

KILLEN FALLS VEGETATION RESTORATION MANAGEMENT PLAN



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This report was prepared for the Big Scrub Rainforest Landcare Group by:
Bower Bush Works – *Ecological Assessment & Restoration Services*

Executive Summary

The Big Scrub Rainforest Landcare Group contracted Bower Bush Works to prepare a vegetation restoration management plan for the Killen Falls rainforest remnant and adjacent properties situated downstream of the Emigrant Creek Dam near Tintenbar, Northern New South Wales. The remnant and adjacent properties are described as the Killen Falls Restoration Project Site. The Project Site consists of three properties that span 500m of Emigrant Creek. The restoration project involves a partnership between local government, landholders and community groups.

The Killen Falls remnant is the most significant vegetation community on the Project Site consisting of 2 hectares of relatively intact original Big Scrub lowland rainforest. Less than 1% of the original Big Scrub, which covered 75,000 hectares, remains as isolated fragmented remnants. This remnant supports at least seven threatened plant species listed on Schedules 1 and 2 of the Threatened Species Conservation Act 1995 (TSC Act 1995). A number of these plants are also found across the Project Site. The lower flood prone portion of the remnant is recognised as an Endangered Ecological Community (Lowland Rainforest on Floodplain) on Part 3 Schedule 1 of the TSC Act 1995.

The Killen Falls Project Site provides potential habitat for at least 16 threatened species of fauna listed on Schedule 1 and 2 of the TSC Act 1995. The rainforest remnant plays an important role for rainforest dependant fauna in the locality and acts as a stepping stone to other remnant for mobile fauna species in a fragmented landscape. The remnant provides an important source point of propagules for dispersal into the surrounding landscape. The Project will compliment restoration works being undertaken by Rous Water around the perimeter of the Emigrant Creek dam.

Vegetation communities adjacent to the Killen Falls remnant are largely disturbed and in varying condition and stages of recovery. Camphor Laurel regrowth with early successional rainforest species is the predominate community in the area, forming part of an important riparian corridor. At least 20 weed species are recorded from the remnant and are prevalent on the remnant edges. Weed species such as Slash Pine, Large-leaved Privet, Small-leaved Privet and Camphor Laurel are widespread through the project site and to varying degrees are inhibiting natural regeneration.

A long-term restoration program involving strategic weed control and planting of highly disturbed areas is required to help to improve the condition and restoration capacity of the Killen Falls Project Site. Regular follow-up weed management will be necessary and will improve the success of the Project. The Killen Falls remnant should be the primary focus for restoration work based on its relatively good vegetation condition and ecological values. The restoration of adjacent vegetation communities is also important as it will effectively increase the area of native vegetation in the locality, reduce weed sources and will improve the viability of the remnant and riparian vegetation.

Four separate management areas have been developed based on vegetation type and land tenure. Vegetation restoration guidelines have been prepared for each management area based on an assessment of the site's conservation significance, vegetation condition and restoration capacity. This plan provides a practical restoration program that will help bush regenerators and land managers to restore and enhance the viability of the Killen Fall Project Site.

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1.0. Introduction

1.1. Scope of the Killen Falls Vegetation Restoration Management Plan

The Killen Falls Vegetation Restoration Management Plan was prepared by Bower Bush Works for the Big Scrub Rainforest Landcare Group (BSRLG) as part of the BSRLG's Rainforest Remnant Restoration Program. This program targets the restoration of high conservation value Big Scrub rainforest remnants and their surrounds. The Killen Falls Vegetation Restoration Project involves a partnership between local government, landholders and community groups to assist the restoration of the Killen Falls remnant and surrounding regrowth vegetation (the project site).

Killen Falls remnant is situated on Emigrant Creek, Teven, downstream of Emigrant Creek Dam. The remnant is privately owned and adjoins lands within the project site that are managed by Ballina Shire Council, Rous Water and various private holdings (Figure 2). Project participants include the BSRLG, Rous Water, Ballina Shire Council, Environmental Training and Employment (EnvITE), Rainforest Rescue and local landholders.

This plan forms part of the BSRLG's contribution to the Project, detailing strategies for the restoration of the remnant and surrounding lands below the Emigrant Creek Dam. The BSRLG and EnvITE will also assist in facilitating on-ground restoration actions. This plan compliments vegetation restoration planning and works being undertaken by Rous Water around the perimeter of the Emigrant Creek Dam.

The Big Scrub Rainforest Landcare Group has been highly successful in implementing remnant restoration work in over 25 Big Scrub remnants since 1996, and is currently assisting with the ongoing maintenance of these remnants. This work has helped to address the impacts of weed invasion, edge effects and other issues that are degrading the viability of high conservation Big Scrub rainforest remnants.

BSRLG recognises that to effectively manage isolated and weed impacted native vegetation communities, a long-term commitment by private land-holders, relevant government agencies, the BSRLG and the community is required. Such management requires a strategic yet flexible range of options including: fencing, weed management, remnant expansion and connection, cooperation with land holders and community education.

2.0. Report aims and objectives

2.1. Aim

The aim of this report are to:

- provide practical strategies to help restore and maintain, as far as practical, the Killen Falls rainforest remnant as a functional example of lowland subtropical rainforest from the Emigrant Creek, Teven area; and,
- to provide strategies to enhance the recovery of regrowth vegetation and degraded land to self sustaining plant communities with floristic and structural attributes that are relevant to the local soil landscapes and site conditions.

2.2. Objectives

The objectives of this report are to:

- 1). identify the conservation significance of the Killen Falls rainforest remnant and the Project Site;
- 2). identify threats that are, or are likely to degrade the viability of plant and animal communities at Killen Falls remnant and provide ameliorative measures;
- 3). assess the condition and regeneration potential of the Killen Falls remnant and properties within the Project Site;
- 4). develop a practical vegetation restoration and weed management strategy for the Project Site and provide information on weed control techniques;
- 7). provide information on revegetation techniques;
- 8). provide habitat management guidelines;
- 9). identify legislative requirements for undertaking restoration actions; and,
- 10). provide information that will help to raise community and government agency awareness of the importance of adopting ecologically sound and long-term restoration strategies for the effective management of Big Scrub remnants.

3.0. Report methods

The development of this plan involved a review of relevant literature, a number of field inspections and consultation with landholders, land managers and local government authorities.

Field inspections and review included:

- vegetation survey;
- assessment of threatened plant species listed as either: Rare or Threatened Australian Plants (ROTAP) (Briggs and Leigh 1996); or Vulnerable or Endangered under the New South Wales

Threatened Species Conservation Act 1995 (TSC Act 1995); and the Commonwealth Environmental Protection and Biodiversity Conservation Act 1998 (EPBC Act 1999);

- classification of rainforest and non rainforest vegetation using a compilation of classification systems according to species dominance, life form, vegetation structure including foliage projective cover and height (Walker and Hopkins 1994);
- where possible, further classification of rainforest vegetation according to Floyds structural, physiognomic and floristic classification for NSW rainforests (Floyd 1990a);
- weed species survey and mapping;
- assessment of vegetation condition and regenerative potential (based on disturbance history, structural complexity, floristic integrity, seedling recruitment and patch size);
- assessment of potential threatened fauna and fauna habitats;
- assessment of threats and other management problems; and,
- photographing remnant features and pertinent management points.

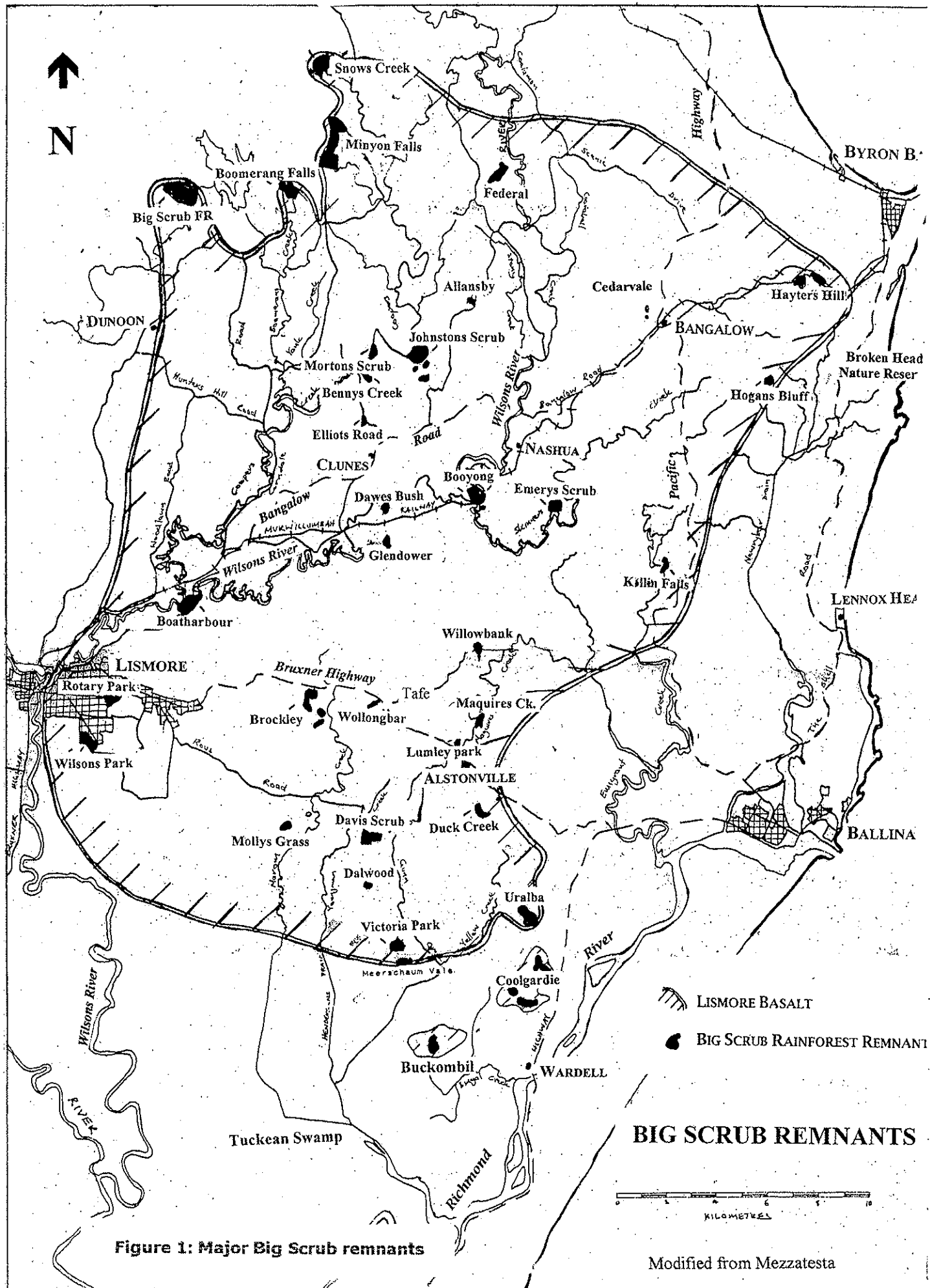
The report covers three general themes, which include:

1. Background information to the Big Scrub, overview of the Project Site and rainforest restoration processes.
2. Vegetation assessment and restoration guidelines for individual management areas (section 7.1. – 7.4.). These sections form a working document to direct on-ground restoration actions and can be interpreted for use by for each land manager. Other site specific management issues are also addressed (section 8.0.).
3. Supporting information which is contained in the appendices. This includes an overview of the threats and impacts to remnant vegetation (Appendix 3), weed control techniques (Appendix 4) and restoration guidelines (Appendix 5). A review of fauna habitats, the importance of fauna (Appendix 9A) and threatened fauna profiles are also provided (see Appendix 9B). Fauna profiles should be reviewed prior to undertaking restoration work to ascertain species habitat requirements and to minimise potential impacts. The appendices contain additional information such as a vegetation species list for the entire site, a list of noxious weeds, weed distribution - mud map, review of legislative requirements, genetic guidelines for planting and planting lists.

4.0. Background to the Big Scrub

4.1. History of the Big Scrub

The Killen Falls remnant is an isolated rainforest remnant of the once vast Big Scrub, which was approximately 75,000 hectares of lowland subtropical rainforest associated with the Mount Warning Volcanics (Holmes 1987). The Big Scrub is approximately located between east Lismore, Alstonville, St. Helena and Dunoon (Holmes 1987; Floyd 1990a; Mezzatesta 1992; Lott & Duggin 1993). By the early 1900's much of the Big Scrub had been reduced to a series of isolated remnants that comprise less than 1% (or 300 ha.) of the original vegetation (Frith 1976; Floyd 1990a; Lott & Duggin 1993; Adam 1994), (Figure 1).



4.2. Conservation significance of Big Scrub remnants

Big Scrub remnants are of regional and national conservation significance as they support endemic flora and fauna (including a high number of threatened species), exhibit high plant species diversity, are poorly reserved (due to previous broad scale land clearing) and due to the restricted distribution of rainforest in Australia. The ecological significance of the Big Scrub remnants is recognised with thirty-four of the major remnants being listed on the Interim Register of the National Estate (Mezzatesta 1992). The significance of lowland rainforest remnants has been further acknowledged with the listing of Lowland Rainforest on Floodplain (within the NSW northern bioregion) as an Endangered Ecological Community under Part 3 of Schedule 1 of the TSC Act 1995. All rainforest remnants confined to the Big Scrub region are currently under review for similar listing. The draft Richmond Regional Vegetation Plan has identified rainforest as Very High Conservation Value and prohibits the clearing of communities over 10 years old. Most Big Scrub Rainforest remnants have been zoned for environmental protection under Local Government Local Environmental Plans.

There has been extensive review into the importance of Big Scrub rainforest remnants as habitat for both flora and fauna and their need for restoration (Date *et al.* 1996; Kooyman 1996; Recher *et al.* 1995; Adam 1994; Gosper 1994; Lott & Duggin 1993; Floyd 1990a; 1990b; Eby & Palmer 1991 and NPWS 1988). The region exhibits a wide range of floristic and structural variation whilst potentially providing habitat for over 30 threatened fauna and 30 flora species listed under the TSC Act 1995. The remnants of the Big Scrub support a rainforest formation distinct to other rainforests in Australia and in NSW (Connelly and Specht 1988).

The Big Scrub lies within the McPherson-Macleay biogeographical overlap zone (NPWS 1995). This zone is a convergence area for northern and southern biota, so that many species reach their southern or northern limits in the region. The north eastern region of NSW supports the highest number of rare or threatened plant species in Australia (NPWS 1998) and is equal to the wet tropics for faunal diversity (NPWS 1995). Subsequently the area is recognised for its outstanding biodiversity at both the national and international level with significant areas listed on the World Heritage register.

The Big Scrub remnants are generally fragmented, isolated and less than 20 hectares in size (except for those contiguous with the Nightcap Range). This has resulted in a major decline in biodiversity and increased threats (see Appendix 3). Despite this, Big Scrub remnants are considered to be important regardless of their size as they provide refuge for the original flora and fauna, for the role they play in providing corridors and/or stepping stones amongst a fragmented ecosystem and as a genetic pool and seed source for regrowth areas and remnants. The remnants contain important ecological information regarding the original species mixes throughout the region and are invaluable for scientific research. Remnants provide crucial reference points to what may have existed in an area prior to large scale land clearing.

5.0. Background to rainforest restoration

Rainforest restoration describes the processes of restoring, reinstating and maintaining the natural features and ecosystem functions of rainforest communities and degraded rainforest land. It is achieved primarily through reducing the impacts of degrading processes such as weeds and edge effects, by stimulating regenerative processes and through ecosystem reconstruction. Ecological restoration is a means of returning a site or a remnant to a level of naturalness or representativeness of its former structure, floristics and ecosystem function (Goosem and Tucker 1995).

Remnants need to be managed on a whole system basis (Dunphy 1992), incorporating an awareness of rainforest dynamics and utilising management options that are ecologically relevant to the landscape context (Hobbs 1995). Flexibility is required from site to site, and techniques applied in regard to an ecosystem's condition and anticipated level of recovery. Techniques used should be those that are most effective, efficient and ecologically viable and based on available resources and funding.

The control of weeds alone should not be the basis for a regeneration program, although it is a very important aspect of it. Instead, the restoration of the natural processes of regeneration and succession to resist and replace weeds to improve the long-term viability for native flora and fauna should be the focus (Joseph 1995). Weed control should not target certain weeds **unless** early control of a minor infestation of a serious weed (eg Cat's Claw Creeper and Climbing Asparagus Fern etc.) will prevent further or more serious infestations (Joseph 1995). To effectively control weeds, a systematic, strategic and integrated weed control program is required that involves regular and long term commitment (see Appendix 4 and 5).

To ensure the long-term viability of floral and faunal communities in the small, fragmented Big Scrub remnants it is necessary to increase their size to buffer harsh edge effects and to create links between neighbouring remnants and/or areas of regrowth. Remnant expansion is recommended to help buffer the core areas of the remnant by promoting and/or creating a new edge and increasing the area of available rainforest habitat. In disturbed Big Scrub sites a combination of both assisted regeneration and planting (framework and accelerated succession models) is recommended for expanding remnant edges (see Appendix 5). The choice of remnant extension methods should be assessed with consideration to the site's condition, project limitations, social and ecological implications.

6.0. Overview of the project site

6.1. Location

The Killen Falls Project Site lies directly 7km north-west of Lennox Head and 3 km north of the Tintenbar Village on the Far North Coast of NSW (Easting – 551100; Northing – 6817300, Ballina map sheet 9640-3-N). The project site is situated on Emigrant Creek downstream of the Emigrant Creek Dam (Plate 1). The Project Site occurs within the Shire of Ballina.

The Project Site is accessed from Killen Falls Drive off Friday Hut Road, west of the Pacific Highway. The Project Site incorporates three properties, with frontage to Emigrant Creek and covers a 500m stretch of riparian habitat that runs from the base of the dam wall and downstream of Killen Falls.

6.2. Geology & soils

The Project Site occurs on krasnozems soils derived from the Lismore basalts of the Mount Warning shield volcano Tertiary volcanics (Morand 1994). The soils are free draining and well-structured, generally with a clay loam topsoil with potential high fertility in the organic layer decreasing with a shallower profile. They are also highly acid and are prone to aluminium toxicity with fertility rapidly declining after clearing and ongoing exposure (Morand 1994). Krasnozems mainly occur in areas that have high rainfall (> 1300) and warm temperatures and grow lush, subtropical rainforests in the Big Scrub region (Floyd 1990a, Lott & Duggin 1993).

The Project Site exhibits a convergence of three soil landscapes (Morand 1994). These include two erosional landscapes typified as Bangalow and Rosebank, and a residual landscape typified as Wollongbar. Residual landscapes exhibit deeper soil profiles and undulating topography. This is evident along the top eastern edge of the remnant. The remainder of the site comprises erosional landscapes, which exhibit shallow soil profile (with occasional depth), benches, undulating hillslopes and rock outcrops. The Krasnozems soils associated to the soil landscapes are comparable in composition and physical characteristics to each other (Morand 1994).

6.3. Topography

The elevation of the Project Site ranges between 40m to 100m above sea level. The project site comprises varied landform features associated with the creek and waterfall. These include variable creek bank profiles, creek flats, cliff lines and steep to undulating slopes. The waterfall runs off an overhanging cliff line (about 20m in height) into a narrow basin, resulting in a relatively moist and protected environment. The creek flats are prone to flooding and scouring.

6.4. Climate

North eastern N.S.W. experiences a warm temperate to subtropical climatic regime that is generally characterised by a warm, moist summer and autumn (Dec.-May) to a mild dry winter (June-Aug.) and a warm dry spring (September to November). Annual rainfall in the Big Scrub area ranges from between 1300-2000 mm/yr. (Holmes 1987, Lott & Duggin 1993, Morand 1994).

6.5. Vegetation of the project site

Killen Falls remnant comprises lowland subtropical rainforest belonging to the White Booyong *Heritiera trifoliolata* alliance (previously *Argyrodendron*) which is characteristic of the Big Scrub. Floyd (1990b) describes this alliance as the most structurally complex rainforest alliance in N.S.W. It requires protection from salt laden winds, cold or hot drying winds and often occurs on some of the best agricultural land. It has been virtually destroyed in the Big Scrub area, except for small remnants which were either flood prone, poorly drained, stony or left due to surveying errors (Lott and Duggin 1993), or actually set aside for preservation.

Floyd (1990a) has further classified the White Booyong alliance into suballiances determined by canopy species abundance and structural and physiognomic features. Of the six major floristic suballiances described, Floyd recognises four as being represented within the 'true' Big Scrub remnants (Floyd 1990b). Three of these are within the *Heritiera* (Booyong) alliance:

- *Heritiera trifoliolata* suballiance No. 1.
- *Cryptocarya obovata*-*Dendrocnide excelsa*-*Ficus* spp.-*Araucaria* suballiance No. 3.
- *Castanospermum australe*-*Dysoxylum mollissimum* (muelleri) suballiance No. 5.

The other is within the *Drypetes*-*Araucaria* alliance;
Araucaria suballiance No 21.

Killen falls remnant belongs to the *Castanospermum australe*-*Dysoxylum mollissimum* (muelleri) suballiance No. 5. Other Big Scrub remnants in the local area that are also recognised as belonging to suballiance No.5 include Davis Scrub Nature Reserve and Wollongbar remnant. Floyd (1990 b) considers soil moisture as a factor limiting the distribution of this association, which often occurs on deep fertile soils formed from eroded plateaux or alluvial accumulations in valleys.

The heavily disturbed portions of the Project Site are likely to have predominantly supported lowland subtropical rainforest of the *Heritiera trifoliolata* alliance with sclerophyll species present on shallower soil profiles. It is also possible that the site supported species typically associated with dry/littoral rainforest. Palm forest and wetland plant communities (e.g. sedgeland and swamp forest) are likely to have occurred upstream of the falls in the areas prone to periodic flooding and poor drainage.

The Project Site contains a number of threatened rainforest plants. Details of threatened and common rainforest plants species occurring at the Project Site are listed for each management area (see sections 7.1- 7.4).



Plate 1. Killen Falls project site – upper Emigrant Creek catchment
Source: DLWC Alstonville (1997).

Scale 1:17500

6.6. Fauna of the project site

No formal fauna surveys were undertaken at the Killen Falls project site for this report. Fauna data from similarly sized remnants in similar situations throughout the Big Scrub indicate that remnants provide important habitat for a diversity of reptile, bird and mammal species (particularly mobile species such as birds and bats) and invertebrates. Threatened fauna species identified under the TSC Act 1995 that are likely to utilise the Killen Falls remnant and potentially the surrounding habitats are listed below (see Table 1). Without seasonal targeted fauna surveys many of these species (and other common fauna) may remain undetected. This is particularly relevant for cryptic and/or nocturnal species such as micro-chiropteran bats, reptiles, frogs and invertebrates.

Further review of fauna habitats, fauna habitat requirements and background information on some of the threatened species likely to occur at the Killen Falls project site is provided in Appendix 9.

Table 1. Threatened fauna likely to occur at the Killen Falls remnant/project site

Common Name	Scientific Name	TSC Act schedule	Likelihood of occurrence
Invertebrates			
A Carabid Beetle	<i>Nurus atlas</i>		Low-Moderate
	<i>Nurus brevis</i>		Low
Reptiles			
Three-toed Snake-tooth Skink	<i>Coeranoscincus reticulatus</i>	S2	Low-Moderate
Birds			
Black Bittern	<i>Dupetor flavicollis</i>	S2	High
Bush Hen	<i>Amaurornis olivacea</i>	S2	High
Wompoo Fruit-dove	<i>Ptilinopus magnificus</i>	S2	High
Rose-crowned Fruit-dove	<i>Ptilinopus regina</i>	S2	Known
Superb Fruit-dove	<i>Ptilinopus superba</i>	S2	Moderate - high
Coxen's Fig Parrot	<i>Cyclopsitta diopthalma coxeni</i>	S1	Very Low
Barred Cuckoo-shrike	<i>Coracina lineata</i>	S2	Moderate
White-eared Monarch	<i>Monarcha leucotis</i>	S2	Moderate - High
Mammals			
Common Planigale	<i>Planigale maculata</i>	S2	Moderate-low
Yellow-bellied Sheath-tail-Bat	<i>Saccolaimus flaviventris</i>	S2	Moderate- High
Beccari's Freetail-bat	<i>Mormopterus beccari</i>	S2	Low
Eastern Freetail-bat	<i>Mormopterus norfolkensis</i>	S2	Low
Grey-headed Flying-fox	<i>Pteropus poliocephalus</i>	S2	High
Black Flying-fox	<i>Pteropus alecto</i>	S2	Moderate
Common Blossom Bat	<i>Syconycteris australis</i>	S2	Moderate
Golden-tipped Bat	<i>Kerivoula papuensis</i>	S2	Low
Little Bent-wing Bat	<i>Miniopterus australis</i>	S2	High
Common Bent-wing Bat	<i>Miniopterus schreibersii</i>	S2	Moderate
Large-footed Mouse-eared Bat	<i>Myotis adversus</i>	S2	High
Eastern long-eared Bat	<i>Nyctophyllus bifax</i>	S2	Moderate
Greater Broad-nosed Bat	<i>Scoteanax ruepellii</i>	S2	Moderate

6.7. Landscape context

The Killen Falls Project Site is located toward the eastern periphery of the former Big Scrub. The study area is situated within the Emigrant Creek catchment which is directly west of the Knockrow ridgeline that runs parallel to the coast above the Newrybar Swamp (Fig. 1). Emigrant Creek runs in a north south direction from Newrybar and drains into the Richmond River near Ballina.

The Killen Falls remnant is severely isolated from other Big Scrub remnants (Plate 1). The closest significant rainforest remnants to Killen Falls include Emery's Scrub (located about 5km north-west), Hogan's Scrub (located about 8km north-east) and Willowbank (located about 8km south-west). There are considerable areas of regrowth vegetation (largely weed dominated) in the local landscape with riparian sites and previously cleared steep land supporting vegetation dominated by Camphor Laurel, Privet and Lantana shrubland. Regrowth vegetation serves to increase the size of the remnant and assist in connecting a patchwork of regrowth vegetation along riparian corridors.

The dominant land use within the Emigrant Creek catchment and surrounds comprises large scale plantations (Macadamia, Coffee and Stone Fruit) and pasture. Exotic pine plantations are also scattered throughout the area.

The paucity of native vegetation in the landscape highlights the significance of the Killen Falls remnant and the importance in managing and recovering regrowth vegetation. Remnant expansion and the development of corridors between the remnant, regrowth and agricultural tree crops will help improve vegetation connectivity in the landscape and will help to improve the long-term viability of the remnant.

6.8 Management areas

To assist the development and implementation of restoration works the project site has been divided into four main management areas based on property ownership and vegetation condition (Figure 2). Detailed site descriptions, vegetation assessment and restoration schedules are provided in the following text (see section 7.1-7.4). The management areas include:

Area 1 – Killen Falls remnant (private)

Area 2 – Deenford regrowth (Areas 2a,b,c)

Area 3 – Ballina Council Reserve

Area 4 – Lane's regrowth & pine forest

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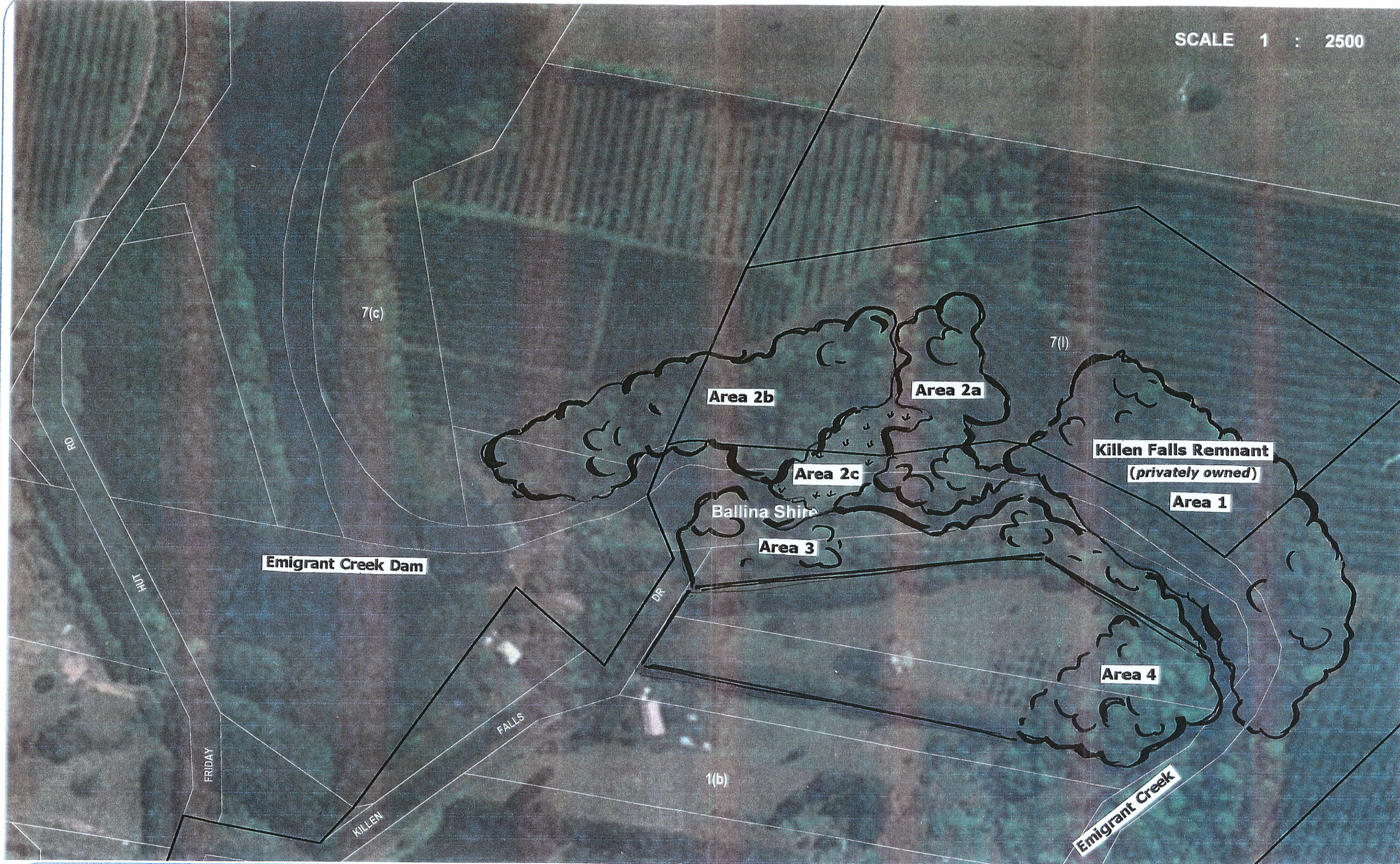


Figure 2: The Killen Falls Project Site - Management Areas

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7.0. Description of management areas and restoration schedules

7.1. Killen Falls remnant (private) - Area 1

7.1.1. General site description

The remnant is about two hectares in size and is oval shaped. The remnant flanks the steep southwest facing slope directly adjacent to the 'Killen Falls' waterfall on Emigrant Creek. The upper slope of the remnant drops steeply forming small cliff lines, benches and rock-strewn slopes. A narrow alluvial flat occurs at the base of the slope adjacent to the creek which forms the southwest boundary of the remnant. The remnant has about 350m of creek frontage. Macadamia plantation demarks the northern edge of the remnant, which is separated by a minor access track (Plate 5 & 7).

7.1.2. Site history & management

The Killen Falls remnant is privately owned and is situated on Deenford Plantation. The property has been owned by a number of land holders. The Killen Falls remnant is named after the Killen sisters' circa 1885. The property was later purchased by the Wadsworth's, prior to the Second World War. Although the property has been managed by a number of land holders the remnant remains fairly intact, which suggests that the site has not experienced any significant disturbance, possibly owing to its complex topography (Plate 2).

Bush regeneration works have not been undertaken at the site to date. A fence line runs from the top edge of the falls across to adjacent regrowth forest (Area 2a) which helps reduce human access into the top section of the remnant.

7.1.3. Classification of remnant vegetation

The remnant has been classified as **complex notophyll tall closed vine forest**. This is indicative of the sites structural complexity and fairly intact condition.

Killen Falls remnant comprises of lowland subtropical rainforest belonging to the White Booyong *Heritiera trifoliolata* alliance and has been further classified into Suballiance No. 5 *Castanospermum* - *Dysoxylum mollissimum* Floyd (1990b), these species being well represented in the main canopy, above a diverse lower stratum.

The lower sections of the remnant occurring on the alluvial flat above the creek is recognised as Lowland Rainforest on Floodplain (within the NSW northern bioregion) an Endangered Ecological Community under Part 3 of Schedule 1 of the TSC Act 1995.

7.1.4. Native plant floristics

The site supports a high diversity of native plant species. Within the remnant itself this includes; at least 125 species of trees and shrubs, 29 species of vines and scramblers, 16 herbs and forbs

been added to vegetation lists prepared by Floyd (1985) and Holmes (1987) with a number of new species recorded by the author (Appendix 1). Refer to Table 2 for list of species that are common to each stratum.

Killen Falls remnant contains several plant species that are unique in their distributional context. These are Brushbox *Lophostemon confertus*, Water Gum *Tristaniaopsis laurina*, Creek Lilly Pilly *Acmena smithii* - rheophytic form, Blue Lilly Pilly *Syzygium oleosum*, Beefwood *Stenocarpus sinuatus*, Emundi Quangdong *Elaeocarpus eumundii* (identified by Floyd 1985), Medicosma *Medicosma cunninghamii* and Riberry *Syzygium leuhmanii* (well represented as a canopy tree). These species are commonly associated to the periphery of the Big Scrub occurring in areas of rhyolitic basalt influence, coastal sites or generally areas with poorer soil fertility. The presence of these species may indicate the convergence of residual and erosional soil landscapes with shallow soil profiles and exposed rock.

Table 2. Native plant species common to each stratum - Area 1

Emergent - Small-leaved Fig <i>Ficus obliqua</i> , Blue Fig <i>Elaeocarpus angustifolia</i>
Canopy - Red Bean, White Booyong, Blackbean, Riberry, Yellow Pear Fruit <i>Mishocarpus pyriformis</i> , Giant Water Gum <i>Syzygium francissii</i> , Red Cedar <i>Toona ciliatus</i> , Churnwood <i>Citronella moorei</i> , Coolamon <i>Syzygium moorei</i> , Baloghia <i>Baloghia inophylla</i> , Maidens Blush <i>Sloanea australis</i>
Mid - Green Tamarind <i>Ellatostachys nervosa</i> , Green Bolly Gum <i>Neolitsea australiensis</i> , Bog Onion <i>Anthocarapa nitidula</i> , Prickly Tree Fern <i>Cyathea leichhardtiana</i> , Smooth Helicia <i>Helicia glabriflora</i> , White Bolly Gum <i>Neolitsea dealbata</i>
Lower - Large-leaved Wilkea <i>Wilkea macrophylla</i> , Actephila <i>Actephila lindleyi</i> , Cleistanthus <i>Cleistanthus cunninghamii</i> Walking Stick Palm <i>Linospadix monostachyus</i> , Acalypha sp. Smooth Mock-olive <i>Notelaea johnsoni</i> , <i>Cordyline rubra</i> , Orange Thorn <i>Pittosporum multiflorum</i>
Ground - Creeping Shield Fern <i>Lastriopsis microscora</i> , Bordered Shield Fern <i>Lastriopsis marginans</i> , Naked Shield Fern <i>Lastriopsis munita</i> , Jungle Brake <i>Pteris umbrosa</i> . Various seedlings of tree species present.

7.1.4.1. Riparian vegetation downstream of Killen Falls

Vegetation occurring directly on the edges of Emigrant Creek beside the remnant comprises a range of exotic grasses, native sedges such as *Carex appressa*, Tassle Sedge *Carex polyantha*, River Clubrush *Schoenoplectus validus* and herbs; including Lesser Joy Weed *Alternanthera denticulata* and *Persicaria* spp. These plant communities will fluctuate with changes in water flow resulting from seasonal influences and water management in the dam.

The noxious waterweeds (Water Hyacinth *Eichhornia crassipes* and Salvinia *Salvinia molesta*) were evident in the creek. They were sparsely scattered along the waterway and are more likely to be problematic to areas with low water flow and nutrification. The dam is a known source of these noxious waterweeds.

Some of the more common rainforest tree and shrub species occurring within the riparian zone include Scrub Cherry *Syzygium australe*, Creek Lilly Pilly (rheophytic form), Creek Sandpaper Fig, Water Gum, Giant Water Gum, Coolamon, Maidens Blush and Brown Tamarind *Castanospora alphandii*.



Plate 2: Killen Falls remnant is a fine example of subtropical rainforest from the Emigrant Creek catchment.



Plate 3: Vegetation at the base of the falls is prone to disturbance from high water flow. Large-leaved Privet, Lantana, Trad & exotic grasses occur in this area.

7.1.5. Threatened plants

The remnant supports at least 9 plant species that are of conservation significance. These are identified under state and commonwealth legislation and national reference lists (see Table 3). The identification of another species (*Acalypha* sp. aff. *eremorum*) requires further investigation (see below).

Table 3. Threatened and ROTAP plants identified at Killen Falls remnant (Area 1)

Common Name	Botanical Name	TSC Act 1995	ROTAP	EPBC Act 1999
Isoglossa (herb)	<i>Isoglossa eranthemoides</i>	Schedule 1 Endangered	2E	E
Arrow-head Vine	<i>Tinospora tinosporoides</i>	Schedule 2 Vulnerable	3RC-	V
Ball Nut (tree)	<i>Floydia praealta</i>	Vulnerable	3VC-	V
Red Lilly Pilly (tree)	<i>Syzygium hodgkinsoniae</i>	"	3VC-	V
Rough-shelled Bush Nut (tree)	<i>Macadamia tetraphylla</i>	Vulnerable	2VC -	V
Veiny Laceflower (tree)	<i>Archidendron muellerianum</i>	-	3RCa	
Smooth Scrub Turpentine	<i>Rhodamnia maldeniana</i>	-	2Rc-	
Quassia (shrub)	<i>Quassia</i> sp 'Mt Nardi'	-	3RC-	
Acalypha	<i>Acalypha</i> sp. aff. <i>eremorum</i>	?	?	?

Refer to Appendix 8 for ROTAP codes

***Acalypha* sp. aff. *eremorum*.** The *Acalypha* species recorded from Killen Falls remnant requires further taxonomic review. This plant has been identified from a number of sites in the Big Scrub and has been previously recorded as the more common *Acalypha capillipes*, which is found in dry rainforest north from Casino (Harden 1990). Recent collections of fertile material from a number of Big Scrub remnants, including Killen Falls show similarities to *A. eremorum* noted by the sessile female flowers, lenticellate bark and lack of spines. In the interim the *Acalypha* species is referred to as *Acalypha* sp. aff. *eremorum* based on the identification of specimens that have been identified by the Queensland Herbarium, Royal Botanic Gardens and the Coffs Harbour Regional Herbarium. Further taxonomic assessment and investigation of the plant's conservation status is required.

Isoglossa eranthemoides is an endangered rainforest herb potentially reaching its southern distributional limit at Killen Falls. This is a new site location for this species. Only a few plants were located during the survey.

Macadamia tetraphylla is represented by several trees situated toward the centre of the remnant (noted by A. Floyd, 1985).

Syzygium moorei approaches its southern distributional limit at the site. A number of mature canopy specimens and saplings are represented in the remnant. Floods may play an important role in seed dispersal and recruitment for this species at this site.

The riparian edge of Killen Falls remnant provides potential habitat for two species of threatened riparian plants listed under the TSC Act 1995. These are *Sauropus Phyllanthus microcladus* (Endangered) and Thorny Pea, *Desmodium acanthocladum* (Vulnerable).

7.1.6. Exotic plant species

Up to 21 common weed species (including environmental and agricultural weeds) have been identified from Killen Falls remnant (Table 4). Of the weeds identified, 19 are listed as major weeds in *Common Weeds of Northern NSW Rainforests* (2000).

Table 4. Weed species identified at Area 1

Common Name	Botanical Name	Abundance
Vines and creepers		
Madeira Vine X	<i>Anredera cordifolia</i>	Nil (located nearby)
Edible Passionfruit	<i>Passiflora edulis</i>	Low
White Passionfruit	<i>Passiflora subpeltata</i>	Low
Climbing Nightshade	<i>Solanum seaforthianum</i>	Low
Ground covers, herbs		
Mistflower W	<i>Ageratina riparia</i>	Low
Crofton W	<i>Ageratina adenophora</i>	Moderate
Hairy Commelina	<i>Commelina benghalensis</i>	Low
Tropical Chickweed #	<i>Drymaria cordata</i> subsp <i>cordata</i>	Low
Freckle Face	<i>Hypoestes phyllostachya</i>	Nil (located nearby)
Coral Berry	<i>Rivina humilis</i>	Floyd 1985
Palm Grass	<i>Setaria palmifolia</i>	Low
Trad X	<i>Tradescantia fluminensis</i>	Low
Shrubs		
Lantana X	<i>Lantana camara</i>	Moderate
Ochna / Mickey Mouse Bush	<i>Ochna serrulata</i>	Low
Barner Grass	<i>Pennisetium purpureum</i>	Low
Smooth Senna	<i>Senna x septemtrionalis</i>	Low
Winter Senna	<i>Senna pendula</i> var. <i>glabrata</i>	Low
Tobacco Bush	<i>Solanum mauritianum</i>	Low
Trees and small trees		
Camphor Laurel X	<i>Cinnamomum camphora</i>	Low
Coccos Palm	<i>Syagrus romanzoffianum</i>	Very Low
Large-leaved Privet X	<i>Ligustrum lucidum</i>	Moderate
Small-leaved Privet X	<i>Ligustrum sinense</i>	Moderate

Denotes native plant with potential weed characteristics. W - Denotes noxious weed, X - regionally significant weed (Appendix 4b). Refer to the Appendix 4 for weed control techniques.

7.1.6.1. Description of the main weeds

Trad: Trad is mainly restricted to moister areas along the riparian edge. A robust infestation of Trad is located at the base of the falls where it is covering boulders, smothering ferns and is restricting the recruitment of native seedlings (Plate 3). Trad is also located upstream of the remnant but is more parched where it occurs on exposed rocky substrate. Where Trad occurs amongst ferns, threatened plants (e.g. *Isoglossa*) and riparian areas, it should be hand removed where practical to avoid non-target impacts.

Large-leaved Privet: This species has a scattered distribution and is more frequent along the remnant edges, particularly along the riparian zone (Plate 5). It is also found within the remnant interior occurring as a patch of smaller shrubs & saplings on rock scree (plant sizes at 2-4m). Further trees & shrubs are likely to occur on site but can be difficult to observe as they easily blend into the native foliage.

Small-leaved Privet: Small -leaved Privet has a scattered distribution. It is more prevalent along the remnant edges where it forms shrubby thickets, dense seedling patches or occurs as scattered plants in the understorey (Plate 5). Small-leaved Privet is readily dispersed by birds and can persist in low light conditions. It is more common along the upper north - eastern edge of the remnant, beside the falls and occurs sporadically along the lower riparian edge.

Ochna: Ochna occurs sporadically along the remnant edges (Plate 8). Saplings and seedlings are prevalent. Ochna grows in shaded conditions and will form a dense thicket. Early control of this species is highly recommended.

Lantana: Lantana occurs sporadically along the northern and riparian edge of the remnant. It also occurs in some of the smaller gaps near the northern edge. A Lantana covered slope demarks the southern edge of the remnant (Plate 6). This slope is identified as protected land (see Appendix 6).

Madeira Vine: This exotic vine occurs in the local catchment on the same property (see location – Figure 2). The presence of this weed in close proximity to the remnant is of great concern as there is potential for Madeira Vine tubers to be dispersed to the remnant by birds and machinery. Madeira Vine infestations can be difficult to control and require a regular and long-term management strategy using a range of techniques including the control of aerial infestations, follow-up spraying of tuberling beds and hand weeding (in sensitive areas) until all tubers are effectively removed. Monitoring of this infestation is highly recommended.

Freckle Face: This plant occurs in the vicinity of the Madeira Vine infestation. Freckle Face is likely to have been a garden escape from the previous homestead site on the Deenford Plantation property. Freckle Face has tiny seeds that are spread by local seed drop and by water. It forms a dense ground cover and will inhibit native seedling regeneration. Early control of this plant is advised to reduce its spread in the local environment and it is very difficult to control requiring repeated treatments (see Appendix 4).

Infestations of serious weeds such as Large-leaved Privet, Small-leaved Privet, Ochna, and Trad have the potential to compromise the regeneration capacity and ecosystem integrity of the remnant. The weed species within vicinity of the remnant are currently at a practical management stage. Strategic and systematic weed control will help reduce on site weed sources and potential future impacts. Follow-up maintenance and control of weed regrowth is required to exhaust weed seed banks and to create conditions that are less favourable for weeds to establish such as a dense cover of native species.

7.1.7. Remnant condition and restoration capacity

Despite the remnants limited size, Killen Falls is considered to be in relatively good condition noted by the remnants structural complexity and diverse native plant species composition (see Appendix 1). The remnant supports relatively intact forest comprising of emergent trees above a mature layered tree canopy with few canopy gaps (Plate 2), with a diverse mid-stratum. The lower stratum is sparse on steeper gradients to more complex on undulating terrain supporting Walking Stick Palms, shrubs and a diversity of suppressed and regenerating tree seedlings, herbs and ferns (see Table 2). The forest edges on the upper slope generally comprise early secondary regrowth species (Plate 7). Vine tangles occur throughout and vine-curtains are a common feature along the edges, and in canopy gaps.

Weed species are mainly concentrated to the remnant edges with incursions of Privet, Ochna and Lantana scattered throughout (Plate 4, 5,6). These weed species pose a threat to the future integrity of the remnant as they are able to persist in low light conditions and will gradually out compete and replace native species over time (see Appendix 3). A moderate level of inputs will be required over the first few years following the initial control of weeds.

Overall, the remnant exhibits relatively good regenerative potential evident by the intact forest and diverse seedling recruitment. The remnant edges will always be subject to weed invasion. It is expected that seedling regeneration and development will be variable as a result of exposed edge conditions and weed competition and will require a longer term of follow-up. The site exhibits a high level of regeneration potential but the ability of the site to recover from future disturbances (such as natural tree falls, storm damage or pest attack) is compromised by the small size of the remnant occurring within a modified landscape. This is exacerbated by the high level of bird dispersed weeds within the local vicinity.

Human intervention is required to improve the condition, regenerative capacity and long term viability of the remnant. A long-term program involving strategic weed control, monitoring of the remnant edges and tree falls is required, and where practical edge enhancement and remnant extension.



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Plate 4: Riparian edge of the remnant down stream of the falls. Large-leaved Privet is common along this edge.

Plate 5: North- east remnant edge abutting Macadamia plantation. Small-leaved Privet is frequent along this edge occurring with a diversity of other weeds.

Plate 6: This steep Lantana slope demarks the southern edge of the Killen Falls remnant.



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9.

Plate 7: Upper northern edge of remnant next to Macadamia plantation. Sweet Pittosporum and other early successional species are common.

Plate 8: Inside the northern edge of the remnant. Denser vegetation lies at the crest of the slope. The foreground area has experienced some disturbance in the past. Ochna is located in this area.

Plate 9: Chunky mature rainforest trees are a feature of the remnant interior.

7.1.8. Restoration guidelines: Killen Falls remnant (private) - Area 1

To maintain and enhance the viability of the Killen Falls remnant the following guidelines are recommended. The remnant has been divided into four work zones to assist in the location of weeds and the identification of management problems (Appendix 2). The implementation of work zones at this site may vary according to weather conditions and farm activities.

Zone 1. Northern edge

This zone encompasses the forest edge along the upper slope of the remnant.

Zone 2. Emigrant Creek edge

This zone extends along the creek edge from the base of the falls to the southern most end of the remnant.

Zone 3. Forest core

This zone incorporates the central section of the remnant.

Zone 4. South-eastern edge

This zone occurs at the southern most edge of the remnant where it abuts a steep lantana infested slope.

ZONE 1. Northern Edge

Weed Control

- Commence primary weed control work along the top south eastern edge of the remnant working towards Killen Falls. Control weeds along the edge in a broad swathe (weeds are mainly restricted to the first 10 metres of the edge).
- Strategically inject Camphor Laurels along remnant edges to minimise impacts to adjacent vegetation including regenerating trees. Where required remove overhanging Camphor limbs prior to tree injection or strategically fell tree minimising impacts to adjacent native plants.
- Control weeds in the understorey prior to controlling weeds in the upper strata. Cut-scape & paint smaller woody weeds and spot spray weed seedlings.
- Stem inject Privets occurring along the remnant edge (both Small-leaved Privet and Large-leaved Privet).
- Identify weeds along the forest edge that may be problematic to the management of the macadamia plantation. Ensure these are managed by the regeneration team.
- Maintain patches of rainforest ferns and herbs. Where required, undertake hand weeding.
- Stage the control of Small-leaved Privet thicket located near the edge of Killen Falls. It may be necessary to maintain some microclimate to assist native seedling recruitment.
- Undertake periodic follow-up control of weed seedlings & weed regrowth using strategic spot spraying, cut-scape & paint and hand removal techniques.

Edge Enhancement

- Aim to sharpen up the remnant edges through regenerating convoluted / depressions in the edge. Encourage the establishment of pioneers and other native species in edge gaps.
- Maintain fence near the top of Killen falls to restrict public access into the remnant & regeneration site.
- Assess canopy tree health and the need for strategic vine management (for all zones).

- Where practical avoid slashing under the edges of canopy trees (unless farm access is required) to promote a dense forest edge.

Zone 2. Emigrant Creek edge

- Commence work at the base of Killen Falls working downstream to the end of the remnant, along the riparian / remnant edge and on the alluvial creek flat.
- Systematically inject Privets and Camphor Laurels along the creek edge. Control Lantana using cut scrape and paint.
- Hand-weed Trad infestation located on the edge of the waterfall pool and around native ground covers and native ferns. Pile and compost biomass away from the flood zone. Strategically spray dense patches of Trad in other less sensitive areas.
- Control exotic grasses near the waterfall pool. Spot spray or cut back foliage and spray regrowth; otherwise crown out plants. Confirm the identification of grasses prior to their control.
- Undertake periodic follow-up control of weed regrowth.
- Avoid creating tracks leading into the forest edge from the creek line.

Zone 3. Forest core

- Control the small infestation of Large-leaved Privet situated about 50m into the forest edge. Access can be gained above the cliff line near the top of the falls, and navigating across slope to a bench below. Stem-inject or cut-scrape & paint the Privet to minimise soil disturbance.
- Systematically control weeds throughout the forest interior such as sporadic Lantana infestations occurring in canopy gaps and scattered weeds (e.g. Ochna, Privet, Climbing Nightshade etc).
- Strategically control native vines that are inhibiting the regeneration of canopy gaps (Appendix 5).

Zone 4. South east edge

- Cut a break between the Lantana thicket and the remnant edge. Aim to gradually expand the southern edge of the remnant out into the steep Lantana infested slope.
- Promote the establishment of pioneers, figs and other hardy species.
- Broadcast rainforest seed onto the Lantana slope. Use seed from large fruited, locally occurring rainforest species (Appendix 11).
- The steep Lantana infested slope is recognised as Protected Lands and requires strategic management (Appendix 6). In the interim it should be left.

Summarised restoration guidelines - Killen Falls remnant Area 1

- Work along the Emigrant Creek edge of the remnant**
- Work along the top northern-eastern edge**
- Work though the forest core**
- Work along the southern edge - steep slope**

7.2. Deenford regrowth - Area 2

7.2.1. General site description

Area 2 comprises three differing plant communities, which have been placed into separate management areas (Area 2a, 2b and 2c). These are situated adjacent to Emigrant Creek upstream of Killen Falls (see Figure 2).

Area 2a comprises of two small patches of rainforest with a narrow strip of vegetation along the riparian zone connecting to the Killen Falls remnant (see Plates 10 -11). Area 2a is about 0.5 hectares in size.

Area 2b is about 1.5 hectares in size and comprises of regrowth forest dominated by Camphor Laurel with patches of regrowth rainforest there in. Area 2b has 150m frontage to Emigrant Creek and extends toward the base of the Emigrant Creek Dam wall (Plate 13,14).

Area 2c is about 0.25 hectares in size and consists of a Lantana infested drainage line and a wetland area that is colonised mainly by Crofton (Plates 15,16).

7.2.2. Site history & management

Area 2 has experienced a varied disturbance history and land use regime. Area 2a appears to have had a less prolonged disturbance history and may contain some remnant trees. The main patches are separated by small tracks that are periodically slashed. Area 2b is highly modified yet exhibits sections with good natural regeneration to more impoverished areas. Area 3a is highly modified. Bush restoration works have not been undertaken in Area 2.

7.2.3. Vegetation classification

The vegetation in Area 2 has been classified as:

Area 2a: complex notophyll tall closed vine forest (subtropical rainforest with Camphor Laurel)

Area 2b: simple-complex notophyll tall closed-open forest (Camphor Laurel dominated forest with early successional subtropical rainforest species)

Area 2c: shrubland (Lantana and woody weed regeneration) and **closed sod grass and forb land** (dominated by Crofton and exotic grasses)

Area 2a is indicative of the White Booyong *Heritiera trifoliolata* alliance. It is impractical to assign a suballiance to this patch owing to its small size and disturbance history. Area 2a also includes a narrow patch of forest on stony substrate adjacent to the riparian zone that supports species more typical to dry rainforest.

Area 2b is likely to have supported vegetation similar to that displayed at Killen Falls remnant.

Area 2c is a degraded wetland that is dominated by Crofton, Lantana and exotic grasses. Area 2c may have supported a complex of vegetation communities ranging from rainforest and palm forest on slight elevation grading into a swamp land community on lower lying topography.

Remnant wetlands are scattered throughout the Big Scrub including the Emigrant Creek catchment. Botanical surveys of these wetlands are required to help provide a reference point for planning restoration strategies for Area 2c.

7.2.4. Vegetation floristics

Area 2 has not been comprehensively surveyed, however up to 50 trees and shrubs have been recorded (Appendix 1). Area 2a exhibits fairly intact structure with a greater component of native species in all stratum (see Table 5).

Table 5. Species common in each stratum – Area 2a

Emergent – Small-leaved Fig
Canopy – White Booyong, Teak <i>Flindersia australis</i> , Pepperberry, Yellow Pear Fruit, Giant Water Gum, Rosewood <i>Dysoxylum fraserianum</i> , Cudgerie, Coolamon, Red Ash, Ribbonwood <i>Euroschinus falcata</i> var. <i>falcata</i> , *Camphor Laurel
Mid – White Bolly Gum, Red Kamala, Green Bolly Gum, Riberry, Myrtle Ebony <i>Diospyros pentamera</i> , Sassafras <i>Doryphora sassafras</i> , Sandpaper Fig <i>Ficus fraseri</i> , Sweet Pittosporum
Lower – Smooth Mock-olive, Actephila, Walking Stick Palm, Orange Thorn, Veiny Wilkea <i>Wilkea hugeliana</i> , Red Fruited Palm Lily <i>Cordyline rubra</i> , *Small-leaved Privet
Ground – Creeping Shield Fern, Bordered Shield Fern, Harsh Ground Fern <i>Hypolepis muelleri</i> , *Mistflower

Area 2b is dominated by Camphor Laurel in the upper stratum with a limited representation of early successional and later stage rainforest tree species in the canopy. In sections the lower strata exhibits a good diversity of regenerating seedling, shrubs and smaller trees (Table 6). Canopy sized Brush Box trees occur sporadically through this area.

Table 6. Species common in each stratum – Area 2b

Emergent - Nil
Canopy – *Camphor Laurel, Cudgerie, Red Ash, Brush Box, Red Bean, Foambark, Hard Quandong, Guioa, Brown Kurrajong <i>Commersonia bartramia</i> *Large-leaved Privet, Riberry, Red Cedar
Mid – *Camphor Laurel, Sweet Pittosporum, Red Kamala, Guioa, *Small-leaved Privet, *Large-leaved Privet, Red Bean, Green Bolly Gum, White Bolly Gum, Twin-leaf Coogera.
Lower – *Small-leaved Privet, * Large-leaved Privet, Guioa, *Lantana, Steelwood, Green Bolly Gum, Red-fruited Palm Lilly, Guioa, Red Bean.
Ground – *Mistflower *Privet spp. (seedlings), Rough Maidenhair Fern <i>Adiantum hispidulum</i> , Creeping Shield Fern and various seedlings of rainforest trees.

* Denotes introduced species.

Area 2c has had limited survey effort but generally comprises weed species (Table 7). A few remnant Bangalow Palms and Brush Box trees and Camphor Laurel occur on slight elevation on the edges of the wetland.



Plate 10: Riparian edge of Area 2b, located next to the Killen Falls remnant.



Plate 11: Area 2b – less complex forest occurring on stony substrate.



Plate 12: A stand of *Medicosma cunninghamii*. occurs in Area 2b (Plate 11).



Plate 13: Vegetation on the northern side of Emigrant Creek upstream of the falls. Relic Bangalow Palms (Area 2a) occur on the edge of the Crofton wetland (mid ground - Area 2c). Area 2b is in the background.



Plate 14: Southern riparian edge of Area 2b below the Emigrant Creek Dam wall



Plate 15: Northeastern edge of Area 2b (mid ground) & Lantana gully, top edge of Area 2c.

Table 7. Species common in each stratum – Area 2c

Canopy - (along elevated edges of the site) – Bangalow Palm, Brush Box, Red Cedar, *Camphor Laurel
Lower – *Crofton, *Mistflower, *Lantana intertwined with *Five-leaved Morning Glory <i>Ipomoea cairica</i> *, native sedge and fern species and *Para Grass <i>Urochloa mutica</i>
* Denotes introduced species.

7.2.5. Threatened plants

Four plants of conservation significance were identified from Area 2 (Table 8). Coolamon is represented as an individual canopy-sized tree and a number of recruits.

Table 8. Threatened and ROTAP plants identified from Area 2

Common Name	Botanical Name	TSC Act 1995	ROTAP	EPBC Act 1999	Area
		Schedule 2			
Arrow-head Vine	<i>Tinospora tinctoroides</i>	Vulnerable	3RC-	V	2a
Coolamon	<i>Syzygium moorei</i>	Vulnerable	3VC-	V	2a
Smooth Scrub Turpentine	<i>Rhodamnia maideniana</i>	-	2RC-		2a,2b
Quassia (shrub)	<i>Quassia</i> sp 'Mt Nardi'	-	3RC-		2b

7.2.6. Exotic plant species

At least 22 weed species have been recorded from Area 2 (Table 9). This list is excluding many of the annual herbaceous weeds that occur throughout the site.

Table 9. Weed species identified at Area 2

Common Name	Botanical Name	Abundance
Vines and creepers		
Five-leaf Morning Glory X	<i>Ipomoea cairica</i>	Low
Corky Passionfruit	<i>Passiflora suberosa</i>	Moderate
White Passionfruit	<i>Passiflora subpeltata</i>	Low
Climbing Nightshade	<i>Solanum seaforthianum</i>	Low
Ground covers, herbs		
Mistflower W	<i>Ageratina riparia</i>	Moderate
Crofton W	<i>Ageratina adenophora</i>	High
A Goatweed	<i>Ageratina houstonianum</i>	Moderate
Hairy Commelina	<i>Commelina benghalensis</i>	Low
Tropical Chickweed #	<i>Drymaria cordata</i> subsp <i>cordata</i>	Low
Trad	<i>Tradescantia fluminensis</i>	Low
Setaria	<i>Setaria sphacelata</i>	Moderate
Para Grass	<i>Urochloa mutica</i>	Moderate
Shrubs		
Lantana W	<i>Lantana camara</i>	Moderate
Ochna / Mickey Mouse Bush	<i>Ochna serrulata</i>	Low
Smooth Senna	<i>Senna x septemtrionalis</i>	Low
Winter Senna	<i>Senna pendula</i> var. <i>glabrata</i>	Low
Tobacco Bush	<i>Solanum mauritianum</i>	Low
Trees and small trees		
Camphor Laurel X	<i>Cinnamomum camphora</i>	High
Large-leaved Privet X	<i>Ligustrum lucidum</i>	High
Small-leaved Privet X	<i>Ligustrum sinense</i>	High
Slash Pine	<i>Pinus elliotii</i>	Low
Cherry Guava	<i>Psidium cattleianum</i>	Low

Denotes native plant with potential weed characteristics. W - Denotes noxious weed, X - regionally significant weed (Appendix 4b). Refer to the Appendix 4 for weed control techniques.

7.2.6.1. Description of the main weeds

Lantana is frequent on the forest edges, in gaps and along exposed drainage lines.

Five-leaf Morning Glory: This species occurs throughout Area 2c and along the floodplain edges of both forest patches where it is growing amongst Crofton and Lantana shrubland. This climber can be difficult to control and may smother the forest edges. A break should be made between the forest edge and the weedy shrubland.

Corky Passionfruit: This species occurs sporadically along the northern edge of Area 2b.

Small-leaved and Large -leaved Privet: These species occur frequently in both forest patches. Large-leaved Privet is most prevalent in Area 2b along the edge of Emigrant creek and adjacent to the dam wall. It also is prevalent as saplings along the northern edge.

Camphor Laurel: This is the most dominant weed species particularly in Area 2a. In Area 2b it occurs predominantly on the forest edges.

7.2.7. Vegetation condition and restoration capacity

Area 2a exhibits structural complexity with a good canopy cover and a diversity of native plant species. Seedling regeneration of early to later successional species is evident, suggesting good restoration capacity especially if given appropriate management, however the patches are small with irregular edges and are prone to future disturbances and weed invasion. Weeds such as Camphor Laurel and Lantana occur along the edges with Mistflower and Small-leaved Privet prevalent throughout.

Area 2b is a highly modified and is largely dominated by weeds namely Camphor Laurel, Privet and Mistflower. However, the central/north-eastern section of Area 2b contains a fair representation of native plants (rainforest saplings of various species and successional stages and the occasional rainforest canopy tree). The majority of the native regrowth plants are species that are bird dispersed. It is expected that if provided with strategic weed management the site will largely regenerate to a forest dominated by earlier successional species and to a lesser extent with later stage mature phase species over the long term. The regeneration capacity of the lower slopes of Areas 2b is low owing to the high level of weed infestation and steep creek banks. A significant amount of resources is required to improve the condition of Area 2b and results will be dependent on the regeneration measures and amount of effort applied.

The drainage line in Area 2c, located between Area 2a and 2b is likely to regenerate with pioneer and early secondary species and various weeds following the removal of Lantana.

The low lying flood prone part of 2c is highly disturbed, weed dominated and is subject to periods of inundation. A strategic [plan should be developed for this site which includes a survey of other



Plate 16: The Crofton infesta wetland feature Area 2c.



Plate 17: Eastern Water Dragon *Physignathus lesueurii* ssp. *lesueurii*. Enjoying a nice sunbake on the remnant edge near the wetland.



Plate 18: *Quassia* sp. 'Mt Nardi'. This ROTAP plant occurs throughout the project site.

wetland sites in eth locality. Strategies to recover this site may need to be flexible and rely on experience gained on the site overtime.

Area 2a has a moderate restoration capacity whereas Area 2b and 2c are less robust as a result of modified conditions and will require a longer term work program, including strategic planting to accelerate the development of forest complexity and to improve habitat resources.

The resilience of Area 2 in context to recovering the sites ecological function to a self sustaining capacity is highly limited and will require a long term restoration program owing to the small patch size, disturbance history and large area of edge. The restoration of Area 2 is highly important however to improve the long term viability of the remnant through effectively increasing the area of native vegetation and habitat in the locality and reducing weed sources.

7.2.8 Restoration guidelines: Deenford regrowth - Area 2a,b,c

Area 2A: Rainforest patch

- Commence weed control in Area 2a starting from the edge nearest to the Killen Falls remnant. Control all weeds in a systematic and strategic fashion. However, retain woody weeds for temporary microclimate where required.
- Control Trad infestation in this area through strategic spot spraying, and hand weeding near ferns and herbs.
- Strategically stem-inject mature woody weeds. Control weeds in the understorey prior to controlling weeds in the upper stratum.
- Clear weeds around the edge of the regrowth patches, making a break between the Lantana and Morning Glory infested drainage line (Area 2c). This is important to reduce the spread of the Morning Glory into the forest and to promote the expansion of the forest edge. The area should be surveyed for ground nesting birds such as the Bush Hen prior to weed control works.
- Control weeds on the small peninsular (with the remnant Bangalow Palms). Avoid cutting Lantana up into small sections in moist areas to minimise reshooting of stems. Alternatively, hang cut stems off the ground.
- Strategically inject Camphor Laurels along remnant edges to minimise impacts to adjacent vegetation including regenerating trees. Where required remove overhanging Camphor limbs prior to tree injection or strategically fell tree.
- Follow-up control weed seedlings & weed regrowth using strategic spot spraying or cut-scrape & paint control techniques.
- Control Five-leaved Morning Glory - hand pulling runners and spot-spraying regrowth.
- Where practical avoid slashing under the edges of canopy trees (unless farm access is required) to promote a dense forest edge by allowing regeneration under canopy trees. Spray exotic grasses to assist seedling recruitment. Identify weeds along the forest edges that may be problematic to the macadamia plantation and ensure these are managed by the regeneration team.
- Investigate the practicalities of broadening the narrow band of vegetation next to the remnant with a planting of early successional - fast growing species (see Appendix 1).
- Aim to consolidate the forest patches in Area 2a through regenerating tracks and convoluted edges. Promote natural regeneration and undertake strategic planting to accelerate development of canopy cover where required.
- Following the successful management of weeds through Area 2a aim to expand the forest edges into the drainage line through gradual control of Lantana in Area 2c - eventually linking up to the adjacent Camphor dominated forest (Area 2b). Assess regeneration response after Lantana control and plant trees where required. Consider establishing stands of Bangalow Palms and other moisture favouring species (Appendix 11).

Area 2B. Camphor Laurel patch.

- Commence weed control from near the eastern edge of Area 2b and focus work in areas with a component of native species in the upper and lower stratum (Plate 15).
- Strategically stem-inject mature woody weeds around patches of native regrowth. Control weeds in the understorey prior to controlling weeds in the upper stratum. This will create a mosaic of active regeneration sites throughout the Camphor forest.

- The extent of Camphor Laurel control must correspond to the level of resources available for follow-up weed management until canopy cover develops.
- Follow-up control weed regrowth using strategic spot spraying, cut-scrape & paint and hand weeding techniques (see Appendix 4).
- Control Corky Passionfruit in the area, as part of the systematic control of weeds. Hand-pull or cut-scrape & paint mature vines and strategically spray regrowth and seedlings (see Appendix 4).
- Undertake planting where natural regeneration is limited in Area 2b and where the establishment of riparian vegetation, edge buffers or the accelerated development of forest complexity is required (see Appendix 5 & 11).

Area 2C – Crofton Wetland

- Further assessment of the sites plant species diversity, hydrological characteristics and functions is required prior to undertaking restoration works in the lowlying parts of this wetland.
- Undertake vegetation surveys of wetland areas occurring in the upper Emigrant Creek catchment to determine native plant species lacking in Area 2c (see Appendix 11).
- Restoration work can be undertaken up to the edge of the low lying wetland area expanding the edges of the forest communities (Area 2a and 2b). Establish rainforest species, Brush Box and Bangalow Palms on the slightly elevated edges of the wetland.
- Trial over spraying strips of Crofton along the lower edges of the wetland and rake back dead biomass. Control weed seedlings and weed regrowth and assess regeneration potential. Where this is limited undertake planting using appropriate species (based on further assessment).
- Area 2c will require a flexible and long-term management program. Until resources are available the area should be retained in the interim for its habitat values e.g. for crakes, rails and the Bush Hen.

Summarised restoration program – Deenford Regrowth Area 2

1. ***Regenerate Area 2a (forest patches adjacent to the remnant).***
2. ***Regenerate the drainage line linking Area 2a & 2b.***
3. ***Commence work in Area 2b focussing weed control in areas with a component of native regrowth – expanding and linking centres of regrowth.***
4. ***Undertake strategic planting in regrowth areas with limited regenerative capacity.***
5. ***Rehabilitate Area 3c - Crofton dominated wetland.***

7.3. Ballina Council Reserve - Area 3

7.3.1. General site description

The Ballina Council Reserve (Area 3) is a narrow parcel of land that lies opposite the Killen Falls remnant, on the southern side of Emigrant Creek (Figure 2). Area 3 is about 1.38ha in size. It is 450m long and ranges in width from 75m – 50m, tapering to a narrow point towards the southern edge of the remnant. Area 3 has a fairly exposed north facing position with extensive areas of surface rock.

7.3.2. Site history & management

The land has a history of clearing and cattle grazing. It now comprises about 20 years of regrowth. A walking track meanders through the reserve accessed from Killen Falls Drive (Plate 19,20). The track was formerly used for vehicular access to the falls. Ballina Council is supporting the restoration of this site. During the preparation of this report EnviTE has undertaken some track work and strategic weed control.

7.3.3. Vegetation classification

The regrowth vegetation in Area 3 has been classified as:

- **simple-complex notophyll mid-high closed-open forest** (dominated by Camphor Laurel and early successional rainforest species)
- **shrubland** (dominated by Lantana and woody weed regeneration)
- **closed sod grass and forb land** (dominated by exotic grasses, native sedges and forbs)

The reserve supports a diversity of habitats attributed to its varied topography, exposed rock and riparian environments. The site is in various stages of recovery containing a mosaic of weed regrowth, exotic pasture grasses and early successional native regrowth associated with Camphor Laurel (Plate 21).

Prior to clearing the site is likely to have supported complex forest similar to the Killen Falls remnant on the deeper soil profiles and the alluvial flats along the eastern edge of the reserve. Sections of the reserve with shallow soil and sub surface rock are more likely to have supported a drier formation of less complex rainforest potentially with sclerophyll attributes such as Brushbox, which is still evident.

7.3.4. Floristics

A limited diversity of native plant species were recorded from Area 3 with 45 species of trees and shrubs, 18 vines, 12 ferns, 9 herbs and ground covers and 6 native grass species (see Appendix 1). At least 13 native water plants were recorded within the immediate riparian zone.

The reserve comprises patches of exotic grasses (Molasses Grass *Melinis minutiflora*, Broad-leaved Paspalum *Paspalum wettsteinii* and Whiskey Grass *Andropogon virginicus*), Lantana and woody

weed thickets. Camphor Laurel is the dominant species on site being interspersed with early successional rainforest species. Early successional species (see Table 10) are most common. A few later stage species such as Bennetts Ash, Water Gum, Scrub Turpentine and Green Bolly Gum, and regrowth Brush Box are also evident.

Table 10. Species common in each stratum – Area 3

Canopy – * Camphor Laurel, Cudgeri, Bennetts Ash, Red Ash, Brush Box, Foambark, Guioa, Sally Wattle <i>Acacia melanoxylon</i> , *Large-leaved Privet, *Slash Pine
Mid - lower *Camphor Laurel, Sweet Pittosporum, Red Kamala, Guioa, Steelwood *Small-leaved Privet, *Large-leaved Privet, Scrub Turpentine, Native Guava, Winter Senna * <i>Senna pendula</i> *Lantana
Ground – *Mistflower, *Molasses Grass, Bracken Fern <i>Pteridium esculentum</i> , Rough Maidenhair Fern Gristle Fern <i>Blechnum cartilagineum</i> . Seedlings: Guioa, Red Kamala, Red Ash, Yellow Carrabeen <i>Sloanea</i> <i>woolsii</i> , *Privet spp, Steelwood, Hard Quandong, Green Bolly Gum, Red Bean, Bennetts Ash
* Denotes introduced species.

7.3.4.1. Riparian vegetation above Killen Falls

Permanent water pools and intermittent waterways upstream of the falls support a range of grasses, sedges and herbs. Vegetation in these areas varies with Swamp Ricegrass *Leersia hexandra* (a native grass) dominant in the intermittent waterways, Lantana on slightly elevated land with a range of grasses and herbs including Setaria, Para Grass, Hairy Commelina, Crofton, Trad, Native Smart Weeds *Persicaria* spp. along the creek edges. This low dense shrubby vegetation including the weed species provides nesting and foraging habitat for waterbirds. Remnant Bangalow Palms also occur on the adjacent creek bank. A description of the wetland plant species occurring below the falls is addressed in section 7.1.4.1.

7.3.5. Threatened plants

Two plants of conservation significance are identified from Area 3 (see Table 11). Quassia is represented by a number of plants (Plate 18).

Table 11. Threatened and ROTAP plants recorded at Area 3

Common Name	Botanical Name	TSC Act 1995	ROTAP	EPBC Act 1999
		Schedule 2		
Arrow-head Vine	<i>Tinospora tinoporoides</i>	Vulnerable	3RC-	V
Quassia (shrub)	<i>Quassia</i> sp. 'Mt Nardi'	-	3RC-	-

7.3.6. Exotic plant species

At least 33 exotic plant species are recorded from Area 3 (Table 12). Over half of these species are recognised as environmental weeds that have the capacity to invade and modify natural ecosystems or inhibit the recovery of disturbed landscapes. The main weeds that are a management issue to the site are Camphor Laurel, Privet spp., Senna spp. and Slash Pine. Exotic grasses are well represented on the site with at least 13 species occurring across a range of habitats ranging from riparian to exposed rock ledges. The diversity of grass species on the site is a response to the high level of light, patchy canopy cover and remnants of pastureland.

Weeds that may hinder the regeneration of the immediate riparian edges and moister habitats include Goatweed, Trad, Crofton, Mistflower, Hairy Commelina, Para Grass and Setaria.

Table 12. Weed species identified at Area 3

Common Name	Botanical Name	Abundance
Vines and creepers		
Sliver-leaved Desmodium	<i>Desmodium uncinatum</i>	Low
Edible Passionfruit	<i>Passiflora edulis</i>	Very Low
White Passionfruit	<i>Passiflora subpeltata</i>	Low
Grasses, ground covers, herbs		
Mistflower W	<i>Ageratina riparia</i>	Low
Crofton W	<i>Ageratina adenophora</i>	Moderate
Goatweed	<i>Ageratina houstonianum</i>	Moderate
Para Grass	<i>Urochloa mutica</i>	Moderate
Hairy Commelina	<i>Commelina benghalensis</i>	Moderate
Trad X	<i>Commelina fluminensis</i>	Low
Broad-leaved Paspalum	<i>Paspalum wettsteinii</i>	Moderate
Tropical Chickweed #	<i>Drymaria cordata</i> subsp <i>cordata</i>	Low
Whiskey Grass	<i>Andropogon virginicus</i>	Low
Narrow-leaved Carpet grass	<i>Axonopus affinis</i>	Low
Couch	<i>Cynodon dactylon</i>	Low
Molasses Grass	<i>Melinis minutiflorus</i>	Moderate
Red Natal Grass	<i>Melinis repens</i>	Low
Vasey grass	<i>Paspalum urvillei</i>	Moderate
Broad-leaved Paspalum	<i>Paspalum wettsteinii</i>	Low
Kikuyu	<i>Pennisetum clandestinum</i>	Low
Salvia	<i>Salvia splendens</i>	Low
Setaria	<i>Setaria sphacelata</i>	Moderate
Setaria - Slender Pigeon Grass	<i>Setaria gracilis</i>	Low
Buffalo Grass	<i>Stenotaphrum secundatum</i>	Low
Shrubs		
Groundsel W	<i>Baccharis halimifolia</i>	Low
Lantana X	<i>Lantana camara</i>	Moderate
Ochna	<i>Ochna serrulata</i>	Low
Winter Senna	<i>Senna pendula</i> var. <i>glabrata</i>	Mod- High
Smooth Senna	<i>Senna septemtrionalis</i> (syn. <i>floribunda</i>) X	Low
Trees and small trees		
Camphor Laurel X	<i>Cinnamomum camphora</i>	High
Large-leaved Privet X	<i>Ligustrum lucidum</i>	High
Small-leaved Privet X	<i>Ligustrum sinense</i>	High
Slash Pine	<i>Pinus elliotii</i>	Moderate
Cocco's Palm	<i>Syagrus romanzoffianum</i>	Very Low

- Denotes native plant with potential weed characteristics. W - Denotes noxious weed, X - regionally significant weed (Appendix 4b). Refer to the Appendix 4 for weed control techniques.

7.3.6.1. Description of the main weeds

Camphor Laurel: This is the most abundant weed throughout the site forming a mid-high canopy along the upper slope and riparian edge (Plate 21). Camphor Laurel seedlings and dense patches of young saplings are also prevalent (Plate 22).

Large-leaved Privet: This plant is prolific toward the eastern portion of the reserve where it occurs on the rocky slopes below the cliff line forming a monoculture of trees, dense patches of saplings and seedlings.



Plate 19: The western edge of the Ballina Council Reserve (Area 3). Weed control and planting is recommended at this point.



Plate 20: Track running along the edge of the Reserve. Mature Slash Pines on the neighbouring property are a dominant feature (Area 4). Planting up the grass patches is required to assist site recovery.



Plate 21: Riparian edge of the Reserve upstream of Killen Falls consisting of Camphor Laurel, Slash Pine & rainforest regrowth. Molasses grass is prevalent on shallow soil with exposed rock.



Plate 22: Exotic grassland on the Council Reserve (Area 3) is regenerating with weeds such as Slash Pine, Camphor Laurel, Lantana and Winter Senna.



Plate 23: Camphor Laurel regrowth along the Emigrant Creek edge of Area 4. Killen Falls remnant is in the background.

Small-leaved Privet: It is scattered throughout and forms dense stands on the alluvial flats at the southern portion of the Reserve.

Molasses Grass and other exotic pasture grasses: Remnants of exotic pasture grasses occur at the entrance to the reserve and are scattered across the site, which are gradually being replaced by woody weeds (Plate 22). Some of patches of Molasses Grass and Whiskey Grass are indicative of poor soil conditions influenced by a shallow soil substrate (e.g. above the cliff line and rock benches along the creek).

Slash Pines: Slash Pines are establishing in Area 3 spreading from neighbouring properties. Larger trees and seedlings are evident (Plate 21).

7.3.7. Vegetation condition and restoration capacity

The vegetation within Area 3 is highly modified, weed dominated and exposed. The site is regenerating from a former grazing paddock into a matrix of woody weeds and regrowth rainforest. Based on the sites current level of weed impacts, limited representation of native plants and long history of disturbance Area 3 is in poor to moderate condition.

A few remnant rainforest trees are situated near the base of the falls. The most complex patches of native regrowth occur above the cliff line (in proximity to Killen Falls near a stand of Brush Box) and further upstream along the riparian zone in association with Camphor Laurel. Natural regeneration mainly comprises early secondary species and to a lesser extent later stage species. It is expected that natural regeneration will continue to be dominated by early successional species and weeds.

The level of plant species recruitment under the dense row of Slash Pines along the neighbouring boundary of the reserve/southern edge is fairly limited. The main species comprising of Slash Pine, Camphor Laurel saplings, Winter Senna, Lantana thicket with a few native species such as *Wikstroemia indica*, Poison Peach *Trema tomentosa* var. *viridis*, Bleeding Heart *Omalanthus nutans* and Red Bean.

Currently Area 3 exhibits a low to moderate level of regeneration capacity and resilience in terms of its ability to recover to a self-maintaining native plant community. Killen Falls remnant is sited very close to Area 3, which provides an excellent seed source for natural regeneration. The current level of natural regeneration is limited however. This is likely to be a result of the high level and extent of past disturbance, exposure, degraded soils, and weed infestation on site and adjacent properties. A long-term program involving weed management, monitoring and strategic planting of grass patches is required to improve the sites regenerative potential by attracting seed dispersers and improving soil and microclimatic conditions, which will assist in the recruitment of native species.

7.3.8. Restoration guidelines: Ballina Council Reserve - Area 3

Two main work zones have been designated for the council reserve. The zones are described as:

ZONE 1: Upper Slope

This zone incorporates the vegetation occurring upslope of the riparian zone up to the boundary fence, running from the reserve entrance to the eastern edge of the Reserve.

ZONE 2: Riparian Zone

This zone includes the vegetation occurring along the edge of Emigrant Creek (lower and upper creek banks at about 5 to 10m width) both upstream and downstream of Killen Falls.

ZONE 1 - Upper Slope: Aim to expand and link areas of regrowth.

Weed Control

- Start regeneration works at the entrance of the reserve and work downstream towards the eastern edge of the reserve, past Killen Falls. Focus regeneration/weed control work in areas with a good component of native regrowth.
- In good regrowth patches strategically stem-inject woody weeds from around native trees. Control weeds in the understorey prior to injecting weeds in the upper stratum. Retain woody weeds for interim microclimate where required.
- Over spray Lantana thicket and thickets of smaller plants of Winter Senna and Camphor Laurel where practical, otherwise cut-scrape & paint stems.
- Control all exotic pines on the site. Chop down/fell larger isolated pine trees to avoid creating a public hazard. Chop up biomass and retain fallen logs for habitat and compost on site. Stem injection or ringbarking of pines is not recommended unless they are occurring within a dense patch of regrowth.
- Promote seedling regeneration under regrowth patches and spray encroaching exotic grasses.
- In areas such as rocky slopes carefully control weeds that are in close proximity to native ferns, herbs and sedges. Native plants will be difficult to establish in these areas. Trial a range of techniques eg; spot spray(spray pack/hand held sprayer), wick-wiping, hand removal etc.
- Stage the control of upper strata weeds in areas where native plants are poorly represented.
- Expand and link good patches of regrowth through continuing work in less developed regrowth patches undertaking strategic weed control, promoting natural regeneration and tree planting where required.

Planting

- Establish plantings in the grassy patches at the reserve entrance extending along the fence line up to the edge of the first main patch of Lantana thicket. A small drainage line runs through the planting area, which will require species suited to periodic wet conditions.
- Prepare the site for planting. Control weed complexes surrounding the proposed planting area. If possible, remove the pines from the neighbouring property or trim off overhanging limbs.
- Establish plantings in areas that display a low regeneration response following weed control (a period of over 6-12 months). In exposed and degraded sites use hardy species such as Figs (see Appendix 11).

ZONE II - Riparian: Aim to establish a dense cover of shrubs and trees along the upper riparian zone to assist shading of the creek edge. Promote the establishment of native herbs, sedges, grasses and water plants along the creek edge.

Weed Control

- Commence restoration work focussing in areas with a good representation of native species. Expand and link good areas of regrowth working towards less developed areas.
- Undertake strategic and staged weed management along the riparian edges. Avoid over clearing in areas prone to erosion. Retain weeds where required for erosion prevention and interim microclimate. This is important for Privet and Camphor dominated patches.
- Avoid cutting up Privet stems into small sections to reduce the level of propagation material. Alternatively replace cut stems on stumps or hang up off the ground to dry stems out.
- Promote native herbs, sedges and grasses in the lower riparian edge by strategically controlling weeds such as Setaria Grass, Goatweed and Hairy Commelina. Avoid spray drift into aquatic environments and hand weed where appropriate.
- Retain the Fishbone Fern occurring on the waterfall face. It is within its natural habitat and should not be removed. Fishbone Fern occurs sporadically throughout northern NSW in rocky outcrops and waterfall environments.
- Minimise impacts to native ferns, herbs and sedges occurring on rocky slopes and in the riparian area. Strategically spray, wick-wipe or remove weeds by hand.
- Strategically control Trad on the slope adjacent to the falls. Hand weed where required.
- Control Lantana thicket at the top of the rock scree below the cliff line near the falls. Over spray or wick-wipe Molasses Grass in this area. Scrape back dead biomass to help promote seedling germination.
- Spot spray exotic grasses along the riparian edge. Confirm identification of grasses prior to work as there are a variety of native species in the area.
- To control dense patches of Privet saplings, cut back saplings to about 30cm high and spray regrowth.
- In areas dominated by Camphor Laurel and Privet focus efforts on controlling/thinning out Privet, particularly Small-leaved Privet. Stem-inject larger Privets and spray extensive Privet seedling patches.

Planting and direct seeding of native seeds

- Broadcast local rainforest seeds onto rocky slopes that are poorly vegetated and with limited regeneration response (see Appendix 11).
- In areas where Camphor Laurels and Privet have been stem-injected assess regeneration response after 6-12 months. Where natural regeneration is poor under-plant in wide spacings using a range of species (e.g. Brush Box, Figs, Water Gum, Dubosia, Giant Water Gum, Creek Lillypilly. See Appendix 11).
- Strategically control Lantana and other weeds on the small island covered with Lantana thicket located directly north of the reserve entrance (see Figure 2). Avoid disturbance to area while in use by breeding waterbirds. Establish Bangalow Palms and other rainforest trees suited to periodic - poor drainage conditions.

Summarised restoration guidelines Ballina Council Reserve - Area 3

- 1. Formalise the track network and rehabilitate old tracks (Zone 1).**
- 2. Enhance the front entrance of the Council reserve (undertake weed control and planting) (Zone 1).**
- 3. Commence restoration works starting from the reserve entrance working downstream. Focus weed control in good patches of native regrowth (Zone I & II). For example:**
 - Riparian edge at front entrance of reserve**
 - Brush Box patch adjacent to Killen Falls**
 - Regrowth patch at the base of Killen Falls**
- 4. Systematically and strategically regenerate the more degraded areas along the upper slope and riparian zone linking to good areas of regrowth.**
- 5. Undertake planting and direct seeding in areas with limited regenerative capacity.**

7.4. Lane's regrowth – Area 4

7.4.1. General site description

Area 4 is located directly south of the Council Reserve - Area 3 (see Figure 2). Area 4 contains a small patch of regrowth dominated by Camphor Laurel (about 0.75 ha in size) adjacent to Emigrant Creek and a boundary planting of Slash Pine (about 600m in length).

7.4.2. Site history & management

The regrowth near the creek is estimated to be at least 20 years old (Plate 23). The property is currently used for grazing. Vegetation restoration work has not been carried out on the property. The owner of the property is interested in regenerating the regrowth forest and replacing the pine plantation with local rainforest species.

7.4.3. Vegetation classification

The regrowth vegetation in Area 4 is classified as:

- **simple -complex microphyll mid- high mid-dense forest** (dominated by Privet, Camphor Laurel and Lantana).
- **simple -complex microphyll tall closed forest** (dominated by Camphor Laurel).

Prior to clearing for agriculture, Area 4 is likely to have supported lowland subtropical rainforest belonging to the *Heritiera trifoliolata* alliance (Floyd 1990b). The lower alluvial flats and areas with deeper soil profile may have supported Suballiance No. 5 *Castanospermum - Dysoxylum mollissimum*.

7.4.4. Floristics

A limited diversity of native plant species were recorded from Area 4. This includes 33 species of trees and shrubs, 15 vines, 9 ferns, 7 herbs, at least two species of native grass and three water plants (see Appendix 1). Many of the native species recorded from this site are only represented by a few individuals. Early successional species are most common in Area 4 with later stage species such as Green Bolly Gum (see Table 13).

Table 13. Species common in each stratum – Area 4

Canopy – *Camphor Laurel, Red Bean, >Cudgeri, >Native Tamarind, Red Ash, Foambark, Guioa, Red Kamala, *Small-leaved Privet, *Large-leaved Privet
Mid – Sweet Pittosporum, Red Kamala, *Small-leaved Privet, *Large-leaved Privet
Lower – *Small-leaved Privet, >Smooth Mock-olive, >Walking Stick Palm, Steelwood, Green Bolly Gum, *Lantana >Veiny Wilkea
Ground – Harsh Ground Fern, Bordered Shield Fern, *Mistflower. Seedlings: Yellow Carrabeen, > Maidens Blush, Steelwood, *Privet spp.

* Denotes introduced species.

> Denotes species represented by few individuals.

7.4.5. Threatened plants

Two plants of conservation significance are recorded for this site (see Table 14).

Table 14. Threatened and ROTAP plants located at Area 4

Common Name	Botanical Name	TSC Act 1995	ROTAP	EPBC Act 1999
		Schedule 2		
Arrow-head Vine	<i>Tinospora tinosporoides</i>	Vulnerable	3RC-	V
Quassia (shrub)	<i>Quassia</i> sp. 'Mt Nardi'	-	3RC-	-

7.4.6. Exotic plant species

Up to 12 common weed species (excluding annual and perennial paddock weeds) have been identified from the regrowth forest in Area 4 (Table 15). The majority of the weed species on site are bird dispersed with these species largely represented throughout the local landscape.

Table 15. Weed species identified at Area 4

Common Name	Botanical Name	Abundance
Vines and creepers		
White Passionfruit	<i>Passiflora subpeltata</i>	Low
Ground covers, herbs		
Mistflower W	<i>Ageratina riparia</i>	Moderate
Crofton W	<i>Ageratina adenophora</i>	Low
Billygoat Weed	<i>Ageratina houstonianum</i>	Low
Broad-leaved Paspalum	<i>Paspalum wettsteinii</i>	Moderate
Tropical Chickweed #	<i>Drymaria cordata</i> subsp. <i>cordata</i>	Low
Shrubs		
Lantana	<i>Lantana camara</i>	Moderate
Winter Senna	<i>Senna pendula</i> var. <i>glabrum</i>	Low
Trees		
Camphor Laurel X	<i>Cinnamomum camphora</i>	High
Slash Pine	<i>Pinus elliotii</i>	High
Large-leaved Privet X	<i>Ligustrum lucidum</i>	High
Small-leaved Privet X	<i>Ligustrum sinense</i>	High

Denotes native plant with potential weed characteristics. W - Denotes noxious weed, X - regionally significant weed (Appendix 4b). Refer to the Appendix 4 for weed control techniques.

7.4.6.1. Description of the main weeds

Large-leaved Privet and Small-leaved Privet are the most serious weeds at this site. Small-leaved Privet is more problematic as it is shade tolerant and is forming dense stands.

Slash Pine: This is more of a problem on edges and exposed environments requiring relatively high light conditions to germinate. The plantation on this property and on the adjacent Rous Council land provides a significant seed source for the local area.

Camphor Laurel: This is the most common weed on the site. It should be strategically controlled and replaced with native species through assisting natural regeneration and/or with under planting. An important consideration for this restoration project is to follow-up control germination of weed seed banks and incoming weed seed under injected canopy trees.

7.4.7. Remnant condition and restoration capacity

Area 4a is highly modified and its regenerative capacity is low to moderate. Woody weeds comprise the largest percentage of vegetation cover. A very small patch of native plants, which appear indicative of remnant plants or earlier regrowth, occurs near the council boundary. Otherwise, native species are generally poorly represented.

The lower stratum varies between Lantana thicket, Mistflower, Broad-leaved Paspalum with native ferns such as Jungle Break *Pteris tremula* and Harsh Ground Fern. Extensive seedling beds of the shade tolerant Small-leaved Privet are common. The riparian area contains a limited component of native sedge and fern species with the occasional rainforest tree amongst Camphor Laurels and Privets.

The close proximity of this site to the Killen Falls remnant improves its regeneration potential (that can be supplemented by incoming native seed and may act as a seed sink). However, the area also receives a high level of incoming weed seed from weed infestations in the local landscape. The rehabilitation of this weed dominated forest into a native plant community will require a long-term commitment and a high level of resources owing to the limited cover of native plants in contrast the abundance of weeds occupying all strata.

The condition and viability of the site will be enhanced through a long-term management program that incorporates regular weed management, assisting natural regeneration through seed dispersal (providing perch trees), and supplementary planting. Owing to the limited presence of native species Camphor Laurels could be strategically felled and the area planted. However the site has difficult access.

7.4.8. Restoration guidelines: Lane's regrowth – Area 4

Guidelines have been developed for the rehabilitation of the regrowth forest and replacement of the Slash Pine plantation.

Regrowth Forest

Weed Control

- Commence restoration work starting in the regrowth patch adjacent to the council reserve, working systematically, down to the creek or in sections across the slope.
- Focus regeneration works within and around regrowth patches or individual canopy sized native trees aiming to promote their growth and expansion.
- Strategically stem inject upper stratum weeds adjacent to native plants such as Camphor Laurel and Privet and retain for bird perches.
- Control weeds in the understorey prior to injecting weeds in the upper stratum. This includes the spraying of exotic grasses, weed seedlings, cut-scape & paint Lantana, stem injection of mid stratum woody weeds.
- In areas dominated by Privet and Camphor Laurel strategically control/reduce Privet stands particularly Small-leaved Privet. Stem-inject mature Privets, cut-scape and paint smaller plants. Blanket spray extensive Privet seedling beds.

- Avoid cutting up Privet stems into small sections to reduce the level of propagation material. Alternatively, replace cut stems on cut stumps or hang up off the ground to dry stems out.
- To control dense patches of taller Privet saplings, cut back saplings to about 30cm high and spray regrowth.
- Undertake strategic and staged weed management along the riparian edges. Avoid over clearing in areas prone to erosion. Retain weeds where required for erosion prevention and interim microclimate. This is important for Privet and Camphor dominated patches.
- Stage the control /stem injection of Camphor Laurels in the vicinity of the rock slope above the creek flat. Trial broadcasting rainforest seeds onto the rock scree. Utilise species as they are locally & seasonally available e.g. native vines, pioneer species, Walking Stick Palm etc (See Appendix 11).
- Regularly follow-up/spot spray weed seedlings and weed regrowth.
- In dense stands of Camphor Laurel, selectively stem-inject small clumps of canopy sized Camphor Laurels to provide bird perches. Retain some mid-stratum Camphor Laurels for temporary microclimate. Assess regeneration response over a period of 6-12 months. Where regeneration is limited establish rainforest plants at wide spacings to accelerate plant community development and/or;
- Strategically fell Camphor Laurels to create spaces for planting.
- Create a matrix of natural regeneration and planted sites through the area. See Appendix 5 & 11.

Planting

- Establish a dense rainforest planting above the rock slope (currently supporting Slash Pine). This will assist the regeneration of the area. Refer to Slash Pine replacement program below.
- Establish rainforest plants along the creek line. Partially stem-inject Camphor Laurels to avoid creek bank erosion &/or strategically lop trees to improve growing conditions to planted trees. Completely stem inject Camphor Laurels following development of planted trees.
- If a rapid approach to restoration is preferred in the Camphor Laurel dominated regrowth fell Camphor Laurels below the rock slope and establish a planting of rainforest trees (See Appendix 11). Ensure that all licenses have been sought for this approach.

Slash Pine replacement program

This section provides a background description of the planting site, planting design and a planting schedule. It must be noted that this is a guide only, which the owner is encouraged to adopt. Planting guidelines and plant species selection for the replacement of the Slash Pine plantation have been based on an assessment of the sites condition and of the ecological values that the planting could contribute to the site.

Planting site

The property contains about a 600m perimeter of tall Slash Pine. The pines are planted in two off set rows about 1.5m between each tree and 2m between each row. The pines are up to 20 - 25m tall. The planting area is located between 50m to 300m distance from the remnant.

Planting design

Planting is required to improve soil and microclimatic conditions, and to encourage seed dispersers (such as bats & birds) to the site. This is best achieved by planting fauna attractant species such as

nectar producing plants, but also by providing general habitat features as vegetative cover, perches and roosting sites.

A planting design that incorporates a mix early successional species and later stage species (mature phase species) is recommended for the site. This could include a framework planting with clumps of mature phase species throughout. The mature phase species should comprise a high level of the fleshy-fruited keystone fauna food species (see Appendix 11) and species with poor representation in the remnant. The planting area is narrow and should contain species that perform on edges such as those that retain low branches and maintain dense foliage.

The planting design should comprise of species that occur only from the remnant and adjacent native regrowth vegetation (see Appendix 1).

Some of the pioneer and secondary species that are well represented on the adjacent council reserve and are highly likely to regenerate on site should be omitted from the planting (e.g. Red Ash, Ked Kamala, Foambark and Guioa). Sweet Pittosporum is common on site however but should be considered for planting as an edge species. The early successional/pioneer plants that are quick growing and have a high turnover of leaves will assist the establishment and growth of the slower growing longer lived species, which are important for the development of forest structure and habitat complexity. Over time further supplementary planting or direct seeding of mature phase species and other lower stratum plants can be undertaken where natural regeneration is limited and to increase structural complexity.

Consideration must be given to maintaining the genetic integrity of the native plant species and plant community in the Killen Falls project site (see Appendix 10- genetic guidelines for planting).

Slash Pine replacement & planting schedule

- Establish rainforest plants within 5 metre wide strip (at least) along the property boundary. Plant trees at a spacing of 1.5. to 1.8m.
- Fell Slash Pines at least 4 months before planting. Chip some of the biomass to use for mulching, retain some fallen logs on the ground for habitat. Use the wood chip to mulch individual trees. Wood chip can also be scattered between plants to act as weed suppressant and as a seed germination medium. Compost woodchip for at least 4 months prior to use.
- Test soil pH (which is likely to be acid) and soil nutrient status. If soil pH is below 5, apply a light dressing of agricultural lime (calcium carbonate) to reduce soil acidity. If other nutrients are limited such as calcium or magnesium apply dolomite. The effects of pine needles on soil acidity is thought to be negligible in context to the impacts of previous land clearing and loss of soil organic matter and top soil.
- Check frost proneness of the site. Select species accordingly (see Appendix 11) and order trees from local nurseries well in advance to planting time.
- Collect local seed, as it is seasonally available to contribute to the planting.
- Spot spray circles for planting (1m diameter) at least 4 weeks prior to planting and check again a few weeks before planting.
- Install water supply for initial planting and for future irrigation.

- Plant during the wet season (March – April) or depending on the availability of water and cooler. If the site is frost prone aim to establish trees in early spring, which will require additional watering.
- Arrange the plants so that fast growing trees are planted beside slower growing plants.
- Trees must be watered in during planting, either planting into a watered hole or watered directly after planting. Use water crystals/hydrogel to assist with the retention of soil moisture in areas where soil has a low water holding capacity.
- Mulch trees directly after planting. If using Setaria Grass bales ensure they are seed free.
- Plantings should be regularly maintained. Spot spray encroaching grass and other weeds. This will be required periodically throughout the year particularly during wet conditions and until canopy develops. After canopy establishment the control of incoming weeds such as Privet spp. and Camphor Laurel etc will be required.
- Protect planted trees from wallaby browsing. Where required erect guards or fence the perimeter of the planting.

Summarised restoration guidelines Lane's regrowth - Area 4

1. ***Strategically convert the Camphor Laurel dominated forest into rainforest. Commence restoration works in the regrowth patch starting near the Council reserve boundary. Work sections at a time and trial a range of measures. For example:***
 - ***Stem-inject clumps of Camphor Laurel***
 - ***Under plant &/ or promote natural regeneration under injected Camphor Laurels***
 - ***Undertake strategic felling of Camphor Laurels and prepare site for planting***
2. ***Undertake Slash Pine replacement.***
3. ***Regularly follow-up weed regrowth.***

8.0. Other management issues

Macadamia seedling management: A small population of the threatened *Macadamia tetraphylla* occurs within the Killen Falls remnant. Foreign seed from Macadamia varieties in the adjacent plantations are likely to establish in the remnant being dispersed by gravity, water or mammals which will require monitoring and removal. Research is required to investigate the extent and impacts of cross-pollination between plantation Macadamias varieties and isolated populations of *M. tetraphylla*.

Vine management: Where vines are overly threatening the stability of canopy trees strategic vine management is recommended (see Appendix 5 for vine management strategies).

Agricultural Activities: Throughout the former Big Scrub large scale plantations are frequently situated adjacent to remnant vegetation. The effects of agricultural pesticides on the ecology of remnant ecosystems and associated insect populations are uncertain. Where practical, a spray buffer between a remnant and a plantation is recommended to reduce potential impacts. In the absence of buffers it is advised that pesticide application be undertaken strategically to reduce non-target effects.

Water flow: The affects of water flow restrictions on riparian rainforest vegetation downstream of the Emigrant Creek Dam are uncertain. Restricted water flow during key periods may vary tree longevity and seedling recruitment success.

Tracks: The council reserve has a number of undefined tracks that lead to the base of the falls, thus increasing the level of human traffic over a broader area. Tracks also increase access for pest animal species such as the fox, cat and dog. A defined track system and rehabilitation of informal tracks is required to reduce disturbance to habitat and regeneration sites. Compacted soil surfaces may require soil disturbance and brush matting to assist regeneration.

Visitation: Use of the Killen Falls area by tourist operators should be strongly discouraged to protect the conservation values and the Project Site. Visitation by 'eco-tourist' abseiling operators to is of particular concern as it may result in disturbance to insectivorous bat roost sites, and shy and cryptic rainforest birds. Ballina Council has jurisdiction over public access to the Killen Falls site – with access provided through the Council reserve. It is recommended that visitation, particularly by tourist operators is discouraged or regulated and monitored to determine impacts to site conditions.

Pine trees: The control of pine trees on the Killen Falls Project Site is paramount to reduce the spread of Pine through the local area.

Threatened fauna and population viability: Survey and monitoring of fauna species existing in isolated remnants is required to identify species population viability, shifts in fauna species and abundance, to identify threats and to develop management strategies. This is particularly

important in context to habitat rehabilitation works. Specialists competent in systematic and opportunistic survey techniques for all fauna groups should undertake fauna surveys and who holds a current Scientific Investigation License and relevant Animal Ethics approval (see Appendix 9A).

Plant species population viability: The population viability of poorly represented and threatened plants in the remnant/project site requires assessment. Ineffective population size may threaten the ability of a species to persist and human intervention may be required to avoid its decline from the remnant. This would be particularly important for dioecious species that are represented by a single or a few individuals. The minimum number of individuals required to maintain genetic and population viability differs between species life form and phenology (Cropper 1993).

Wetland restoration: Further assessment of the wetland environment at the project site is required to develop an effective restoration schedule. This should include an assessment of the sites hydrological characteristics, functions and plant and fauna species survey. Wetland reference communities in the local catchment should be surveyed to determine species that may be suitable for planting at the site.

Noxious Weeds: The occurrence of noxious weeds should be regularly monitored and control undertaken according to their category listing for the Far North Coast Weeds Authority Area (see Appendix 4b).

9.0. Summary of restoration guidelines and priorities

The management areas are listed in order of priority for restoration work based on vegetation condition, conservation value and restoration capacity (see below). However where funds and resources are made available (including commitment from volunteers and landholders) restoration actions can be undertaken at any of the sites as long as regular follow-up management is provided. The targeted removal of environmental weeds such as Slash Pine and replanting with appropriate native species should be a high priority.

Management areas in order of restoration priority

1. Killen Falls remnant (Area 1)
2. Deenford regrowth (Area 2a)
3. Ballina Council Reserve (Area 3)
4. Deensford regrowth (Area 2b)
5. Lane's regrowth (Area 4)
6. Wetland (Area 2c) Unless resources are secured !

Summarised restoration guidelines

Killen Falls remnant - Area 1

- ♦ Undertake regeneration work along the Emigrant Creek edge of the remnant; followed by
- ♦ The northern-eastern edge
- ♦ The forest core
- ♦ The southern edge - steep slope

Deensford regrowth - Area 2

- ♦ Regenerate Area 2a (forest patches adjacent to the remnant).
- ♦ Regenerate the drainage line linking Area 2a & 2b.
- ♦ Commence work in Area 2b focussing weed control in areas with a component of native regrowth – expanding and linking centres of regrowth.
- ♦ Undertake strategic planting in regrowth areas with limited regenerative capacity.
- ♦ Rehabilitate Area 3c - Crofton dominated wetland.

Ballina Council Reserve - Area 3

- ♦ Formalise the track network and rehabilitate old tracks (Zone 1).
- ♦ Enhance the front entrance of the Council reserve (weed control and planting) (Zone 1).
- ♦ Commence restoration works starting at the reserve entrance working downstream. Focus weed control in good patches of native regrowth (Zone I & II). For example:
 - Riparian edge at front entrance of reserve
 - Brush Box patch adjacent to Killen Falls
 - Regrowth patch at the base of Killen Falls
- ♦ Systematically and strategically regenerate the more degraded areas along the upper slope and riparian zone linking to good areas of regrowth.
- ♦ Undertake planting and direct seeding in areas with limited regenerative capacity.

Lane's regrowth - Area 4

- ♦ Strategically convert the Camphor Laurel dominated forest into rainforest. Commence restoration works in the regrowth patch starting near the Council reserve boundary. Work sections at a time and trial a range of measures. For example:
 - Stem-inject clumps of Camphor Laurel
 - Under plant &/ or promote natural regeneration under injected Camphor Laurels
 - Undertake strategic felling of Camphor Laurels and prepare site for planting
- ♦ Undertake Slash Pine replacement.

10.0. Summary of the management areas

Area 1 – Killen Falls remnant:

<i>Lot DP & tenure</i>	Private Lot 2 DP - 614600
<i>Vegetation</i>	Original Big Scrub lowland subtropical rainforest.
<i>Size</i>	2ha
<i>Vegetation condition</i>	Good condition, relatively intact
<i>Regeneration capacity</i>	High. Moderate level of inputs required in the initial years and low level of inputs required for follow-up maintenance
<i>Threatened plants</i>	Endangered – 1 (possibly 2), Vulnerable – 4, ROTAP – 7. Total = 9. The remnant also forms part of an Endangered Ecological Community.
<i>Native shrubs & trees</i>	125 species
<i>Weeds & cover</i>	No. of weeds = 20, Cover = 10%
<i>Zoning</i>	7 (I) Environmental Protection – Habitat

Area 2 – Deenford regrowth (Areas 2a,b,c):

<i>Lot DP & tenure</i>	Private Lot 2 DP 614600, Lot 6 DP 245987
<i>Vegetation</i>	2a – regrowth subtropical rainforest, 2b – Camphor Laurel dominated forest, 2c – wetland with Crofton
<i>Size</i>	2a – 1.2 ha, 2b – 1 ha, 2c – 0.5 ha
<i>Vegetation condition</i>	2a – good, 2b – moderate to poor, 2c poor – highly disturbed
<i>Regeneration capacity</i>	2a: Good, moderate level of inputs required. 2b: Low, moderate to high level of inputs required. 2c: Low, requires high level of inputs. Some planting required for area 2b and 2c and to connect all areas.
<i>Threatened plants</i>	Vulnerable – 2, ROTAP – 4. Total = 4
<i>Native shrubs & trees</i>	Up to 50 species (2a&b) Area 2c (further surveys required)
<i>Weeds & cover</i>	No. of weeds for Area 2 = 22. Cover 2a = 35%, 2b = 75%, 2c = 95%
<i>Zoning</i>	7 (I) Environmental Protection – Habitat 7 (C) Environmental Protection – Water Catchment

Area 3 – Ballina Council Reserve:

<i>Lot DP & tenure</i>	Public - Lot 1 DP 251994
<i>Vegetation</i>	Regrowth rainforest dominated by Camphor Laurel and exotic grassland with Lantana shrubland.
<i>Size</i>	1.38 ha
<i>Vegetation condition</i>	Poor to moderate (about 20 years of regrowth).
<i>Regeneration capacity</i>	Variable across site, low- moderate. Will require moderate to high level of inputs and strategic planting.
<i>Threatened plants</i>	Vulnerable – 1, ROTAP – 2. Total = 2
<i>Native shrubs & trees</i>	45 species
<i>Weeds & cover</i>	No. of weeds = 32. Cover 50%
<i>Zoning</i>	1 (b) Rural – Secondary Agricultural Land

Area 4 – Lane's regrowth & pine forest:

<i>Lot DP & tenure</i>	Private - Lot 2 DP -251994
<i>Vegetation</i>	Camphor Laurel dominated regrowth & planted Slash Pine
<i>Size</i>	Regrowth patch – 0.75 ha, revegetation area – 0.3ha (600m x 5m)
<i>Vegetation condition</i>	Highly disturbed & modified
<i>Regeneration capacity</i>	Relatively low – will require high level of inputs and strategic planting
<i>Threatened plants</i>	Vulnerable – 1, ROTAP – 2. Total = 2
<i>Native shrubs & trees</i>	33 species
<i>Weeds & cover</i>	No. of weeds = 12. Cover = 85%
<i>Zoning</i>	1 (b) Rural – Secondary Agricultural Land

9.0. Summary of restoration guidelines and priorities

The management areas are listed in order of priority for restoration work based on vegetation condition, conservation value and restoration capacity (see below). However where funds and resources are made available (including commitment from volunteers and landholders) restoration actions can be undertaken at any of the sites as long as regular follow-up management is provided. The targeted removal of environmental weeds such as Slash Pine and replanting with appropriate native species should be a high priority.

Management areas in order of restoration priority

1. Killen Falls remnant – *private* (Area 1)
2. Deenford regrowth (Area 2a)
3. Ballina Council Reserve (Area 3)
4. Deenford regrowth (Area 2b)
5. Lane's regrowth (Area 4)
6. Wetland (Area 2c) Unless resources are secured !

Summarised restoration guidelines

Killen Falls remnant (private) - Area 1

- ♦ Undertake regeneration work along the Emigrant Creek edge of the remnant; followed by
- ♦ The northern-eastern edge
- ♦ The forest core
- ♦ The southern edge - steep slope

Deenford regrowth - Area 2

- ♦ Regenerate Area 2a (forest patches adjacent to the remnant).
- ♦ Regenerate the drainage line linking Area 2a & 2b.
- ♦ Commence work in Area 2b focussing weed control in areas with a component of native regrowth – expanding and linking centres of regrowth.
- ♦ Undertake strategic planting in regrowth areas with limited regenerative capacity.
- ♦ Rehabilitate Area 3c - Crofton dominated wetland.

Ballina Council Reserve - Area 3

- ♦ Formalise the track network and rehabilitate old tracks (Zone 1).
- ♦ Enhance the front entrance of the Council reserve (weed control and planting) (Zone 1).
- ♦ Commence restoration works starting at the reserve entrance working downstream. Focus weed control in good patches of native regrowth (Zone I & II). For example:
 - Riparian edge at front entrance of reserve
 - Brush Box patch adjacent to Killen Falls
 - Regrowth patch at the base of Killen Falls
- ♦ Systematically and strategically regenerate the more degraded areas along the upper slope and riparian zone linking to good areas of regrowth.
- ♦ Undertake planting and direct seeding in areas with limited regenerative capacity.

Lane's regrowth - Area 4

- ♦ Strategically convert the Camphor Laurel dominated forest into rainforest. Commence restoration works in the regrowth patch starting near the Council reserve boundary. Work sections at a time and trial a range of measures. For example:
 - Stem-inject clumps of Camphor Laurel
 - Under plant &/ or promote natural regeneration under injected Camphor Laurels
 - Undertake strategic felling of Camphor Laurels and prepare site for planting
- ♦ Undertake Slash Pine replacement.

10.0. Summary of the management areas

Area 1 – Killen Falls remnant (private):

<i>Lot DP & tenure</i>	Private - Lot 2 DP - 614600
<i>Vegetation</i>	Original Big Scrub lowland subtropical rainforest.
<i>Size</i>	2ha
<i>Vegetation condition</i>	Good condition, relatively intact
<i>Regeneration capacity</i>	High. Moderate level of inputs required in the initial years and low level of inputs required for follow-up maintenance
<i>Threatened plants</i>	Endangered – 1 (possibly 2), Vulnerable – 4, ROTAP – 7. Total = 9. The remnant also forms part of an Endangered Ecological Community.
<i>Native shrubs & trees</i>	125 species
<i>Weeds & cover</i>	No. of weeds = 20, Cover = 10%
<i>Zoning</i>	7 (I) Environmental Protection – Habitat

Area 2 – Deenford regrowth (Areas 2a,b,c):

<i>Lot DP & tenure</i>	Private - Lot 2 DP 614600, Lot 6 DP 245987
<i>Vegetation</i>	2a – regrowth subtropical rainforest, 2b – Camphor Laurel dominated forest, 2c – wetland with Crofton
<i>Size</i>	2a – 1.2 ha, 2b – 1 ha, 2c – 0.5 ha
<i>Vegetation condition</i>	2a – good, 2b – moderate to poor, 2c poor - highly disturbed
<i>Regeneration capacity</i>	2a: Good, moderate level of inputs required. 2b: Low, moderate to high level of inputs required. 2c: Low, requires high level of inputs. Some planting required for area 2b and 2c and to connect all areas.
<i>Threatened plants</i>	Vulnerable – 2, ROTAP – 4. Total = 4
<i>Native shrubs & trees</i>	Up to 50 species (2a&b) Area 2c (further surveys required)
<i>Weeds & cover</i>	No. of weeds for Area 2 = 22. Cover 2a = 35%, 2b = 75%, 2c = 95%
<i>Zoning</i>	7 (I) Environmental Protection – Habitat 7 (C) Environmental Protection – Water Catchment

Area 3 – Ballina Council Reserve:

<i>Lot DP & tenure</i>	Public - Lot 1 DP 251994
<i>Vegetation</i>	Regrowth rainforest dominated by Camphor Laurel and exotic grassland with Lantana shrubland.
<i>Size</i>	1.38 ha
<i>Vegetation condition</i>	Poor to moderate (about 20 years of regrowth).
<i>Regeneration capacity</i>	Variable across site, low- moderate. Will require moderate to high level of inputs and strategic planting.
<i>Threatened plants</i>	Vulnerable – 1, ROTAP – 2. Total = 2
<i>Native shrubs & trees</i>	45 species
<i>Weeds & cover</i>	No. of weeds = 32. Cover 50%
<i>Zoning</i>	1 (b) Rural – Secondary Agricultural Land

Area 4 – Lane's regrowth & pine forest:

<i>Lot DP & tenure</i>	Private - Lot 2 DP -251994
<i>Vegetation</i>	Camphor Laurel dominated regrowth & planted Slash Pine
<i>Size</i>	Regrowth patch – 0.75 ha, revegetation area – 0.3ha (600m x 5m)
<i>Vegetation condition</i>	Highly disturbed & modified
<i>Regeneration capacity</i>	Relatively low – will require high level of inputs and strategic planting
<i>Threatened plants</i>	Vulnerable – 1, ROTAP – 2. Total = 2
<i>Native shrubs & trees</i>	33 species
<i>Weeds & cover</i>	No. of weeds = 12. Cover = 85%
<i>Zoning</i>	1 (b) Rural – Secondary Agricultural Land

11.0. Conclusion

The Killen Falls remnant is considered to be of regional and national significance due to its environmental attributes. The remnant provides a good reference community and seed source to the local environment. Infestations of serious environmental weeds are mainly restricted to the remnant edges. The remnant and adjoining regrowth patches on the same property have a good restoration capacity and will respond well to a strategic and a long-term weed management program.

The remnant is highly isolated and is surrounded by agricultural land and regrowth vegetation that is in various stages of recovery. Camphor Laurel regrowth is a feature of the site in which early successional stage rainforest species are commonly represented. Camphor Laurel dominated regrowth plays an important role as a seed sink in the local area. The strategic management of Camphor Laurel stands to promote the further establishment and development of a rainforest community is of high importance. These communities have a limited restoration capacity and will require a high level of resources and time to activate their rehabilitation.

The wetland area in the project site is dominated by exotic herbaceous species. Further assessment and comparison to less impacted wetland communities in the local catchment is required to help determine the previous plant community and restoration goals. Regardless of the modified nature of the wetland area it provides important water bird habitat and enhances the ecological attributes of the project site.

The main weed species that are an issue to the project site include Small-leaved Privet, Large-leaved Privet, Camphor Laurel, Ochna, Slash Pine, Crofton, exotic grasses and potentially water weeds. Madeira Vine infestations in the local area are also of concern. The replacement of Slash Pine with appropriate native species is of high priority. It is recognised that local and catchment based management of weeds is necessary for their effective control in the long term.

The restoration of the remnant and regrowth vegetation on the project site will require a long-term management program that incorporates regular weed management, assisting natural regeneration and strategic planting. Regular monitoring and follow-up weed management will be necessary owing to the small remnant size and of the extent of weed infestations in the local area. The restoration of the Killen Falls remnant and rehabilitation of adjacent lands will play an important role in improving the viability of the remnant, by increasing the area of native vegetation and fauna habitat in the locality, improving the quality of riparian vegetation and controlling serious weed sources.

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APPENDIX 1 Native flora of the Killen Falls project site, Emigrant Creek.

List prepared by Susan Bower (2003) - adapted from Floyd (1985), Holmes (1987).

Codes:

1 = Killen Falls remnant (Area 1)

2a = Rainforest regrowth (Area 2a)

2b = Camphor regrowth (Area 2b)

3 = Ballina Council Reserve (Area 3)

4 = Lanes regrowth (Area 4)

FAMILY	BOTANICAL NAME	COMMON NAME	1	2a	2b	3	4
FERNS							
ADIANTACEAE							
	<i>Adiantum diaphanum</i>	Filmy Maidenhair	x			x	x
	<i>Adiantum hispidulum</i>	Rough Maidenhair	x	x	x	x	x
	<i>Adiantum formosum</i>	Gaint Maidenhair	x				
ASPLENIACEAE							
	<i>Asplenium attenuatum</i>	Simple Spleenwort	x				
	<i>Asplenium australasicum</i>	Birds Nest Fern	x			x	x
BLECHNACEAE							
	<i>Blechnum cartilagineum</i>	Gristle Fern				x	
	<i>Doodia aspera</i>	Rasp Fern	x	x	x		
	<i>Doodia caudata</i>	Small Rasp Fern	x			x	
CYATHEACEAE							
	<i>Cyathea cooperi</i>	Straw Tree Fern	x		x	x	x
	<i>Cyathea leichhardtiana</i>	Prickly Tree Fern	x		x		
	<i>Nephrolepis cordata</i>	Fishbone Fern	x				
DAVALLIACEAE							
	<i>Arthropteris tenella</i>	Climbing Fishbone Fern	x				
DICKSONIACEAE							
	<i>Calochlaena dubia</i>	Common Ground Fern	x			x	
DENNSTAEDTIACEAE							
	<i>Hypolepis muelleri</i>	Harsh Ground Fern	x	x	x	x	x
	<i>Hypolepis glandulifera</i>	Hairy Ground Fern			x		
	<i>Pteris esculentum</i>	Bracken Fern	x	x	x	x	x
DRYOPTERACEAE							
	<i>Lastrisopsis acuminata</i>	Shiny Shield Fern	x				
	<i>Lastreopsis marginans</i>	Bordered Shield Fern	x	x	x	x	x
	<i>Lastreopsis microsora</i>	Creeping Shield Fern	x	x			
	<i>Lastreopsis munita</i>	Naked Sheild Fern	x				
POLYPODIACEAE							
	<i>Platynerium bifurcatum</i> subsp <i>bifurcatum</i>	Elkhorn				x	x
	<i>Platynerium supberum</i>	Staghorn	x				
	<i>Pyrossia rupestris</i>	Rock Felt fern				x	
PTERIDIACEAE							
	<i>Pteris tremula</i>	Tender Brake					x
	<i>Pteris umbrosa</i>	Jungle Brake	x				
THELYPTERIDACEAE							
	<i>Christella dentata</i>	Binung	x		x	x	x

FAMILY	BOTANICAL NAME	COMMON NAME	1	2a	2b	3	4
WATER PLANTS							
AMARANTHACEAE	<i>Alternanthera denticulata</i>	Lesser Joy Weed				x	
	<i>Eclipta prostrata</i>	White Eclipta				x	
CYPERACEAE	<i>Carex appressa</i>		x	x	x	x	
	<i>Carex polyantha</i>	Tassle Sedge	x			x	
	<i>Schoenoplectus validus</i>	River Clubrush				x	
CARYOPHYLLACEAE	<i>Drymaria</i> subsp. <i>diandra</i>	Tropical Chickweed				x	x
JUNCACEAE	<i>Juncus usitatus</i>	Common Rush				x	x
	<i>Juncus</i> sp.	Rush			x		
MENYANTHACEAE	<i>Nymphoides indica</i>	Water Snowflake				x	
ONAGRACEAE	<i>Ludwigia octovalvis</i>	Willow Primrose				x	
	<i>Ludwigia peploides</i> subsp. <i>montevidensis</i>	Water Primrose				x	
POLYGONACEAE	<i>Persicaria decipiens</i>	Slender Knotweed				x	
	<i>Persicaria strigosa</i>	Spotted Knotweed				x	x
POTAMOGETONACEAE	<i>Potamogeton javanicus</i>	Pondweed				x	
HERBS and GROUND COVERS							
ACANTHACEAE	<i>Psuederanthemum variabile</i>	Pastel Flower	x	x	x	x	x
	<i>Isoglossa eranthemoides</i> S1 ROTAP	Isoglossa	x				
APIACEAE	<i>Centella asiatica</i>	Pennywort	x			x	x
ARACEAE	<i>Alocasia brisbanensis</i>	Cunjevoi	x		x		
	<i>Gymnostachys anceps</i>	Settlers Flax	x				
CYPERACEAE	<i>Cyperus tetraphyllus</i>	Sedge	x		x		x
	<i>Cyperus enervis</i>	Soft Sedge				x	x
COMMELINACEAE	<i>Aneilema biflorum</i>	Aneilema	x				
	<i>Commelina cyanea</i>	Commelina	x	x	x	x	x
	<i>Polia crispata</i>	Polia	x				
LAMIACEAE	<i>Plectranthus</i> sp	Native Mint	x	x		x	
LILIACEAE	<i>Dianella caerulea</i>	Blue Flax Lily	x	x	x		
LOMANDRACEAE	<i>Lomandra spicata</i>	Rainforest Mat-rush	x				
PEPEROMIACEAE	<i>Peperomia blanda</i>	Peperomia	x	x	x	x	x
ROSACEAE	<i>Rubus rosifolius</i>	Native Raspberry	x	x	x	x	
URTICACEAE	<i>Elatostemma reticulatum</i>	Smooth Nettle	x			x	
ZINGERBACEAE	<i>Alpinia caerulea</i>	Native Ginger	x		x	x	x

FAMILY	BOTANICAL NAME	COMMON NAME	1	2a	2b	3	4
GRASSES							
POACEAE							
	<i>Agrostis avenacea</i> var. <i>avenacea</i>	Blown Grass		x			
	<i>Leersia hexandra</i>	Swamp Ricegrass			x	x	
	<i>Microlaena stipoides</i> var. <i>stipoides</i>	Microlaena	x				
	<i>Oplismenus aemulus</i>	Basket Grass	x	x	x	x	
	<i>Oplismenus imbecillis</i>	Basket Grass	x	x	x	x	x
	<i>Cynodon dactylon</i>	Common Couch				x	
	<i>Imperata cylindrica</i> var. <i>major</i>	Bladey Grass				x	
VINES AND CLIMBERS							
ARACEAE							
	<i>Pothos longipes</i>	Pothos	x			x	x
ARECACEAE							
	<i>Calamus muelleri</i>	Lawyer Vine	x				
AMARANTHACEAE							
	<i>Deeringia arborescens</i>	Climbing Derrigia	x				
ANNONACEAE							
	<i>Rauwenhoffia leichardtii</i>	Zig-Zag Vine	x				
APOCYNACEAE							
	<i>Melodinus australis</i>	Southern Melodinus	x		x	x	x
	<i>Parsonia ventricosa</i>	Acuminate Silkpod	x				
ARISTOLOCHACEAE							
	<i>Pararistolochia pravenosa</i>	Aristolochia	x				
ASCLEPIADACEAE							
	<i>Marsdenia rostrata</i>	Common Milk Vine	x		x	x	x
BIGNONIACEAE							
	<i>Pandora baileyana</i>	Large-leaved Wonga Vine		x			
	<i>Pandorea jasminoides</i>	Bower Vine	x			x	
CAESALPINIACEAE							
	<i>Caesalpinia scortechinii</i>	Large Prickle Vine				x	
	<i>Caesalpinia subtropica</i>	Corky Prickle Vine	x	x			
CELASTRACEAE							
	<i>Celastrus subspicatus</i>	Large-leaf Staff Vine	x				
	<i>Hippocratea barbata</i>	Knot Vine				x	
CUCURBITACEAE							
	<i>Diplocyclos palmatus</i>	Native Bryony	x				
	<i>Sicyos angulata</i>	Star Cucumber		x			
DILLENIACEAE							
	<i>Hibbertia scandens</i>	Twining Guinea Flower				x	
DIOSCOREACEAE							
	<i>Dioscorea transversa</i>	Native Yam	x	x	x	x	x
FABACEAE							
	<i>Austrosteenisia glabristyla</i>	Giant Blood Vine	x	x		x	x
	<i>Derris involuta</i>	Native Derris					x
	<i>Milletia megasperma</i>	Native Wisteria	x	x	x	x	
FLAGELLARIACEAE							
	<i>Flagellaria indica</i>	Whip Vine	x	x			
LUZURGIAGACEAE							
	<i>Geitonoplesium cymosum</i>	Scrambling Lily	x	x		x	x
MENISPERMACEAE							
	<i>Carronia multisepala</i>	Carronia	x			x	x
	<i>Stephania japonica</i> var. <i>discolor</i>	Snake Vine					x
	<i>Tinospora tinosporoides</i> S2 ROTAP	Arrow-head Vine	x			x	x

FAMILY	BOTANICAL NAME	COMMON NAME	1	2a	2b	3	4
MONIMIACEAE	<i>Palmeria scandens</i>	Anchor Vine			x		
MORACEAE	<i>Maclura cochinchinensis</i>	Cockspur Thorn	x	x		x	x
	<i>Trophos scandens</i>	Burny Vine	x	x		x	x
MYRSINACEAE	<i>Embelia australiana</i>	Embelia	x				
PIPERACEAE	<i>Piper novae-hollandiae</i>	Giant Pepper Vine	x				
RIPOGONACEAE	<i>Ripogonum album</i>	White Supplejack	x	x	x	x	x
	<i>Ripogonum discolor</i>	Prickly Supplejack	x		x		
	<i>Ripogonum elseyanum</i>	Hairy Supplejack	x			x	
RUBIACEAE	<i>Morinda jasminoides</i>	Morinda	x	x	x	x	x
RANUNCULACEAE	<i>Clematis glycinoides</i>	Forest Clematis			x		
VITACEAE	<i>Cayratia clematidea</i>	Slender Grape	x		x		
	<i>Cissus antarctica</i>	Water Vine	x	x		x	x
	<i>Cissus sterculiifolia</i>	Long-leaf Water Vne	x				

TREES AND SHRUBS

AKANIACEAE	<i>Akania bidwillii</i>	Turnipwood	x				
ALANGIACEAE	<i>Alangium villosum</i> subsp. <i>polysmoides</i>	Muskwood	x				
APOCYNACEAE	<i>Tabernaemontana pandacqui</i>	Banana Bush	x	x	x	x	x
ANARCARDIACEAE	<i>Euroschinus falcata</i> var. <i>falcata</i>	Ribbon Wood		x			
ARALIACEAE	<i>Polyscias elegans</i>	Celerywood	x				
ARECACEAE	<i>Archontophoenix cunninghamiana</i>	Bangalow Palm	x	x			
	<i>Linospadix monostachya</i>	Walking Stick Palm	x	x			x
ASTELIACEAE	<i>Cordyline rubra</i>	Red-fruited Palm Lily	x		x	x	
BORAGINACEAE	<i>Ehretia acuminata</i>	Koda	x				
CAPRIFOLIACEAE	<i>Sambucus australasica</i>	Native Elderberry	x				
CAPPARACEAE	<i>Capparis arborea</i>	Brush Caper Berry	x				x
CELASTRACEAE	<i>Cassine australis</i>	Red Olive Plum	x			x	x
	<i>Hedraianthera porphyropetala</i>	Hedraianthera	x				
	<i>Siphonodon australe</i>	Ivorywood		x			
CUNONIACEAE	<i>Geissois benthamii</i>	Red Carabeen	x				
EBENACEAE	<i>Diospyros pentamera</i>	Myrtle Ebony	x	x	x		

FAMILY	BOTANICAL NAME	COMMON NAME	1	2a	2b	3	4
ELAEOCARPACEAE							
	<i>Elaeocarpus angustifolius</i> (syn <i>grandis</i>)	Blue Quandong	x		x		
	<i>Elaeocarous eumundi</i>	Eumundi Quangdong	x				
	<i>Elaeocarpus kirtonii</i>	Silver Quandong	x				
	<i>Elaeocarpus obovatus</i>	Hard Quandong	x	x	x	x	x
	<i>Sloanea woolfsii</i>	Yellow Carabeen	x	x		x	x
	<i>Sloanea australis</i>	Maiden's Blush	x	x	x	x	x
ESCALLONIACEAE							
	<i>Abrophyllum ornans</i>	Native Hydrangea	x				
	<i>Polyosma cunninghamii</i>	Featherwood	x				
EUPHORBIACEAE							
	<i>Acalypha</i> sp. aff. <i>eremorum</i> **	Acalypha	x				
	<i>Actephila lindleyi</i>	Actephila	x	x	x		
	<i>Baloghia inophylla</i>	Brush Bloodwood	x				
	<i>Breynia oblongifolia</i>	Breynia			x	x	
	<i>Claoxylon australe</i>	Brittlewood	x				
	<i>Cleistanthus cunninghamii</i>	Cleistanthus	x				
	<i>Croton verreauxii</i>	Native Cascarilla	x				
	<i>Glochidion ferdinandi</i>	Cheese Tree	x			x	
	<i>Mallotus discolor</i>	White Kamala	x	x	x		
	<i>Mallotus philippensis</i>	Red Kamala	x	x	x	x	x
	<i>Omalanthus populifolius</i>	Bleeding Heart	x			x	
EUPOMATIACEAE							
	<i>Eupomatia bennettii</i>	Small Bolwarra	x				
	<i>Eupomatia laurina</i>	Bolwarra				x	
FABACEAE							
	<i>Castanoperмум australe</i>	Black Bean	x				
ICACINACEAE							
	<i>Citronella moorei</i>	Churnwood	x				
LAURACEAE							
	<i>Beilschmiedia elliptica</i>	Grey Walnut	x				
	<i>Cinnamomum oliveri</i>	Oliver's Sassafras	x		x		
	<i>Cryptocarya laevigata</i>	Glossy Laurel			x		
	<i>Cryptocarya obovata</i>	Pepperberry	x	x	x	x	
	<i>Cryptocarya microneura</i>	Murrogun			x		
	<i>Endiandra muelleri</i> subsp. <i>muelleri</i>	Green-leaved Rose Walnut	x				
	<i>Endiandra pubens</i>	Hairy Walnut	x				
	<i>Litsea australis</i>	Brown Bolly Gum	x	x	x	x	x
	<i>Neolitsea australiensis</i>	Green Bolly Gum	x	x	x	x	
	<i>Neolitsea dealbata</i>	White Bolly gum	x	x	x	x	x
MELIACEAE							
	<i>Anthocarapa nitidula</i>	Incense Cedar	x				
	<i>Dysoxylum fraserianum</i>	Rosewood	x	x			
	<i>Dysoxylum mollissimum</i>	Red Bean	x	x	x	x	x
	<i>Synoum glandulosum</i>	Scentless Rosewood	x	x		x	
	<i>Toona ciliata</i>	Red Cedar	x		x		
MIMOSOIDEAE							
	<i>Acacia melanoxylon</i>	Sally Wattle / Blackwood	x	x		x	x
	<i>Archidendron grandiflorum</i>	Lace Flower Tree	x				
	<i>Archidendron muellerianum</i>	Veiny Laceflower	x				
	<i>Pararchidendron pruinosum</i> var. <i>pruinsum</i>	Snowwood	x	x	x		
		ROTAP					

FAMILY	BOTANICAL NAME	COMMON NAME	1	2a	2b	3	4
MONIMIACEAE							
	<i>Daphnandra micrantha</i>	Socketwood	x		x		
	<i>Doryphora sassafras</i>	Sassafras	x	x			
	<i>Wilkiea huegeliana</i>	Veiny Wilkiea	x	x	x	x	x
	<i>Wilkiea macrophylla</i>	Large-leaved Wilkea	x	x	x	x	x
MORACEAE							
	<i>Ficus coronata</i>	Creek Sandpaper Fig	x	x	x	x	
	<i>Ficus fraseri</i>	Sandpaper Fig	x	x	x		x
	<i>Ficus obliqua</i>	Small-leaved Fig	x	x			x
	<i>Ficus rubiginosa</i>	Rusty Fig	x				x
	<i>Ficus watkinsiana</i>	Strangler Fig	x				
MYRSINIACEAE							
	<i>Rapanea subsessilis</i>	Red Muttonwood	x				
MYRTACEAE							
	<i>Acmena ingens</i>	Red Apple	x		x		
	<i>Amena hemilampra</i>	Broad-leaved Lilly Pilly	x				
	<i>Acmena smithii</i>	Common Lilly Pilly	x				
	<i>Acmena smithii (rheophytic form)</i>	Creek Lilly Pilly	x			x	x
	<i>Austromyrtus bidwillii</i>	Python Tree	x	x			
	<i>Lophostemon confertus</i>	Brush Box	x	x		x	
	<i>Ptilidostigma glabrum</i>	Plum Myrtle	x	x			
	<i>Rhodamnia argentea</i>	Malletwood	x				
	<i>Rhodamnia maideniana</i>	Smooth Scrub Turpentine	x	x			
	<i>Rhodamnia rubescens</i>	Scrub Turpentine	x			x	
	<i>Rhodomyrtus psidioides</i>	Native Guava	x			x	x
	<i>Syzygium australe</i>	Brush Cherry				x	
	<i>Syzygium crebrinerve</i>	Purple Cherry	x				
	<i>Syzygium francisii</i>	Giant Water Gum	x	x			
	<i>Syzygium hodgkinsoniae</i>	Red Lilly Pilly	x				
	<i>Syzygium leuhmannii</i>	Riberry	x		x	x	
	<i>Syzygium moorei</i>	Coolamon	x	x			
	<i>Syzygium oleosum</i>	Blue Lilly Pilly	x			x	
	<i>Tristanopsis laurina</i>	Water Gum	x			x	
OLEACEAE							
	<i>Notelaea johnsonii</i>	Veinless Mock-olive	x			x	x
PITTOSPORACEAE							
	<i>Pittosporum multiflorum</i>	Orange Thorn	x	x	x		
	<i>Pittosporum revolutum</i>	Hairy Pittosporum	x	x	x	x	
	<i>Pittosporum undulatum</i>	Sweet Pittosporum	x	x	x	x	x
PODOCARPACEAE							
	<i>Podocarpus elatus</i>	Plum Pine	x				
PROTEACEAE							
	<i>Floydia praealta</i>	Ball Nut	x				
	<i>Helicia glabriflora</i>	Smooth Helicia	x		x		
	<i>Macadamia tetraphylla</i>	Rough Leaved QI Nut	x				
	<i>Stenocarpus salignus</i>	Beefwood	x				
	<i>Stenocarpus sinuatus</i>	Firewheel Tree		x			
	<i>Truinia youngiana</i>	Honeysuckle Bush	x		x		
RHAMNACEAE							
	<i>Alphitonia excelsa</i>	Red Ash	x	x	x	x	x
RUBIACEAE							
	<i>Atractocarpus chartaceus</i>	Narrow-leaved Gardenia	x				
	<i>Canthium coprosmpides</i>	Coast Canthium	x		x		

FAMILY	BOTANICAL NAME	COMMON NAME	1	2a	2b	3	4
RUTACEAE	<i>Bosistoa pentacocca</i>	Large-leaved Bosistoa	x				
	<i>Citrus australasica</i>	Finger Lime					
	<i>Flindersia australis</i>	Teak	x	x		x	x
	<i>Flindersia bennettiana</i>	Bennet's Ash	x	x		x	
	<i>Flindersia schottiana</i>	Cudgerie	x	x	x	x	x
	<i>Flindersia xanthoxyla</i>	Yellowwood			x		
	<i>Medicosma cunninghamii</i>	Medicosma		x			
	<i>Pentaceros australe</i>	Bastard Crow's Ash	x	x			x
	<i>Sarcomelicope simplicifolia</i>	Bauerella	x				
	<i>subsp. simplicifolia</i>						
SAPINDACEAE	<i>Alectryon subcinereus</i>	Wild Quince	x				
	<i>Arytera distylis</i>	Twin-leaf Coogera	x	x	x		
	<i>Arytera divaricata</i>	Coogera		x		x	
	<i>Castanospora alphanthii</i>	Brown Tamarind	x		x		
	<i>Diploglottis australis</i>	Native Tamarind	x	x	x		x
	<i>Elatostachys nervosa</i>	Green Tamarind	x				
	<i>Guioa semiglaucula</i>	Guioa	x	x	x	x	x
	<i>Harpullia alata</i>	Wing Leaved Tulip	x				
	<i>Jagera pseudorhus</i> var. <i>pseudorhus</i>	Foambark Tree	x	x	x	x	x
	<i>Mischocarpus australis</i>	Red Pear-fruit	x	x			
	<i>Mischocarpus pyriformis</i>	Yellow Pear-fruit	x	x	x	x	
	<i>Rhysotoechia bifoliolata</i>	Twin-leaf Tuckeroo			x		
	<i>subsp. bifoliolata</i>						
	<i>Sarcopteryx stipata</i>	Steelwood	x	x	x	x	x
	<i>Toeckia dasyrrache</i>	Blunt-leaved Steelwood	x		x		
SAPOTACEAE	<i>Pouteria australis</i>	Black Apple	x			x	x
	<i>Pouteria laurifolia</i>	Blush Coondoo	x				
SIMAROUBACEAE	<i>Guilfoylia monostylis</i>	Guilfoylia	x				
	<i>Quassia</i> sp. 'Mt Nardi'	Quassia	x		x	x	x
STERCULIACEAE	<i>Brachychiton acerifolius</i>	Flame Tree					
	<i>Commersonia bartramia</i>	Brown Kurrajong	x		x	x	
	<i>Heritiera trifoliolata</i>	White Booyong	x	x			
	<i>Symplocos thwaitesii</i>	Buff Hazelwood	x				
THYMELAEACEAE	<i>Wikstroemia indica</i>	Wikstroemia	x	x	x	x	
ULMACEAE	<i>Aphananthe philippinensis</i>	Native Elm	x				
	<i>Trema tomentosa</i> var. <i>viridis</i>	Poison Peach	x		x	x	
URTICACEAE	<i>Dendrocnide excelsa</i>	Giant Stinging Tree	x				
	<i>Dendrocnide photinophylla</i>	Shiny-leaved Stinging Tree	x				
VERBENACEAE	<i>Clerodendron floribundum</i>	Smooth Clerodendron	x				
	<i>Gmelina leichhardtii</i>	White Beech	x				

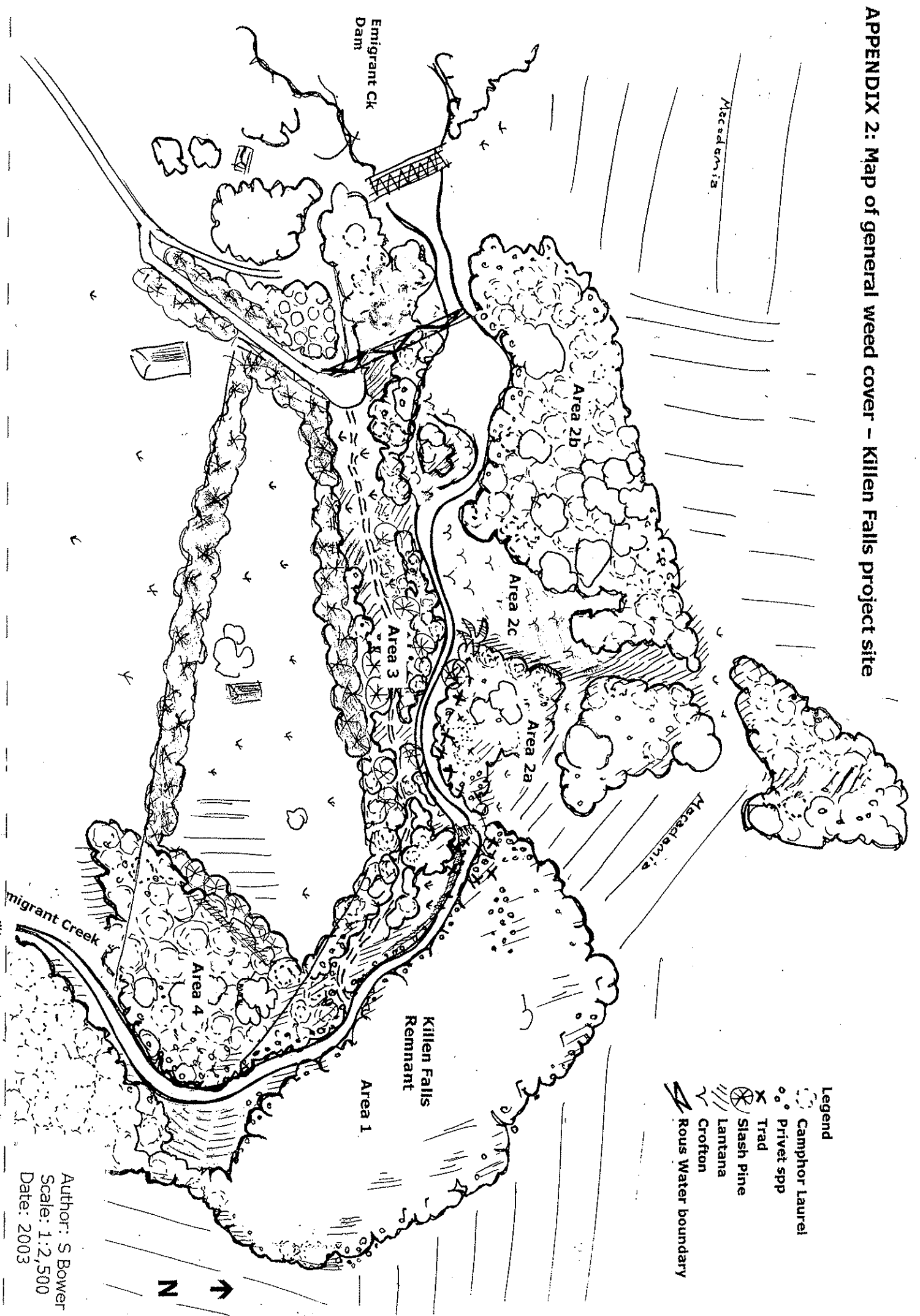
NB: The *Acalypha* recorded from the remnant is under investigation.
Specimens from this site and other Big Scrub remnants show similarities to *A. eremorum*.
The *Acalypha* species from the remnant is being referred to as *Acalypha* sp. aff. *eremorum*

ROTAP - Rare or Threatened Australia Plant

S 1 Listed as threatened on the Threatened Species Conservation Act 1995

S 2 Listed as Vulnerable on the Threatened Species Conservation Act 1995

APPENDIX 2: Map of general weed cover – Killen Falls project site



APPENDIX 3: Rainforest remnant - threats

Threats resulting from fragmentation

Edge effects and the impacts of forest fragmentation

Fragmented and isolated remnants are highly prone to edge effects. Edge effects are external factors that impact and penetrate into remnant edges (Sisk & Margules 1993) changing natural environmental conditions. Edge effects enhance conditions for weed invasion, may disadvantage lifecycles of native fauna, and the establishment of rainforest plants that require shaded and protected conditions. The impacts of edge effects are compounded in remnants that are small, have a large edge to area, have a high level of structural disturbance, lack a substantial core area of less disturbed forest and exhibit weed infestations. Remnants subject to harsh edge effects are vulnerable to future disturbances such as tree falls and are less able to recover without human assistance due to further weed invasion or vine domination.

Changes in successional pathways

Webb *et al.* (1985) and Kooyman (1996) consider small, fragmented/isolated remnants unlikely to be able to be self-sustaining and viable in the long-term due to a regression towards secondary successional species. Saunders *et al.* (1991) indicate that the degree of alteration together with remnant size, shape and degree of isolation greatly influences species survival in native habitat remnants. In small remnants successional regression or 'stagnation' (Lovejoy 1985) is exacerbated by fragmentation (limiting movement of genetic material), by harsh edge effects, agricultural impacts, deflection by exotic weed species and domination by native woody vines. Fragmentation has disrupted successional pathways and reduced the effectiveness of faunal distribution of some mature phase species throughout isolated Big Scrub remnants. However the use of Big Scrub remnants and regrowth areas as "stepping stones" for frugivorous avifauna and flying-foxes and the role they play in seed & pollen dispersal is fundamental to the long-term viability of a remnant (Date *et al.* 1991).

Weed impacts

The diversity of environmental weeds that commonly occur in subtropical rainforest remnants collectively pose a significant threat to the integrity of a remnant, mainly because weeds can occupy all niches/strata within the forest ecosystem (the ground, shrub layer, midstorey and the canopy). Many of the weeds inhabiting remnants are serious environmental weeds. A serious environmental weed is considered as a plant that can cause a major modification to the species richness, abundance and ecosystem functions of a plant community (ANPWS 1991). Vine weeds such as Madeira Vine are particularly destructive in that they are quick growing and can smother all layers of the forest.

Re-infestation of weeds will remain an on going problem in remnants that have high light conditions suited for new invasions or contain existing weed infestations. Weed infestations within the local landscape will also be a problem with reintroduction's occurring through flooding, wind or animal dispersal (including dumping of waste by humans).

Native vines – their impacts, importance and management

Complex notophyll vine forest (CNVF) describes the structural and life form attributes of lowland subtropical rainforest in which vines are an integral component. Dense vine thickets and native vine curtains that are often evident on remnant edges are a natural ecosystem response to disturbance. Vine edges can be an effective

means of reducing edge effects such as wind, light and temperature fluctuations. However, where vines are causing severe degradation and toppling of canopy trees, vine management is required. Vines that are typically advantaged by disturbances are generally the fast growing species including *Cissus* spp, Blood Vines – *Austrosteenisia* sp., and Whip Vine - *Flagellaria indica* and Wait-a-while. Refer to rainforest restoration – theory and practise (Appendix 5). Vines also provide important habitat (shelter and food resources) for a range of fauna (see Appendix 9a&b Fauna profiles).

Adjacent landuse

Adjoining landuse activities may impact remnant vegetation directly and indirectly (e.g. via pesticide drift, weeds, fire, cattle browsing etc). It is essential that liaison with neighbouring land managers is undertaken in regard to remnant restoration activities to develop favourable practises that will achieve management goals for the restoration project and for the land manager.

Tracks & human visitation

A network of tracks within small remnant ecosystems may pose a threat to the condition of a remnant through increased light conditions and impacts associated with human activities. Visitation to small isolated remnants is best kept to a minimum level and to low-key low-impact activities to minimise disturbance to fauna and to maintain scenic amenity and ecological integrity.

Summary of impacts and processes which degrade remnants

- isolation from large areas of contiguous forest (connection to larger areas of forest);
- edge effects, narrow shape, small size = loss of microclimate;
- wind turbulence (resulting in increased canopy and structural damage);
- changes in vegetation structure and composition;
- changes in faunal communities, increased predation & competition;
- altered food and habitat resources for rainforest dependant fauna;
- high level of weed infestations and shade tolerant weed species;
- excessive vine domination of canopy trees;
- weed infestations in the surrounding landscape;
- potential loss of ecofunctions (eg specialist pollinators, loss of seed dispersers, predators)
- impacts of pesticides on rainforest plant pollinators;
- ineffective plant population size (limited genetic base, low reproductive capability, vulnerability to disturbances and loss).

APPENDIX 4: Weed control techniques for the main environmental weed species occurring at the Killen Falls restoration project site

Key: Recommended weed control techniques and herbicides

G	Glyphosate products with an active constituent of 360G/L glyphosate as isopropylamine (e.g. Weedmaster ® & Roundup Biactive ®) are used for most herbicide applications e.g. cut-paint, inject and strategic spraying.
MM	Metsulfuron methyl (brushkiller ®) is a herbicide mainly used for spray applications
LI 700	LI700 ® = an additive – surfactant /penetrant & acidifier
Ag	Agral ® = wetting agent
C&P	cut and paint
S&P	scrape and paint
C,S & P	cut, scrap and paint
FI	Frill and inject (stem injection)
Crown	crowning with knife to remove subterranean growth structures
HW	hand weed, hand removal of weeds.

The following herbicide mixes are commonly used for controlling a range of environmental weed species (see recommended applications below).

Recommended herbicide ratios for stem injection and painting of cut or scraped stems:

Glyphosate 100% – for painting scraped stems of Madeira Vine.

Glyphosate at a ratio of 1part to 1.5 parts water for cut – scrape and paint, scrape and paint, and stem injection.

Recommended herbicide spray applications:

Herbicide mix No. 1 (Glyphosate 1:100 + LI-700 1:200)

Herbicide mix No. 2 (Glyphosate 1:100 + Metsulfuron methyl 1.5 gm/10L + Agral 2ml/10L)

Herbicide mix No. 3 (Glyphosate 1:50 + LI-700 1:200)

Herbicide mix No. 4 (Glyphosate 1:50 + Metsulfuron methyl 1.5 gm/10L + Agral 2ml/10L)

Herbicide mix No. 5 (Metsulfuron methyl 1-2gms/10L + Agral 2ml/10L)

Note: 1:50 = 20ml per litre, 1:100 = 10ml per litre, 1:200 = 5ml per litre

LI-700 is a surfactant that is often used with herbicide spray applications within a bush regeneration context. Other additives such as marker dyes, adjuvants (oils), wetting agents (such as Agral ® often used with MM) and other surfactants may be used to assist and improve the effectiveness of spray applications. Refer to product labels to determine compatibility of additives to herbicides. All herbicide applications must be in accordance to the product label. Off label use of herbicides must be registered with the National Registration Authority for agricultural and veterinary chemicals. The BSRLG is registered under permit No.5206 (exp.2007) for a range of off label applications.

BOTANICAL NAME	COMMON NAME	REMOVAL TECHNIQUES
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VINES/SCRAMBLERS

<i>Anredera cordifolia</i>	Madreia Vine	<u>Climbing vines:</u> scrape & paint with neat - 100% G. Scrape vines to ½ thickness of the stem. Scrape & paint ground tuber. Avoid cutting vines aim to kill aerial tubers with S&P <u>Tuberlings:</u> spray (No.3. or 4). Repeated spray treatment will be required to exhaust large tubers <u>Tuberlings:</u> Knife out, collect & compost
<i>Desmodium uncinatum</i>	Silver-leaved Desmodium	<u>Individual plants:</u> Crown or CS&P tuberous roots (G 1:1.5). <u>Foliage:</u> spray (No. 4 or No. 5)
<i>Ipomoea calrica</i>	Five-leaf Morning Glory	<u>Cut ascending vines at head height:</u> Hand pull runners on the ground roll-up and hang up off the ground. Spray regrowth or dense blanketing foliage (No.1or 2) <u>Larger stems, roots & nodes:</u> CS&P (G 1:1.5)
<i>Passiflora suberosa</i>	Corky Passionfruit	<u>Climbing stems:</u> hand-pull or CS&P (G 1:1.5) <u>Seedlings and regrowth:</u> spray (No. 4)

BOTANICAL NAME	COMMON NAME	REMOVAL TECHNIQUES
<i>Passiflora subpeltata</i>	White Passionfruit	<u>Climbing stems</u> : hand-pull or CS&P (G 1:1.5) <u>Seedlings and regrowth</u> : spray (No. 4)
<i>Solanum seaforthianum</i>	Climbing Nightshade	<u>Vines</u> : CS&P (G 1:1.5) <u>Seedlings</u> : hand pull <u>Regrowth and seedlings</u> : spray (No.3)
TREES		
* <i>Cinnamomum camphora</i>	Camphor Laurel	<u>Seedlings</u> : hand pull or spray (No. 3 or 4). <u>Shrubs & trees</u> : CS& Paint or frill & inject (G 1:1.5)
<i>Ligustrum lucidum</i>	Large-leaved Privet	<u>Shrubs and trees</u> : CS& Paint or frill & inject (G 1:1.5) <u>Seedlings and regrowth</u> : Spray: (No. 3, 4, or 5)
<i>Ligustrum sinense</i>	Small-leaved Privet	As for Large-leaved Privet
<i>Pinus elliotii</i>	Slash Pine	<u>Seedlings</u> : handpull <u>Shrubs</u> : Cut to ground level or C&P (G 1:1.5) <u>Trees</u> : Fell isolated trees. Frill and inject (G 1:1.5). Must penetrate thick bark
<i>Syagrus romanzoffianum</i>	Cocco Palm	<u>Seedlings & small plants</u> : Crown/knife-out or spray (No. 4) <u>Trees</u> : cut below growing point or F/I (G 1:1.5)
SHRUBS		
<i>Lantana camara</i>	Lantana	<u>Seedlings/small shrubs</u> : Hand pull or CS&P stems (G 1:1.5) <u>Thicket</u> : cut back & spray regrowth or over-spray (No. 3).
<i>Ochna serrulata</i>	Ochna	<u>Small seedlings</u> : hand pull or knife out <u>Shrubs</u> : CS&P or S&P or F/I (G 1:1.5) <u>Small seedlings and regrowth</u> : spray (No. 3,4 or 5).
<i>Psidium cattleianum</i>	Red Cherry Guava	<u>Saplings</u> : CS&P (G 1:1.5) <u>Shrubs</u> : F/I (G 1:1.5). <u>Seedlings</u> spray (No. 3, 4 or 5).
<i>Senna pendula</i> var. <i>glabrata</i>	Winter Senna	<u>Seed pods</u> : collect and dispose <u>Seedlings</u> : handpull or spray (No. 3, 4 or 5) <u>Shrubs</u> : CS&P, or frill & inject with glyphosate at (1:1.5)
GROUNDCOVERS & HERBS		
<i>Ageratina adenophora</i>	Crofton	<u>Hand-pull and hang to dry, or spray</u> (No. 3 or 5).
<i>Ageratina houstonianum</i>	Goatweed	<u>Hand-pull and hang to dry, or spray</u> (No. 1).
<i>Ageratina riparia</i>	Mistflower	Refer to Crofton
<i>Drymaria cordata</i> subsp. <i>cordata</i> (+)	Tropical Chickweed	<u>Hand weed & compost or spray</u> (No.1).
<i>Hypoestes phyllostachya</i>	Freckle Face	<u>Small plants</u> : Knife out or spray (No. 3, 4 or 5).
<i>Paspalum wettsteinii</i>	Broad-leaved Paspalum	<u>Grass patches</u> : spray (No. 1).
<i>Rivina humulis</i>	Coral Berry	<u>Hand weed & compost or spray</u> (No. 1).
<i>Setaria</i> spp.	Setaria	<u>Isolated plants</u> : collect seed heads & crown out plant <u>Grass patches</u> : spray (No. 1).
<i>Tradescantia fluminensis</i> (albiflora)	Trad	<u>Hand weed or roll & rake & compost or Spray</u> (No.3,4 or 5).
<i>Tradescantia benghalensis</i>	Hairy Commelina	Refer to Trad

(+) denotes native plant that displays weed characteristics, colonising areas of disturbance (Harden 1990).

**APPENDIX 4b: Noxious and Regionally Significant Weeds
at the Killen Falls Project site.**

FAMILY	BOTANICAL NAME	COMMON NAME	NOXIOUS CATEGORY	WEEDS OF REGIONAL SIGNIFICANCE
WETLAND PLANTS				
PONTEDERIACEAE	<i>Eichornia crassipes</i>	Water Hyacinth	W3	X
SALVINIACEAE	<i>Salvinia molesta</i>	Salvinia	W2	X
HERBS and GROUND COVERS				
ASTERACEAE	<i>Ageratina adenophora</i>	Crofton	W3	
	<i>Ageratina riparia</i>	Mistflower	W3	
COMMELINACEAE	<i>Tradecentia fluminensis</i>	Trad		X
VINES AND SCRAMBLERS				
BASELLACEAE	<i>Anredera cordifolia</i>	Madeira Vine (near site)		X
CONVOLVULACEAE	<i>Ipomoea cairica</i>	Five-leaf Morning Glory		X
VERBENACEAE	<i>Lantana camara</i>	Lantana (red flowered ?)	W3	X
TREES AND SHRUBS				
ASTERACEAE	<i>Baccharis halimifolia</i>	Groundsel	W2	X
LAURACEAE	<i>Cinnamomum camphora</i>	Camphor Laurel	area exempt	X
OLEACEAE	<i>Ligustrum lucidum</i>	Large-leaved Privet	area exempt	X
	<i>Ligustrum sinense</i>	Small-leaved Privet	area exempt	X

Regionally significant weeds are species that required a coordinated approach to their control. They include noxious and environmental weed species. NSW North Coast Weeds Strategy (2003).

Noxious weed control categories

The control categories relevant to the NSW North Coast are:

- W1 The presence of these weeds on land (or on/in water) must be reported to the Local Control Authority, and the weed must be fully and continuously suppressed and destroyed;
- W2 The weed must be fully and continuously suppressed and destroyed;
- W3 The weed must be prevented from spreading and its numbers and distribution reduced;
- W4 The action specified in the declaration must be taken in respect of these weeds.

The following actions apply to W4 noxious weeds in the NCWAC area:

- W4(b) The weed must not be sold, propagated or knowingly distributed and any existing weed must be prevented from flowering and fruiting;
- W4(d) The weed must not be sold, propagated or knowingly distributed and the weed must be fully and continuously suppressed and destroyed if it is: three (3) metres in height or less, or within half a kilometre of remnant urban bushland, as defined by SEPP 19, and is not deemed by a local control authority as having historical or heritage significance, or over three metres in height and not included in a Management Plan approved by the local control authority;
- W4(f) Shall not be sold, propagated or knowingly distributed. Occupier must implement biological control or other program directed by the LCA, and;
- W4(g) Shall not be sold, propagated or knowingly distributed.

Declared noxious weeds list

Weeds are listed by Local Control Authority areas. Numbers indicate the category under the Noxious Weeds Act, 1993 as Gazetted. i.e 1 = W1, 2 = W2, 3 = W3 & 4 = W4. A blank indicates not declared.

APPENDIX 5: Restoration guidelines

Restoration team

Rainforest restoration work is best undertaken by experienced rainforest regenerators who are skilled in plant identification, vegetation and fauna habitat management and strategic weed control techniques. Regenerators also need to determine the relevant legislation and licenses that are required for working in sites of conservation significance (see Appendix 6). Where threatened or restricted fauna species are present specialist advice should be sought on appropriate management strategies (see Appendix 9B).

Restoration actions and other observations should be recorded on a daily basis (weed species control, herbicide applications, climate, seedling regeneration, fauna observations etc). Long term monitoring is also recommended to assess restoration outcomes such as changes in plant species composition and structure, faunal interactions and success of weed control techniques (in prep - BSRLG -2004).

Weed management

- Weed control is best undertaken in a systematic manner, which involves controlling all weeds in an area prior to moving into a new area, unless the retention of some weeds is required for temporary microclimate, habitat or erosion control - aiming to replace weeds with native vegetation.
- Avoid over clearing and causing drastic changes to microclimate; to prevent impacts to fauna, restoration works should be undertaken with consideration for all fauna including invertebrates and their habitat needs.
- Weed control needs to be undertaken in an effective yet environmentally sound manner. A range of weed control techniques and herbicide applications have been developed for a range of weed species impacting rainforest sites in northern NSW (BSRLG 2nd Ed. 2000).
- Herbicide applications must be in accordance to registered herbicide labels or permits under the National Registration Authority (for agricultural and veterinary chemicals) for off label use. Refer to Appendix 4 for control techniques and herbicide ratios.
- Regular monitoring and follow-up weed control is paramount.
- The level of primary or initial weed control must correspond to the level of resources available for follow-up and a sites regenerative capacity.

Native vine management

- Only cut back native vines that are vigorously degrading/smothering trees or shrubs and deflecting canopy development.
- Prior to cutting natives vines assess the ecological significance of the species and the habitat value of vine thickets (eg. nest, roost, wintering shelter and food resources). If vines provide important habitat resources or protection from predators undertake vine control following the period of peak habitat use or incrementally control vine thicket (See Appendix 9b).
- Incrementally cut back native vines to promote canopy expansion whilst retaining some of the mature stems.
- Avoid cutting vines that are holding a crop of fleshy fruit.
- Vines should only be cut and not poisoned.
- Avoid cutting large vines.

- Retain a mosaic of native vine-dominated areas for habitat values and structural complexity.
- In a small remnant vine cutting must be undertaken gradually.

Methods for remnant expansion

Natural regeneration

- Remnant edges can be enhanced and expanded through promoting natural regeneration underneath and alongside trees occurring on the forest edge. Natural regeneration can occur through stimulating soil seed banks and by seed dispersal.
- For isolated and modified sites, natural regeneration areas should be kept fairly close to the remnant edge. The potential for natural regeneration reduces the greater the distance from the edge. The level and success of seed recruitment will vary with plant community characteristics, site conditions (weed competition, exposure and disturbance) and commitment to maintenance.
- Edges of remnants are often harsh and exposed, which can limit the success of seed dispersal, recruitment and growth. In these cases the establishment of a framework planting or the strategic retention of weeds is required to enhance microclimate and soil conditions, faunal movement and seed dispersal.
- In some instances it may be suitable to leave a gap for natural regeneration directly along the forest edge and establish a framework planting at a further distance to provide microclimate for the regeneration area.
- Regular spot spraying of weeds is required to maintain seedling regeneration areas.
- Monitor the extent of seedling regeneration over a period of time. If natural regeneration is limited supplement the site by planting and /or direct seeding.

Assisted regeneration / vegetation reconstruction

Planting models:

- The Framework or Accelerated Succession planting model is recommended for expanding remnants and for vegetation reconstruction. The adoption of a model will hinge on management goals, resources and a site's regenerative potential.
- The framework model is recommended for sites that are in close proximity to a good seed source or along remnant edges. This model generally uses pioneer to secondary successional species that are early fruiting, have a high turnover of leaves, and will attract seed dispersers. Mature phase plant species can also be interspersed. This model generally has lower species diversity.
- In sites prone to heavy frost or flooding a framework planting of frost tolerant species is used to enhance the site conditions for the establishment of frost sensitive species.
- In areas that are highly degraded and/ isolated from large seed sources and contiguous forest, planting composition and design should follow the Kooyman models of accelerated succession (Kooyman 1991; 1996). The accelerated succession model utilises a high diversity of pioneer, secondary and mature phase species, with a preference towards the late secondary and mature phases. Mature phase species may be difficult to establish in degraded sites however the early stage species will assist their establishment.
- Plant species considered for establishment near remnants should only include those that are currently or were historically known to occur from the local area or occur in similar site conditions. Sources of nursery stock must consider the genetic integrity/provenance of a site (see Appendix 10 Indicative genetic based guidelines for Big Scrub plantings).

APPENDIX 6: Relevant legislation

Various pieces of legislation apply to the protection and management of the remnant and adjacent project sites in context to undertaking vegetation restoration works. These primarily relate to environmental constraints aimed at protecting remnant vegetation, threatened species, soil and water. Environmental legislation that has particular application to the undertaking of ecological restoration actions at the Killen Falls project site includes:

- ♦ *Native Vegetation Conservation Act 1997*;
- ♦ *National Parks and Wildlife Act 1974*;
- ♦ *Threatened Species Conservation Act 1995* ;
- ♦ *Environmental Planning and Assessment Act 1979*;
- ♦ *Ballina Local Environment Plan 1987*;
- ♦ *Pesticides Act 1999*; and,
- ♦ *Noxious weeds Act 1993*.

Native Vegetation Conservation Act (NVC Act)

Consent is required under the NVC Act to clear non-native plants/environmental weeds with Riparian State Protected Land (RSPL). RSPL is land that is on or within 20 metres of the bed and banks of prescribed streams, watercourses and lakes. The clearing of non-native plants/environmental weeds requires strategic measures that minimise environmental impacts (best management principles). In context to this plan the purpose being to restore native vegetation.

National Parks and Wildlife Act 1974 (NPW Act)

A Scientific License is required under Section 132C of the NPW Act to undertake conservation /restoration work within the habitat of an endangered species, endangered population or endangered ecological communities listed on the Schedules of the *Threatened Species Conservation Act 1995*.

Threatened Species Conservation Act 1995 (TSC Act)

The TSC Act has cognate provisions for the protection of threatened species, endangered ecological communities, critical habitat of threatened species and for the development of recovery and threat abatement plans.

The project site contains a number of threatened plant species and provides potential habitat for a range of threatened fauna (Table 1). The flood prone section of Killen falls remnant is listed as an Endangered Ecological Community – Lowland Rainforest on Floodplain. See section above for licensing requirements.

Ballina Local Environment Plan 1987 (Ballina LEP)

The project site falls under a number of zones identified within the Ballina LEP (see zoning map).

The Killen Falls rainforest remnant (Area 1), and adjacent regrowth (Area 2b & 2c) are zoned **7(I) Environmental Protection – Habitat** (see map). The primary objective of this zoning is to protect areas of particular habitat significance. Development consent is required to undertake agricultural, forestry and environmental protection works in this zone.

The regrowth forest below the dam (western section of Area 2b) is zoned **7 (C) Environmental Protection – Water Catchment**. The primary objective of this zoning is to prevent development that will affect water supply quality. Under Part 3 Special Provisions – clause 24 of the LEP (1987) development within zones No 7(c) & 7(l) agricultural activities is allowed without consent, however development consent is required to cut down, lop, destroy a tree (other than planted commercial tree) or clear or alter land surfaces.

Area 3 and 4 is zoned **1 (b) Rural – Secondary Agricultural Land**. The primary objective of this zone is to regulate subdivision. No consent is required for agriculture and forestry practises. The zoning of this land should be reviewed in the future to reflect the restoration works in progress and the associated ecological values of the site.

Development consent will be required to undertake restoration works in the remnant and regrowth patches upstream of the remnant. A threatened species assessment will also need to accompany the development application.

Pesticides Act 1999

The *Pesticides Act* 1999 governs the application of chemicals. Persons using pesticides for commercial or occupational purposes (as part of their job or on farm) must keep records of use (pesticide, target species, climate etc) see example record sheet - Appendix 12. According to the *Pesticides Act* 1999 herbicide applications must be undertaken in accordance with National Registration Authority for Agriculture and Veterinary Chemicals (NRA) registered product labels. Off label use of herbicides must be registered with the NRA (BSRLG PER 5206). The use of herbicides must be undertaken in a safe manner under a Duty of Care for the operator, public and the environment.

Noxious weeds Act 1993

The Act provides for the state wide listing and control of noxious weeds detailing specific control strategies. Refer to list of weeds per management area and Appendix 4b.



Zoning Key:
 7 (l) Environmental Protection - Habitat
 7 (c) Environmental Protection - Water Catchment
 1 (b) Rural - Secondary Agricultural Land



Killen Falls

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 Date : 26/05/2003

DISCLAIMER

While every effort has been made to ensure the accuracy of this map, Ballina Shire Council does not accept any liability for any errors, omissions, or inaccuracies. The information contained on this map is for general reference only. For more detailed information, please contact the relevant authorities.

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APPENDIX 8: ROTAP codes

Conservation Code

- 2 The Distribution Category (can be 1, 2 or 3)
 - 1 Known by one collection only,
 - 2 Geographic range in Australia less than 100 km.
 - 3 Geographic range in Australia greater than 100 km.
- K The Conservation Status (can be X, E, V, R or K)
 - X Presumed Extinct: taxon not collected or otherwise verified over the past 50 years despite thorough searching in all known and likely habitats, or of which all known wild populations have been destroyed more recently.
 - E Endangered: taxon in serious risk of disappearing from the wild within 10–20 years if present land use and other threats continue to operate. This category includes taxa with populations possibly too small (usually less than 100 individuals) to ensure survival even if present in proclaimed reserves.
 - V Vulnerable: taxon not presently Endangered, but at risk over a longer period (20–50 years) of disappearing from the wild through continued depletion, or which occurs on land whose future use is likely to change and threaten its survival.
 - R Rare: taxon which is rare in Australia (and hence usually in the world) but which currently does not have any identifiable threat. Such species may be represented by a relatively large population in a very restricted area or by smaller populations spread over a wide range or some intermediate combination of distribution pattern.
 - K Poorly Known: taxon that is suspected, but not definitely known, to belong to one of the above categories. At present, accurate field distribution information is inadequate.
 - C Reserved: indicates taxon has at least one population within a national park, other proclaimed conservation reserve or in an area otherwise dedicated for the protection of flora. The taxon may or may not be considered adequately conserved within the reserve(s), as reflected by the conservation status assigned to it. Where applicable, the 'C' symbol immediately follows the conservation status symbol in the written code, e.g. 2RC.
- i Size-class of all reserved populations (options are a, i or –)
 - a 1000 plants or more are known to occur within a conservation reserve(s),
 - i less than 1000 plants are known to occur within a conservation reserve(s),
 - reserved population size is not accurately known;
- t Total known population reserved;
- + Overseas occurrence (included if the taxon has a natural occurrence overseas);
- P1 CALM Priority Flora Code (can be P1, P2, P3, P4 – see Appendix for definitions).

State and regional distribution and extent of reservation

- Ws State(s) or Territory in which the taxon still occurs (upper case), or where it once occurred but is now Presumed Extinct (lower case). Any one or more of the symbols WYsqNAVT or wysqnavt are possible: W = Western Australia, Y = Northern Territory, S = South Australia, Q = Queensland, N = New South Wales, A = Australian Capital Territory, V = Victoria and T = Tasmania.
- 6, 23 Regions of occurrence (can be in any of 1–80 regions; see Figure 1, p. 17).
- C The use of the C symbol in conjunction with a region number indicates that the taxon is reserved in that region (region 6 in this example).
- i Size-class of the total population within the reserve referred to (options are a, i or –). In this example, the size-class in Cape Arid National Park is less than 1000 individuals).
- x Indicates that the taxon is Presumed Extinct within a region (region 23 in this example).
- Cape Arid The name of a proclaimed reserve or other area dedicated to the protection of flora within which the taxon occurs in the region referred to (the taxon may occur within several reserves within a particular region and sometimes a reserve may extend across two or more regions).
- NP Indicates the class of reserve which is listed e.g. Nature Reserve, National Park, Heritage Agreement Area (in this example, National Park) (see Table 2, p. 15 for the key to conservation reserve types listed in this publication).

APPENDIX 9A: Fauna assessment - Killen Falls project site

Killen Falls remnant and the adjacent surrounds provide important habitat for a range of sedentary and nomadic fauna. Sedentary species use the site all year round whilst nomadic species opportunistically use the site for feeding and breeding when suitable resources are available. Being an isolated remnant this site is important as a stepping stone for nomadic nectivorous and frugivorous fauna that are important for the dispersal of pollen and seeds into the surrounding landscape.

The fauna that utilise Killen Falls remnant and adjacent regrowth habitat are largely impacted by the surrounding landscape. The majority of the fauna that use the site are habitat generalist species, although the site provides for several habitat specialists. Habitat generalists use the site for refuge and as breeding habitat, but also utilise other habitats within the landscape. Specialist species dependant on rainforests or contiguous forest are disadvantaged by the modified landscape, isolated nature of remnants (being separated from large tracts of surrounding native vegetation), small remnant size and competition from aggressive generalists species such as Pied Currawongs- *Strepera graculina* and Noisy Minors- *Manorina melanocephala*.

HABITAT REQUIREMENTS

Killen Falls remnant displays a range of habitat components essential for the lifecycle requirements of the many species reliant on the remnant. However, this remnant may be too small and disturbed to sustain a viable population for certain species to exist in perpetuity (Lott and Duggin 1993). Small isolated populations are prone to localised extinctions as a result of catastrophic events, inbreeding depression and disease. Such extinctions can take place a long time after fragmentation and is labelled 'extinction debt' - ie the debt of extinction is paid long after the disturbance has occurred. It is therefore important to understand which species are prone to localised extinctions and develop management strategies for their habitat to ensure their survival.

The challenge is to maintain and enhance the viability of fauna populations restricted to or utilising remnant habitats.

A range of factors implicated in affecting the viability of a remnant to sustain a viable population of a particular species in the long term. These include remnant shape and size, time since isolation, distance between remnants, their connectivity, degree of habitat alteration and disturbance, competition for food resources and exposure to edge effects (Bennett 1987, Leach & Recher 1993, Saunders & Hobbs 1995, Silversten 1995). These changes can often promote localised extinctions for specialist species or species required large territories. The problem is exacerbated by increased competition by open habitat species and predation by feral animals.

To ensure the persistence of fauna from fragmented landscapes requires the retention and restoration of existing habitats. Remnant expansion, connection and the reconstruction of larger areas of habitat is recommended as it will increase and enhance habitat resources, reduce the effects of edge influences and improve habitat connectivity. The incorporation of the Killen Falls remnant into a larger local vegetation management project is a positive step towards improving the viability of the site for fauna.

The Killen Falls project site displays several habitat types, which provide a variety of environments and resources for fauna typical to certain habitats.

The rainforest habitat

This is important for rainforest specialist species whilst providing important foraging and breeding habitat for many open habitat species. The structural complexity of the forest and proximity to riparian/water habitat improve the ecological significance of this site. The rainforest environment provides shelter; roost sites, hollows, fruits and nectar, leaf litter for ground foraging birds and reptiles, and supports a myriad of invertebrates/insects. The remnant potentially supports a wide diversity of invertebrates, although this fauna group has not been well studied across the Big Scrub. Of particular management interest are those species confined to the remnant that are unable to migrate to other sites during catastrophic events or when resources are limited (eg food shortages, flood events, drought etc).

Some rainforest dependent species likely to be found in the habitat provided by Killen Falls remnant:

- Gall's Shadestink - *Saproscincus gallii*
- Land Mullet - *Egernia major*
- Southern Angle-headed Dragon - *Hypsilurus spinopes*
- Carpet Snake - *Morelia spilota*
- Bush Turkey - *Alectura latham*
- Rose crowned Fruit dove - *Ptilinopus regina*
- Noisy Pitta - *Pitta versicolor*
- Large-billed Scrubwren - *Sericornis magnirostris*
- Brown Gerygone - *Gerygone mouki*
- Eastern Whipbird - *Psophodes olivaceus*
- Rufous Shrike-thrush - *Colluricincla megarhyncha*
- Figbird - *Specothes viridis*
- Catbird - *Ailuroedus crassirostris*
- Various invertebrates

Some nomadic rainforest birds that are likely to be occasionally recorded from the remnant include:

- Rose Crown Fruit Dove - *Ptilinopus regina*, Purple Crowned Fruit Dove - *Ptilinopus superbus* and Wompoo Pigeon *Ptilinopus magnificus*;
- Rose Robin - *Petroica rosea*;
- Russet-tailed Thrush - *Zoothera heinei*;
- Black-faced Monarch - *Monarcha melanopsis*, Spectacled monarch - *Monarcha trivirgatus* and White-eared Monarch - *Monarcha leucotis*;
- Spangled Drongo - *Dicrurus hottentottus*;
- Regent Bower Bird - *Sericulus chrysocephalus*; and,
- Topknot Pigeon - *Lopholaimus antarcticus*.

Invertebrates

A detailed literature review concerning invertebrates from the rainforest remnants of the Big Scrub has not been undertaken as part of this report. An investigation into the invertebrates of all Big Scrub remnants and potential threats is required.

Invertebrates including both terrestrial (ground) and arboreal (tree dwelling) species are potentially one of the most at risk fauna groups in isolated remnants. This is partially due to the nature of restoration works often requiring strategic low level herbicide spray application for weed control; pesticide use on adjacent farms and due to the changes in micro-climate associated with fragmentation. Special consideration for maintaining areas of untreated habitat in small isolated remnants (or long time between treatments) is recommended for maintaining viable terrestrial invertebrate populations. Fortunately Killen Falls remnant contains areas of healthy forest with minimal to no weed cover. The remnant also provides an important habitat and source point of invertebrates for the surrounding landscape. The remnant is potential habitat for two Carabid Beetles *Nurus atlas* and *Nurus brevis* that are listed under the TSC Act 1995.

- Three commonly observed rainforest dependent invertebrates that are likely to inhabit the remnant include the Richmond Birdwing Butterfly – *Ornithoptera richmondii*, the Australian Leafwing Butterfly *Doleschallia bisaltidae australis* and the Regent Skipper Butterfly – *Euschemon rafflesia rafflesia*.

Species that inhabit rainforest shown in Table 1 (below) are known from larger tracts of rainforest located at the base of the Nightcap Range and are presumed to have been present in the Emigrant Creek locality prior to clearing. It is likely that most of these species are unable to persist in small remnants for extended periods and/or have difficulty dispersing across fragmented landscapes. Holmes (1985) has also suggested that the Eastern Yellow Robin and Pale Yellow Robin are mutually exclusive, with the Eastern Yellow Robin being dominant in excluding the Pale Yellow Robin.

Table 1. Species that inhabit rainforest environments of NE NSW but are not known from Killen Falls remnant.

Common Name	Scientific Name	Common Name	Scientific Name
Wompoo Fruit-dove	<i>Ptilinopus magnificus</i>	Long-nosed Potoroo	<i>Potorous tridactylus</i>
Coxen's Fig-parrot	<i>Cyclopsitta diophthalma coxeni</i>	Red-legged Pademelon	<i>Thylogale stigmatica</i>
Sooty Owl	<i>Tyto tenebricosa</i>	Red-necked Pademelon	<i>Thylogale thetis</i>
Marbled Frogmouth	<i>Podargus ocellatus</i>	Dingo	<i>Canis lupus dingo</i>
Alberts Lyrebird	<i>Menura alberti</i>	Fawn-footed Melomys	<i>Melomys cervinipes</i>
Yellow-throated Scrubwren	<i>Sericornis citreogularis</i>	Bush Rat	<i>Rattus fuscipes</i>
Logrunner	<i>Orthonyx temminckii</i>	Brown Antechinus	<i>Antechinus stuartii</i>
Pale Yellow Robin	<i>Tregellasia capito</i>	Golden-tipped Bat	<i>Kerivoula papuensis</i>
White-eared Monarch	<i>Monarcha leucotis</i>	Eastern Tube-nosed Bat	<i>Nyctimene robinsoni</i>
Paradise Riflebird	<i>Ptilorus paradiseus</i>	Northern Leaf-tailed Gecko	<i>Phyllurus cornutus</i>
Barred Cuckoo-shrike	<i>Coracina lineata</i>	Stephens Banded Snake	<i>Hoplocephalus stephensii</i>
All rainforest dependent frogs eg <i>Assa darlingtoni</i> , <i>Lechiodus fletcheri</i> and all local species of <i>Mixophyes</i>			

The open agricultural (ephemeral) habitat

This habitat favours generalist species that are common throughout disturbed environments in eastern Australia. This include species such as the Noisy Minor, Torresian Crow – *Corvus orru*, Australian Magpie – *Gymnorhina tibicen*, Pied Butcherbird – *Craticus nigrogularis*, Wedge tailed Eagle – *Aquila audax*, Lace Monitor – *Varanus varius*, Brown Snake – *Pseudonaja textilis*, feral animals (eg Black Rat *Rattus rattus*, House Mouse – *Mus musculus*, Red Fox *Vulpes vulpes*, and Cat – *Felis catus*) and ranging domestic animals such as Cats and Dogs.

The remnant provides potential habitat for several mammal species that are well distributed across the Big Scrub area, particularly in the vicinity of regrowth. These are typically generalist species that occupy a range of habitats throughout their range. They include the Short-beaked Echidna *Tachyglossus aculeatus*, Swamp Wallaby – *Wallabia bicolor* Northern Brown Bandicoot *Isodon macrourus*, Long-nosed bandicoot *Perameles nasuta*, Mountain Brush-tail Possum *Trichosourus caninus* and Common Ringtail *Psuedocheirus peregrinus*. The Swamp Wallaby is colonising much of the former Big Scrub, particularly where there is a mix of scrubby regrowth and pasture.

The riparian – aquatic habitat

This habitat along the Emigrant Creek supports a range of species dependant on water, that may utilise the aquatic environment for foraging or as a watering point. The expanses of low shrubland and grassland fringing the edge of waterways and pools below the Emigrant Creek Dam provide important foraging and breeding habitat for a number of common and potentially, threatened species (see Table 1, section 6.6). The trees and vines overhanging the waterway are also valuable for roosting and hunting perches. Species occurring at the Killen Falls project site that would be dependent on this habitat may include Bush Hen *Amaurornis olivaceae*, Eastern Water Dragon – *Physignathus lesueurii*, Black Bittern – *Dupetor flavicollis*, White-bellied Sea Eagle – *Haliaeetus leucogaster*, Platypus – *Ornithorhynchus anatinus*, Water Rat – *Hydromys chrysogaster*, Large footed-Myotis – *Myotis adversus*, various aquatic invertebrates and fish. The site may also provide habitat for several frog species.

Hollows & caves

Hollows are a limited yet highly prized resource for many species, as they constitute their main sheltering and/or nesting habitat. There can be significant competition for hollow resources, particularly where there are few hollows. To complicate matters, hollow dependent fauna do not rely entirely on a single hollow for all of their sheltering or nesting requirements. Individuals generally will move from one hollow to another depending on a range of factors, such as season/climate, competition, parasite infestation, and food resources or escape detection from predators. Subsequently, any species dependant on hollows/caves from the site are vulnerable, unless they are highly mobile and able to move to other habitat areas that support hollows.

Caves, rock overhangs and rocky crevices are important roost sites for a number of threatened insectivorous bats, particularly with site proximity to water and rainforest habitat. Rocky crevices occur along the steep cliff lines in the remnant. Killen Falls itself comprises a large overhang or open cave with a number of smaller caverns and holes scattered along the rock face. The site is likely to

have supported a significant communal roost site. It is important that roost sites are not regularly disturbed. Activities that disturb roost sites should be prohibited or actively managed.

The importance of fauna to ecosystem health

The importance of fauna in dispersing rainforest seeds and pollen and maintaining ecosystem processes has been largely investigated. Studies undertaken by Lott and Duggin (1993) highlight the significance of fauna interactions in maintaining plant community composition. This study found that remnants supporting populations of native *Rattus* moderated the germination success of Black Bean – *Castanospermum australe* (a plant common to the Big Scrub). In comparison, remnants lacking native *Rattus* are developing a high density of Black Beans across varied age ranges possibly excluding the establishment of other species and modifying the remnant floristics over time.

The impact of missing fauna components particularly invertebrates on remnant plant communities requires further investigation for developing management strategies to maintain or imitate ecosystem processes. Furthermore the importance of invertebrates in maintaining ecosystem health requires research especially considering the important role they play in pollination, herbivory and as food for other species.

Threatened fauna

Threatened fauna species that are likely to utilise the Killen Falls remnant and potentially the surrounding habitats are listed in Table 1 - Section 6.6 (main report).

APPENDIX 9B: Threatened fauna species profiles

Black Bittern: Vulnerable

The Black Bittern is a shy and cryptic species that inhabits terrestrial and aquatic wetlands, riparian zones and habitats that provide permanent water and dense vegetation. It is known to feed on fish, reptiles and a range of invertebrates, mainly at dusk and at night. It generally roosts in dense vegetation during the day. It breeds from December to March, and is otherwise a solitary animal. It is known to nest on a branch overhanging water, which is made up of a bed of sticks and reeds on a larger base of sticks. It is threatened by habitat destruction and predation by feral animals.

Recommendation:

- Bush regeneration activities may disrupt nesting or roosting birds. Their shy nature makes them vulnerable to human disturbances. Riparian edges should be assessed prior to controlling and cutting back weeds. Use of herbicides in wet area habitats must be undertaken with care.
- Incremental control of weeds in riparian habitats is advised, avoiding disturbance during the breeding season Dec – Mar.

Bush Hen *Amaurornis olivaceus*: Vulnerable

The Bush Hen is a dusky olive coloured, secretive, diurnal crane like-bird. It inhabits dense grass and reeds, margins of dams, wetlands and waterways near rainforest, and forest regrowth margins. Dense undergrowth is the preferred habitat including Lantana thicket (Marchant & Higgins 1993). Disjunct distribution from Philippines to north-east NSW /northern rivers district (southern most record from Wardell NE NSW). Mostly calls early in its breeding season. It breeds amongst dense grass and reed clumps or under dense bushes. Nests are located in dense sedge/grass clumps, and may consist of entwined leaves forming a base, sides and a loose canopy, or is a curved platform with dome lined with grass & twigs, or without dome. Diet consists of seeds, vegetation, insects and occasionally frogs (Marchant & Higgins 1993). Breeds Oct-Mar. Incubation to fledging recorded to 45 days (Duncan in Marchant & Higgins 1993).

Birds are likely to occur up stream of Killen Falls near the small island and Crofton dominated wetland area, and further downstream in area south of Lantana slope with grass lined creek edges.

Recommendation:

- Bush regeneration activities may disrupt breeding birds. Survey riparian edges prior to weed removal.
- Avoid weed control work in area where breeding pairs are located (inc. heard calling). Breeds Oct-Mar.
- Undertake weed control in stages. Use of herbicides in wet area habitats must be undertaken with care.

Superb Fruit Dove: Vulnerable

In NSW the Rose-crowned Fruit Dove is a nomadic frugivorous bird dependent on closed rainforest communities. This species has not been recorded to nest in NSW. It shares similar habitat requirements as the Rose-crowned Fruit-dove but is shyer and less likely to occur in isolated fragments. It typically feeds in the canopy on the fruits of native laurels and figs.

Recommendation:

- Bush regenerators need to limit activities that will result in a substantial localised decline in fleshy fruits (such as over cutting of native vines that produce fleshy fruits - eg *Cissus antarctica*, *Cissus hypoglauca*, *Maclura cochinchinensis*, *Rauwenhoffia leichhardtii* Zig Zag vine and Round Leaf *Legnephora moorei*).
- Vines should not be cut when holding unripe and ripe fruits.
- Avoid disturbing nesting birds. Modify work activities and return to site after fledging. Record location of nest and forward record to the Parks Service (NPWS).

Rose-crowned Fruit Dove: Vulnerable

In NSW the Rose-crowned Fruit Dove is a nomadic frugivorous bird dependent on closed rainforest communities. Due to a lack of lowland rainforest habitat it is increasingly being found to seasonally utilise regrowth forest dominated by Camphor Laurel (autumn winter fruiting). This species is regularly heard in many remnants, and is most abundant during autumn winter. During their breeding season (typically spring -summer), they favour dense areas with abundant fruiting figs. However, a Rose -crowned Fruit Dove has been observed nesting in Booyong Reserve during late autumn winter in 2001 (pers obs). The active nest was observed about 5m up in a young Native Elm close to vine thicket. Discarded Camphor Laurel seed was found under the nest and later, remnants of shell (Hackett pers comm). It is highly likely that this species is modifying breeding times to coincide with the fruiting of Camphor Laurel. See bush regeneration activities referred to the species mentioned above.

Large-footed Mouse-eared Bat (Myotis): The large footed Myotis is a micro-chiropteran bat that is dependant upon caves and hollows for roosting which occur in close proximity to water bodies. This bat forages over the surface of the water searching for insects, aquatic invertebrates, tadpoles and small fish. *Myotis adversus* would benefit from the enhancement of the riparian zone.

Recommendation:

- Avoid disturbance to roosting sites particularly during daylight. Maintain vine overhangs on cliff faces.
- Bush regeneration activities should not cause any significant impacts to this species.

Eastern Long-eared Bat – *Nyctophilus bifax*: The Eastern Long-eared Bat reaches its southern distributional limit in north east NSW. It is typically found in rainforest, riparian environments and is also known to occur in Coast Banksia association in north east NSW. The ecological requirements of this species are poorly known, although it is known to roost communally in hollows or amongst dense foliage in rainforest. Retention of a range of suitable roost sites is essential to their survival. They change roosts seasonally, seeking edges in summer and the more protected environment of core rainforest during winter. This species is thought to hunt in the lower strata of rainforest as it has a slow but manoeuvrable flight pattern. This flight pattern suggests it might be able to pluck spiders off webs.

Recommendation:

- Retention of stable micro-climatic conditions is recommended.
- Bush regeneration activities should not cause any significant impacts to this species as riparian weed infestations are narrowly distributed.

A Carabid Beetle – *Nurus atlas*: Endangered.

This is a large black, flightless predator beetle 3 – 3.5cm in length. Known from Victoria Park and the Lismore - Alstonville area. Habitat – low elevation rainforest and wet eucalypt habitats with well-developed rainforest understorey (NPWS 2002). Old growth structure, high nutrient soils and consistent – high moisture levels are other habitat features that may be of importance (NPWS 2002). Threats include weed invasion of habitat, fire, clearing, predation, collection and small - isolated population sizes.

Recommendation:

- Retention of stable micro-climatic conditions. Undertake strategic and incremental control of weeds.
- Avoid disturbance to soil. Use weed control methods that minimise soil disturbance.
- Avoid off-target spray impacts to native herbs and ferns.
- Promote development of leaf litter and structural complexity.
- Expansion of remnant edges (increasing buffer to core forest) & connection of remnants.

APPENDIX 10:

INDICATIVE GENETICS BASED GUIDELINES FOR BIG SCRUB RAINFOREST PLANTING.

These interim planting guidelines were prepared by the Big Scrub Rainforest Landcare Group 14/3/99

Introduction

The following indicative guidelines for seed collection and planting around Big Scrub Rainforest remnants were developed from recent research by plant geneticist, Dr Julia Playford (University of Queensland) and following a workshop on "Genetic Issues in Rainforest Conservation" that was held at NPWS Alstonville on the 5th March 1999. It should be emphasised that these guidelines were prepared in very short time and did not allow adequate time for consultation and review. They were intended to be **temporary** and only be **indicative**, as they will be changed in the future as more information comes to hand. They were primarily prepared in order to provide some guidance in relation to genetic issues that are of major significance for landholders in the current planting season (1999). They will be superseded by the NPWS sponsored group's Interim Best Practice Guidelines.

It should be noted that these guidelines do not cover issues related to landscape context or site and habitat enhancement.

Indicative Guidelines

1. Seed should be collected from at least 10 maternal trees at different sites in the same evolutionary significant unit. (The Big Scrub is assumed to be such a unit.)
2. Seed from each late secondary and mature phase maternal tree should be propagated separately and the planting stock grown from the seed of each maternal tree should be labeled (identifying the maternal tree and its locality) and sold separately by nurseries.
3. The planting model adopted should facilitate natural recruitment eg the Kooyman clump model, with patches or clumps of secondary and mature phase species connected by plantings of pioneer species, or the random distribution model in which mature phase, secondary and pioneer species are distributed throughout the planting. The pioneers should be chosen and planted at spacings to facilitate frugivore perching and seed dispersal, to facilitate the germination and growth of rainforest seedlings and to minimise medium and long term problems controlling grasses and other soft weeds. This requires a canopy that allows sufficient light to reach the ground for rainforest seeds to germinate and continue growing but is sufficiently dense to prevent excessive light penetration that results in vigorous growth of soft weeds.
4. Frugivore attractant species and habitat values should be incorporated in the planting. (See our Rainforest Restoration Manual for detailed information)
5. For each mature and late secondary species to be included in the planting, two or three trees grown from seed sourced from different maternal trees should be planted in a patch/clump or, in the random model, a short distance apart (say 5m-15m). Two or three trees of that species grown from other maternal trees should be planted in adjacent patches/clumps or, in the random model, not far away (eg within 50 metres). It is desirable for trees from at least 10 different maternal trees to be included in the planting (or be within pollen dispersal range).
6. To facilitate cross pollination, the spacing between trees of the same species should not exceed 100m and should preferably be between 5m and 50m.
7. It is desirable to expand remnants if space is available. This can be done using clump or random model plantings that facilitate natural recruitment. In the clump model, the natural recruitment zones incorporating pioneers can be sited around the remnant and between the clumps. (Tein McDonald)

has suggested a configuration with the recruitment zones in "wings" perpendicular to the remnant edge rather than surrounding the remnant; the zones retain openings for natural recruitment from the planting and from the remnant, particularly for wind-dispersed species, and includes plantings of lighter-canopied, shorter-lived species to trigger natural recruitment.) In the random model, pioneers can be distributed throughout the planting to encourage recruitment. (See 3 above.)

- 8 Species that occur in the remnant should be considered for inclusion in the planting. To prevent inbreeding, it is desirable to plant species whose population in the remnant is less than 10 individuals (excluding siblings); it is preferable to use planting stock grown from seed collected in the same general area as the remnant rather than from more remote areas. Species with small populations in the remnant should not be "swamped" by planting large numbers of the same species. Planting stock grown from seed of these poorly represented (ie low population) species collected in the remnant should not be planted. Species that are well represented in the remnant may be planted using planting stock grown from seed collected in the remnant.
- 9 Threatened species may only be planted after consultation with NPWS. Genetic and other issues involved in the planting of rare and uncommon species and species that are not wide-spread is under discussion. Planting these species should be deferred until the Interim Best-Practice Guidelines have been developed, or confined to planting stock grown from seed collected in the same locality as the remnant.
- 10 For plantings away from remnants, species that occur in the closest remnants can be included to facilitate gene flow.
- 11 It is not necessary to achieve the minimum population (ie trees grown from seed collected from at least 10 maternal trees at different sites) in one year's planting. This can be achieved over a number of years. In an established planting lacking a genetically effective population of each mature and late secondary phase species, gaps, pathways and nearby areas can be planted subsequently with appropriately sourced planting stock to achieve the desired population size. Culling is a further option if space available for subsequent plantings is limited. Culling may also be necessary if the genes of a particular species are likely to be swamped by an earlier planting of a large number of trees sourced from one or a small number of maternal trees.
- 12 It is strongly recommended that plantings be appropriately documented. This could take the form of a plant list for each year of planting showing, for each species planted, the sources and numbers of maternal plants, the number of individuals planted and the locations where each was planted on a map, which should also show the spatial area planted.

APPENDIX 11: Plant species recommended for remnant expansion, reforestation and wetland restoration at the Killen Falls project site.

NB The following species lists are not comprehensive and are recommended as a guide only

RIPARIAN SPECIES

Lower creek bank/toe

Carex appressa
Carex polyantha
Lomandra hystrix Matrush + other sedge/rushes
Tristaniopsis laurina - Water Gum ^ *
Ficus coronata - Creek Sandpaper Fig ^ * +
Acmena smithii (rheophytic/creek form) Creek Lillypilly ^ * +

Mid creek bank

Acmena smithii (rheophytic/creek form) Creek Lillypilly ^ * +
Ficus coronata - Creek Sandpaper Fig +
 Matrush + other sedge species
Syzygium australe - Scrub Cherry ^
Streblis brunonianus - Whalebone +
Tristaniopsis laurina - Water Gum ^ *
Syzygium francisii - Giant Water Gum ^

Upper creek bank

Castanospermum australe - Black Bean (F+)
Castanophora albandii - Brown Tamarind
Commersonia bartramia - Brown Kurrajong ^
Crypocarya obovata - Pepperberry +
Elaeocarpus angustifolius - Blue Fig + (F+)
Elaeocarpus obovatus - Hard Quangdong ^ * +
Ehretia acuminata - Koda +
Ficus coronata - Creek Sandpaper Fig ^ * +
Heritiera trifoliolatum - White Booyong
Sloanea australis - Maidens Blush +
Sloanea woollsii - Yellow Carabeen +
Syzygium australe - Scrub Cherry ^
Syzygium leuhmanii - Riberry
Syzygium francisii - Giant Water Gum ^
Ficus obliqua - Small-leaved Fig * +
Aphananthe philippinensis - Native Elm +
Streblis brunonianus - Whalebone * +
Include framework species and other species recorded from the Killen falls remnant (see Appendix 1).

DIRECT SEEDING

Example of some species that are suitable for direct seedling under injected Camphor Laurel stands, broadcasting over rock scree or into Lantana thicket.

Bangalow Palm - *Archontophoenix cunninghamiana* +
 Black Bean - *Castanospermum australe*
 Brown Tamarind - *Castanophora albandii*
 Quangdongs - *Elaeocarpaceae* spp.) +
 Figs - *Ficus* species +
 Laurels (*Cinnamomum*, *Cryptocarya*, *Endiandra*) +
 Native Ginger - *Alpinia caerulea*
 Native Tamarind - *Diploglottis australis* +
 Plum Pine - *Podocarpus elatus*
 Red Apple - *Acmena ingens* +
 Red Bean - *Dysoxylum mollissimum* +
 Wilkea - *Wilkea hugeliana*, *W. macrophylla* +
 White Cedar - *Melia azedarach* +

WETLAND AREA SPECIES

Species that may have potentially occurred in the wetland area (Area 2c). Note: This is a guide only.
 Vegetation surveys of relic wetland communities in the upper Emigrant Creek catchment is required to determine species that are appropriate for establishment at the Killen Falls project site.

Alocasia brisbanensis Cunjevoi (as a mass planting)
Archontophoenix cunninghamiana Bangalow Palm (on raised edges of main wet area) +
Callistemon salignus - Willow Bottlebrush
Leptospermum spp.
Lomandra hystrix
Lophostemon suaveolens - Swamp Box
Melastoma affine - Blue Tongue
Melaleuca quinquenervia - Broad-leaved Paperbark (F+)
 Various native sedges & herbs

REMNANT EXPANSION

Framework species - early successional fast growing species. Species recommended for expanding remnants, planting in close proximity to the remnant edges or to trial as a nursery crop to be supplemented by natural regeneration etc.

Acacia melanoxylon - Sally Wattle ^*
Commersonia bartramia - Brown Kurrajong ^ *
Dubosia myoporoides - Soft Corkwood ^*+
Ficus fraseri - Sandpaper Fig ^*+
Macaranga tanarius - Macaranga * +
Melia azedarach - White Cedar ^ +
Omalanthus nutens - Bleeding Heart +
Pipturus argenteus - White Nettle * +
Polycias elegans - Celerywood ^ +
Trema tomentosa - Poison Peach * +

Later successional species - moderate to slower growth rates. To increase forest complexity & habitat values.

- *Euroschinus falcata* +
 - *Elaeocarpaceae* spp. e.g. *Elaeocarpus kirtonii* - Silver Quangdong +
 - Myrtle Ebony - *Diospyros pentamera* +
 - *Ficus* spp e.g. Small-leaved Fig - *Ficus obliqua* +
 - *Flindersia* spp - e.g. *Flindersia australis* Teak ^
 - *Gmelina liechardtii* - White Beech +
 - Native Laurels - *Cinnamomum*, *Cryptocarya*, *Beilschmiedia*, *Endiandra* spp. +
 - *Lophostemon confertus* Brush Box ^* (F+)
 - *Podocarpus elatus* - Plum Pine ^
 - Lilly Pillys - *Syzygium oleosum* *, *S. leuhmanii*, *S. francisii*, *Acmena ingens* * +, *A. hemilampra* - White Booyong

* indicates species suitable for hardy sites (eg shallow soil and exposed areas)
 ^ indicates some level of frost tolerance
 + indicates fruit or (F+) flowers favoured by birds
 NB: Refer to Kooyman (1996) for list of species successional stages

APPENDIX 12: Vegetation Restoration Works - Record Sheet

Regeneration site & project name:

Date:

Regeneration team & hours worked:

Weather conditions (wind speed & direction; clear, overcast, rain; temperature – hot, warm, mild, cool)

Work location and description of restoration actions: (indicate work area on sketch map, relevance of work, site conditions, methods trialed, problems etc)

Weeds treated & techniques:

Growing conditions (Poor - Good): _____

Species	Technique	Species	Technique

Herbicide and volume used:

Herbicide	Batch Number / Date	Volume

Follow-up timeframe & comments on previous work: (effectiveness of prior work, site conditions, weed species recruitment, additional work required)

Other observations (tree health, fruiting/flowering, fauna, native species recruitment)