of life-forms (trees, shrubs, vines, ferns, herbs, etc.). Goosem and Tucker (1995) also provided management guidelines to encourage *natural regeneration*. Three methods from Goosem and Tucker (1995) are detailed: Natural Regeneration, Framework and Maximum Diversity. These equate to the three modes of development for rainforest regeneration as enunciated by Kooyman (1999):

1. Inhibition Mode: addressing the causes for the suppression or delay of natural regenerative processes which is accommodated by the Natural Regeneration Method
2. *Relay (succession)* Mode: Stepwise development through stages of *succession* which is accommodated by the Framework Method
3. Initial Floristic Mode: Reestablishment of original floristics from the outset which is the equivalent of the Maximum Diversity Method.

A fourth technique: the Clumped Mixed Canopy Method has been locally devised to deal with a commonly recurring regional scenario not covered in other rainforest restoration techniques from elsewhere.

*First attempts and early results in south-eastern Australia*
Within the Southeast Corner Bioregion, rainforest restoration was first undertaken in East Gippsland in 1985 by a range of organisations and landholders on the lower Snowy and Brodribb Rivers including the Snowy River Improvement

Trust, the Orbost Shire, local schools and the then Department of Conservation Forests and Lands (Table S1), while to date there are several sites known from New South Wales (Table S2). The early Victorian restoration efforts were based on advice from Richard Owen. This was followed in 1987 by the Kinkuna site in East Gippsland at Lakes Entrance that was set up by the author. These early attempts were instituted on principles gleaned from natural regeneration pathways observed at reference rainforest stands on similar landforms. These methods were later realised to comprise what is now known as the ***Framework Rainforest Restoration Method***. On these sites, only some of the mature canopy species (Sweet Pittosporum *Pittosporum undulatum* and Lilly Pilly *Syzygium smithii*) were available from nurseries at the time. Plantings concentrated on appropriate eucalypts and a ***nursery crop*** of late secondary stage canopy species that included Blackwood *Acacia melanoxylon* and Common Boobialla *Myoporum insulare*. At the time, relatively few shrubs could be sourced, but some of the more commonly planted species included various Tea-trees *Leptospermum* spp., Blanket-leaf *Bedfordia arborescens*, Tree Violet *Melicytus dentatus s. l.*, Musk Daisy-bush *Olearia argophylla* and Kangaroo Apple *Solanum aviculare*.

Where these Framework Rainforest Restoration plantings were near rainforest seed sources, natural regeneration of rainforest species soon followed. The abundance and diversity of the ***natural regeneration*** was directly related to: the distance from the seed source; an absence of grazing by domestic stock; and low levels or complete absence of the transforming weeds: Cape Ivy **Delairea odorata*, Wandering Jew **Tradescantia fluminensis* and Blue Periwinkle **Vinca major* (Peel 2001 unpublished). On the lower Snowy and Brodribb Rivers, 96 species were recorded naturally regenerating across 67 revegetation sites comprising 66ha. These sites were initially maintained by mowing the Kikuyu **Pennisetum clandestinum* sward. Once canopy closure occurred, the Kikuyu sward was weakened and replaced by tufted species such as Prairie Grass **Bromus catharticus*. Weed maintenance ceased at this point. After the initial planting of Common Boobialla *Myoporum insulare* and Blackwood *Acacia melanoxylon*, which acted as 'nursery crop' species, natural regeneration only began as these matured (at 8-10 years of age). The seedling establishment took place in the inter-tussock zones between individual Prairie Grass plants. The critical features of these sites that allowed natural regeneration to occur at this time was that Kikuyu had declined, mowing had ceased, the sward had been converted into patches of leaf litter (germination sites) between the clumps of Prairie Grass and no transforming ***shade weeds*** had established. Seed arrived because birds were attracted to the fruits of Blackwood, Tree Violet and Boobialla, or because of the prodigious flowing events of ***emergent*** Southern Mahoganies *Eucalyptus botryoides*.

This compares with the more recent ***Maximum Diversity Rainforest Restoration*** sites along the same river reaches that are much younger (4 years old), where 115 species were recorded naturally regenerating across 28ha. The abundance of species naturally regenerating was also much greater on the more recent sites (using the latter treatment) because the weeds are much more closely controlled and the diversity of the plantings is much higher within the restoration site itself. The latter is important because it provides a greater array of seed sources within the site, than can be supplied with the lower diversity species mixes available for the earlier use of the Framework Restoration Method.

During a year-long bird census, Sites 13 and 14 that used the Framework Method and an originally lower diversity of species planted, the groundlayer was weed invaded and it continued to be grazed (Figure S45) (and consequently lacked natural regeneration), had fewer birds recorded (38 species) with no rainforest birds present. This is in stark contrast to Site 70b (Figure S46) which had the Maximum Diversity Method applied (opposite sites 13 and 14): it was 17 years younger but had 49 birds, 8 of which were rainforest-dependent species recorded in the same census!

One site at Lake Wat Wat of 0.64ha (10mx64m) used direct seeding. This Littoral Rainforest site was established on black sands and had three rows set 3m apart. Only three species were direct seeded: Black Wattle *Acacia mearnsii*, Blackwood *A. melanoxylon* and Southern Mahogany *Eucalyptus botryoides,* with the first and last species surviving to the current day. The plot is at the base of the ***marginal bluff*** at Lake Wat Wat and is 10m distant from the existing remnant rainforest stands (Figure S47). A survey in 2005 (15 years after sowing) showed that 30 native rainforest species had colonised the direct seeding site. This represents a 90% increase of native species (all free, and not planted); compared with diversity of the original planting. Most importantly, these new species cover all of the life-form categories. This included: three trees; three shrubs; 19 herbs; one fern and four vines. Of the native species recorded, 44% or 12 taxa were bird-dispersed and 18% or five species were wind-dispersed. Figures S48 and S49 both illustrate the extent of natural regeneration beneath the trees that began as a three-species ***direct seeding*** project. Weed control of the original Kikuyu after initial establishment, was largely achieved through the shade cast by the trees that were originally direct seeded. As importantly, no transforming shade weeds had invaded the site and grazing has been kept out The latter two issues (transforming weeds and grazing) are two of the most common ***ecological brakes*** that hold back or prevent the natural regeneration of rainforests across south-eastern Australia.

Table S1. Victorian rainforest restoration sites.

| Site name<br>Location<br>Rainforest type | Organisation and start date | Funding sources and Access | Methods used | Approx. area (ha) |
|---|---|---|---|---|
| Cullinan's Reserve Lake Bunga<br>Warm Temperate | Thought to be Vicroads started in 1985 | Public: land donated by adjacent landholder at time of Princes Highway re-alignment. | Framework Method | 2.5 |
| Kinkuna Lakes Entrance<br>Warm Temperate | Joe and Shirley Walters 1987 | Private/volunteer<br>Private: permission required | Framework Method | 1 |
| Nyerimilang Pilot Site<br>Maringa Ck Kalimna West<br>Warm Temperate/Littoral | *EGCMA*/Parks Victoria 2000<br>Success finally in 2004 | State/federal/volunteer<br>Public: advise ranger | Maximum Diversity Framework | 11 |
| Merrengbaur Gully<br>Warm Temperate | East Gippsland Shire 2005 | Shire and private<br>Public | Maximum Diversity and Framework | 1 and building |
| Lower Snowy River Pilot Sites<br>First and Second Is<br>Lake Wat Wat<br>Warm Temperate/Gallery/Littoral | East Gippsland CMA 2001<br>Parks Victoria/Moogji 2005<br>Parks Victoria 1980s | State/federal/volunteer<br>Public<br>Public | Maximum Diversity<br>Natural Regeneration<br>Natural Regeneration | 33<br>13<br>25 |
| Lower Snowy-Brodribb Rivers<br>Orbost-Marlo<br>Warm Temperate/Littoral | Snowy River Improvement Trust/Orbost Shire/EGCMA 1975-2000 | State/local<br>Public | Framework (planted)<br>Framework (direct seeding) | 66 |
| Tambo River<br>The Cliffs<br>Warm Temperate | Tambo River Improvement Trust (and Richard Owen) 1994-5 | State<br>Public | Framework | 1.2 |
| Infill Gullies Pilot Site<br>Lakes Entrance<br>Warm Temperate/Littoral | EGCMA/Colquhoun-North Arm Landcare 2004 | State/volunteer<br>Private: permission required | Maximum Diversity | 2.2 |
| John Street (Ferndale)<br>Lakes Entrance<br>Warm Temperate/Littoral | Residents/East Gippsland Shire/EGCMA<br>2001 | Volunteer<br>Public<br>Private: permission required | Framework<br>Natural Regeneration<br>Maximum Diversity | 0.75 |
| Kings Cove<br>Metung<br>Warm Temperate/Littoral | King and Heath Real Estate 2004 | Private<br>Private: permission required<br>To become public | Framework<br>Maximum Diversity<br>Natural Regeneration | 4 |
| Mitchell River Walk<br>Bairnsdale<br>Warm Temperate/Littoral | Bairnsdale Landcare/East Gippsland Shire/EGCMA/Land Vic 2002 | Federal/state/volunteer<br>Public | Framework<br>Maximum Diversity<br>Natural Regeneration | 10 |
| Tambo River (waterline vegetation trial)<br>Johnsonville<br>Littoral | Lower Tambo Landcare/EGCMA<br>2004 | State<br>Public | Framework | 1.5 |
| Marshmead (Harrisons Creek)<br>Mallacoota Inlet<br>Warm Temperate | Methodist Ladies College 1990s | Private/volunteer<br>Private: permission required | Framework | ~3 |
| Marshmead (Dowell Creek)<br>Mallacoota Inlet<br>Warm Temperate | Methodist Ladies College 2004 | Private/volunteer<br>Private: permission required | Maximum Diversity | ~1 |
| Lakes Entrance Golf Links Pilot Site<br>Lakes Entrance<br>Littoral | Lakes Entrance Golf Club Inc. 2004 | Federal (Threatened Species)<br>Public: permission required (contact Golf Club) | Maximum Diversity<br>Natural Regeneration | 2 |
| Goldsmiths in the Forest B&B<br>Lakes Entrance<br>Warm Temperate | Private landholder<br>2004 | Federal (Threatened Species)<br>Private: permission required | Clumped Mixed Canopy | 4 |
| Wyanga Winery<br>Lakes Entrance<br>Warm Temperate | Private landholder<br>2004 | Federal (Threatened Species)<br>Private: permission required | Framework | 2 |
| Cann River<br>Warm Temperate/Gallery | EGCMA/Cann River Landcare 2003 | State/Federal/volunteer<br>Public | Framework | 4 |

Table S2. New South Wales Rainforest restoration sites*

| Site name<br>Location<br>Rainforest type | Organisation<br>Start time or duration | Funding sources | Methods used | Approx. area (ha) |
|---|---|---|---|---|
| Newtons Creek old farm site<br>Nadgee Nature Reserve<br>Warm Temperate/Littoral | New South Wales National Parks and Wildlife Service<br>Decades (ongoing) | State | Natural Regeneration | 7 |
| Wally Newtons Beach | New South Wales National Parks and Wildlife Service<br>Decades (ongoing) | State | Natural Regeneration | 6 |
| Hobbs Corner<br>Warm Temperate | Tathra Landcare<br>Decades (ongoing) | Various including: Bega Valley Shire and the funds of the members. | Natural Regeneration following Bitou control | 3 |
| Tathra Dunes Foreshore<br>Littoral | Tathra Landcare<br>Decades (ongoing) | Various including: Bega Valley Shire and the funds of the members. | Direct Seeding and Natural Regeneration following Bitou control | 29 |
| Goalen Head<br>Mimosa Rocks National Park<br>Littoral | New South Wales National Parks and Wildlife Service<br>2005: cattle were consistently excluded | New South Wales National Parks and Wildlife Service | Natural Regeneration | 69 |
| Tuross Landcare<br>Dry Gully<br>Littoral | | State | Natural Regeneration, Framework Planting | 8 |
| South Heads Moruya River mouth<br>Littoral | Ongoing Bitou control in and around the sole remaining stand of Littoral Rainforest in the township (northeast of Dolphin Beach Caravan Park). | New South Wales National Parks and Wildlife Service | Hand pulling and spraying | 5 |
| Broulee Nature Reserve<br>Littoral \ | | New South Wales National Parks and Wildlife Service | Natural Regeneration following weed control | 23 |
| Pebbly Beach<br>Murramarang National Park<br>Littoral | National Parks and Wildlife Service<br>In 1991 and 2000: exclosures to keep Eastern Grey Kangaroos and Red-necked Wallabies out of areas below eucalypts to allow for rainforest regeneration; and<br>Targeted plantings to re-establish the storm shutters in seaward areas of the *marsupial lawn* at the back of the beach to conserve the remaining Littoral Rainforest and allow rainforest restoration works in the re-designed camping ground. | New South Wales National Parks and Wildlife Service | Natural Regeneration Maximum Diversity | 0.33 |
| Durras Mountain<br>Murramarang National Park<br>Subtropical | Two dairy farms on the mountain's summit were purchased and added to Murramarang National Park in 1973: transforming weed control since has allowed paddock rainforest starters to start the process of natural recovery through succession. | New South Wales National Parks and Wildlife Service | Natural Regeneration | 53 |

*Conserving both rainforest and associated vegetation such as Coast Dune Scrub, Grassy Woodlands etc.

TWO METHODS: ONE CHEAPER, THE OTHER DEARER BUT BETTER FOR BIRDS IN THE MEDIUM TERM

Figure S45. Sites 13 and 14 Lochend Road, lower Snowy River Victoria. An example of the 20-year-old Framework Restoration Method from the 1980s. This site had 38 birds overall, but no rainforest birds, in 2002. Site 70f is immediately opposite on the other river bank. No natural regeneration occurred because of grazing and weeds.

Figure S46. Site 70f Marlo Road, lower Snowy River Victoria. An example of the Maximum Diversity Method carried out in the in 2002, 2 years after the first works. After 3 years, it had 49 birds overall and eight rainforest birds. High species diversity plantings controlled weeds and no grazing ensured these results.

DIRECT SEEDING SUCCESS ON THE LOWER SNOWY RIVER

Figure S47. Lake Wat Wat Wildlife Reserve, Victoria. The Lake Wat Wat direct seeded plot (using the Framework Rainforest Restoration Method), that is now Littoral Rainforest 15 years after the original work. The project was undertaken by Dave Kraujca and Greg McCarthy. The site is fenced against grazing and a rainforest seed source is only 10m distant on the adjacent marginal bluff (left side of photo). The Sweet Pittosporum *P. undulatum* is now 2.5m but the Lilly Pilly *Syzygium smithii* is only just establishing.

More extensive work has since been undertaken at a number of sites around East Gippsland on a pilot program basis, with each site being devoted to solving site-specific problems that have to be overcome before rainforest restoration can be widely practiced across south-eastern Australia.

SHADE CAN CONTROL SUN-DEPENDENT WEEDS AND ENSURE NATURAL REGENERATION

Figure S48. Lake Wat Wat Wildlife Reserve, Victoria. Understorey of Figure S47 with: Prickly Currant-bush *Coprosma quadrifida*, Large Mock-olive *Notelaea venosa* and Sweet Pittosporum *P. undulatum*.

Figure S49. Lake Wat Wat Wildlife Reserve, Victoria. Understorey of Figure S47 with shade-loving Weeping Grass *Microlaena stipoides*. Note the demise of the *sun weed* Kikuyu **Pennisetum clandestinum* (red arrows).

The location of pilot sites, the issues studied, the methods used, rainforest EVCs restored and funding sources were:

- Maringa Creek at Nyerimilang on the Gippsland Lakes (11ha) started in 2001:
  - Issues studied: browsing by feral Hog Deer and Swamp Wallaby and severe frosts
  - Methods used: Framework, Maximum Diversity and Natural Regeneration
  - EVCs restored: Warm Temperate Rainforest and Littoral Rainforest
  - Funding sources: Plantations for Greenhouse (State); Natural Heritage Trust (Commonwealth).
- The Snowy River around Orbost (28ha) started in 2001:
  - Issues studied: transforming weeds and flooding effects
  - Methods used: Framework, Maximum Diversity and Natural Regeneration
  - EVCs restored: Warm Temperate Rainforest, Gallery Rainforest and Littoral Rainforest
  - Funding sources: Our Water Our Future, Community Jobs Program (State); Natural Heritage Trust
- Frenchman's (Infill) Gully on the North Arm at Lakes Entrance (2.2ha) started in 2004:
  - Issues studied: sediment swamped creeks and high water tables and salinity in rainforest restoration
  - Methods used: Maximum Diversity and Natural Regeneration
  - EVCs restored: Warm Temperate Rainforest and Littoral Rainforest
  - Funding sources: Landcare Grants (State); Natural Heritage Trust, World Wide Fund for Nature recovery of Grey-headed Flying Fox critical habitat (Commonwealth).
- The Lakes Entrance Golf Club (8.2ha) begun in 2004:
  - Issues studied: weed treatments (spot-spraying, blanket-spraying), natural regeneration trials
  - Methods used: Maximum Diversity and Natural Regeneration
  - EVCs restored: Littoral Rainforest
  - Funding sources: World Wide Fund for Nature recovery of Swift Parrot critical habitat (Commonwealth)
- North Arm at Lakes Entrance (2ha) begun in 2005:
  - Issues studied:
  - Methods used: *Clumped Mixed Canopy*
  - EVCs restored: Warm Temperate Rainforest
  - Funding sources: World Wide Fund for Nature recovery of Grey-headed Flying Fox critical habitat.

Two smaller sites have also been established:

- Merrengbaur Gully at Merrengbaur Heights, Lakes Entrance begun in 2005 (1ha)::
  - Issues studied: development of community partnerships and use of jute matting
  - Methods used: Framework, Maximum Diversity and Natural Regeneration
  - EVCs restored: Warm Temperate Rainforest
  - Funding sources: East Gippsland Shire (Municipal).
- John Street, Lakes Entrance begun in 2001 (0.75ha):
  - Issues studied: development of community partnerships
  - Methods used: Framework, Maximum Diversity and Natural Regeneration
  - EVCs restored: Warm Temperate Rainforest and Littoral Rainforest
  - Funding sources: East Gippsland Shire (Municipal).

Much of the advice regarding rainforest restoration is supplied from these pilot sites and other restoration sites, with the balance derived from the experiences of the author, his colleagues and the literature. Sixteen of these rainforest restoration sites are Victorian (Table S1) and only ten are known to the author in southern New South Wales (Table S2), but others will be known locally. All told within the south-east Corner and South east Coastal Plain Bioregions there are 20 rainforest restoration sites underway or completed. In total, this represents approximately 188ha of rainforest being restored and/or recreated.

In south-eastern Australia today, those with the aptitude, time, money and enthusiasm can successfully create a functioning Warm Temperate Rainforest or Littoral Rainforest stand within 5 years on most sites where rainforest once grew. With some adaptation and consideration of the particular environment of other rainforest types, similar results should be possible.

| SUMMARY | |
|---|---|
| COMPREHENSION: STOP | Rainforests are rare, depleted and threatened at the planetary, landscape and district levels.<br>Most (if not all threats) are human induced. |
| KNOWLEDGE: THINK | There are seven rainforest ecological vegetation classes in south-eastern Australia.<br>Rainforest restoration has only just begun in south-eastern Australia. |
| WHAT TO DO? ACTION | One of the keys to the conservation of rainforest in south-eastern Australia will be rainforest restoration. This fact must be clearly and effectively communicated to the community, land managers and government.<br>Given the threats ranged against rainforests across the region, the role of rainforest restoration in south-eastern Australia is likely to be pivotal to their survival: so hop to it!<br>Trial the Restoration Methods that we suggest, adapt them to your situation and learn. |
| WHAT NEXT? | READ ON. |