RESEARCH REPORT

Weed Incursions Along Roads and Powerlines in the Wet Tropics World Heritage Area

The Potential of Remote Sensing as an Indicator of Weed Infestations

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and Stephen M. Turton

Rainforest CRC

Cooperative Research Centre for Tropical Rainforest Ecology and Management

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EXECUTIVE SUMMARY

SECTION 1: WEED SURVEYS ALONG HIGHWAYS, ROADS AND POWERLINE CLEARINGS TRAVERSING THE WET TROPICS OF QUEENSLAND WORLD HERITAGE AREA

Research Objective

The objective of this study was to undertake an initial basic spatial inventory to provide an understanding of the distribution of weed species and the relative ecological condition of selected road verges and powerline corridors within the Wet Tropics of Queensland World Heritage Area (WTWHA).

Key Findings

- Major weed infestations recorded for powerline clearings and roads include Guinea grass, Molasses grass, Signal grass, Blue Snakeweed, Paspalum, Bluetop, Lantana and Giant Bramble as well as several herbaceous weeds. Forty-four weed species were found along the Chalumbin-Woree network, with fifty along the Palmerston network.
- The ecological condition of the Palmerston network was found mainly to be poor, particularly at lower elevations near the Palmerston Highway and Tully Gorge. However, in several sections at higher elevations with dissected topography, ecological condition was relatively good where the powerline swings above the canopy of remnant or regrowth forests, providing long sections of rainforest connectivity.
- Similarly, along the Chalumbin-Woree network, higher elevation sites with dissected topography tended to be in better ecological condition than lower elevation sections or areas where the powerline or road follows a ridge, where swathe clearing and maintenance has limited recolonisation by native species.
- Exclusion of fire from the Palmerston network and grazing from the Chalumbin-Woree network has allowed some recolonisation by native species to commence and is greatly enhanced by restoration plantings that help to divide the weedy swathes.
- Weed control on the Palmerston road network by EPA (Environmental Protection Agency) South Johnstone has been very successful in reducing weed infestations and improving ecological condition and presentation values.
- Several native species are recommended as showing potential to out-compete weeds.
- One new weed species, the Bamboo Orchid, was found on the Palmerston road network.

Recommendations

- Eradication of the new weed, *Arundina bambusaefolia*, the Bamboo Orchid, as soon as possible while it is confined to a small location and easily controlled.
- Continuation of weed control on the Palmerston road network until canopy connectivity extends completely over the roads and effectively controls weeds without herbicide.
- Restoration plantings that divide the clearings, particularly near gullies, similar to those already undertaken in the lower elevation section of the Palmerston network.
- Continued exclusion of fire and grazing.
- Removal of trees and branches above unsealed roads should be avoided, to increase canopy connectivity and thereby reduce weed infestations and the requirement for herbicide control.
- Ensuring that clearing of swathes is totally rejected. Powerlines being swung above the

canopy on high towers with clearing restricted to the tower footprints will reduce impacts of new powerlines and upgrades.

Management Implications

- Areas previously totally cleared and maintained by fire or grazing remain in worst condition, due to the ability of fire to create a self-perpetuating weedy grass swathe and the potential for livestock to spread weeds.
- Exclusion of fire from the Palmerston powerline network has allowed expansion of natural regeneration in many areas. However, in other sections previously in worse condition as grassy swathes, the expansion of woody weeds now requires control and restoration works.
- Several species of ferns, tree ferns, sedges and low shrubs show potential as alternatives to exotic grasses in the stabilisation of road embankments.
- Swathes of low native species should be encouraged to replace weedy swathes using selective weed control along the Chalumbin-Woree powerline clearing, particularly at high elevations, to retain safety aspects for power distributors whilst improving ecological condition.
- The restoration across lower sections of the Palmerston powerline clearing undertaken by the Centre for Tropical Restoration and the extension of natural regeneration in gullies is gradually improving ecological condition. Further restoration works could speed recovery.
- Weed control along the Palmerston road network is currently very successful and should be continued until canopy expansion over the roads naturally controls weed infestations whilst improving ecological condition and presentation values for visitors.

Further Research

- Examination of other road and powerline networks.

SECTION 2: POTENTIAL OF REMOTE SENSING IN THE MONITORING OF WEED INFESTATIONS ALONG POWERLINE CORRIDORS

Research Objectives

The objectives of this study were:

- To determine whether satellite or airborne imagery could discriminate individual weed species and the degree of spatial resolution provided by such imagery;
- To determine the suitability of ‘spectral mixture analysis’ for determining fractional quantities of weed species at the sub-pixel level;
- To determine which sensor system is likely to provide the best overall result for the WTWHA.

Key Findings

- Field measurements of the percent cover of weed species showed that one to three main species occurred within each $1m^2$ and therefore species ‘spectral mixture analysis’ should be viable for determining the quantity of weed fractions at 1 metre spatial resolution.

found to be separable by a statistical technique designed for this study, showing that weeds should be able to be separated using ‘spectral mixture analysis’. Signatures should take account of seasonality, time of day, consistent light conditions and height above the canopy of hand-held radiometer.

- When data from an Airborne Data Acquisition and Registration (ADAR) system with an excellent 1 metre spatial resolution was examined, calibration was difficult due to poor camera performance.
- Ikonos satellite imagery had high quality data with good spectral coverage but the 4 metre spatial resolution was inadequate for mapping weeds along the Chalumbin-Woree powerline clearing, although possibly adequate in less heterogeneous clearings such as that for the Palmerston powerline.

Recommendations

- Improved characterisation of field spectral responses of weeds requires use of standardised conditions, coloured targets during data capture and consideration of phenology of weeds.
- Estimation of proportions of weed cover from imagery requires:
  a) calibrated imagery;
  b) suitable band widths (20–30nm) in the appropriate areas of the spectrum;
  c) a high spatial resolution (0.5–2m) that contains few spectral components;
  d) correction for illumination effects; and
  e) processing with classifiers that allow for the variation seen in the spectral response patterns of vegetation (‘Fuzzy C-means’, or ‘Artificial Neural Networks’).
- Test alternative image interpretation software with the ability to handle 12-bit data and real numbers to take advantage of the high dynamic range of the latest satellite data to discriminate subtle differences in vegetation signatures.
- Regular use of airborne imagery will require quick set-up times to take advantage of unpredictable cloudless periods in the Wet Tropics that rarely last more than a few days. Ultra–light, computer or radio-controlled aircraft, or powerline maintenance helicopters may provide a more timely means for monitoring of environmental weeds.
- Test hyperspectral imagery (8-20 narrow bands) at 1m spatial resolution and easily-acquired satellite imagery at 2m spatial resolution (available in 2–3 years) for their effectiveness in ‘spectral mixture analysis’ of weeds.

Management Implications

- There is a definite potential to discriminate individual weed species using spectral signatures, using the new statistical technique designed in this study.
- ADAR imagery is not recommended due to poor camera performance and unpredictable cost.
- Ikonos satellite imagery may be useful in some powerline and road networks, but spatial resolution was too coarse for the Chalumbin-Woree network.
- Hyperspectral (CASI) imagery may be ideal, both for camera performance and spatial resolution. Alternatively, a four-camera airborne system (MAVS) or a 4-band satellite sensor with 2 metre resolution should provide possibilities for weed monitoring.

Further Research

- Future work on the spectral response of weeds should be directed at measuring the seasonal variations for each species by establishing permanent plots for regular monitoring. A clustering routine in a GIS that looks for true shoulders or peaks in spectral data should then be used to find spectral groups on a species by species basis.
- Hyperspectral imagery should be tested, as should 2m spatial resolution satellite imagery to become available in 2-3 years.

SECTION 3: WEED PENETRATION, EDGE EFFECTS AND REHABILITATION STRATEGY SUCCESS IN WEEDY SWATHES OF THE PALMERSTON POWERLINE CLEARING

Research Objectives

The objectives of this study were:

- To examine the success of rehabilitation plantings across a powerline clearing in prevention of weed germination;
- To compare the penetration of weeds and weed seeds into the forest from powerline clearings with and without restoration plantings; and
- To examine the effect of edges on vegetation floristic composition at these treatments.

Key Findings

- Rainforest restoration across the clearing undertaken in 2000 by the Queensland Parks and Wildlife Service (QPWS) Centre for Tropical Restoration, using three framework species has almost eliminated grassy weeds that prevent germination of native rainforest species. However, in these early stages of growth, little recruitment of rainforest species has occurred.
- Edge-induced changes in floristic composition penetrate the rainforest to a distance of 3-7m, with early successional stage rainforest species more prevalent.
- Floristic composition was altered further into the rainforest to distances varying between 25 and 45 metres, suggesting a more insidious, longer-term and more widespread effect of wide linear clearings.

Management Implications and Recommendations

- Rehabilitation plantings are already demonstrating success after only two and a half years in terms of reduction in fire-promoting grassy weeds.
- If Palmerston powerline is to remain *in situ* for several more years, rather than be removed in 2003, removal of trees in rehabilitation plantings should only be contemplated where their growth is a source of imminent danger to the powerline. Lopping should be considered as an alternative to removal as these restoration areas are already serving a useful ecological function.
- The dominance of weeds within the powerline clearing almost eliminates the possibility of native species recolonising the cleared swathe in this lower elevation section of the powerline clearing without assistance in terms of restoration works, *i.e.* plantings of native trees after weed control. Where fires have been less frequent over recent years, woody weeds have out-competed the grasses in some areas, spreading across the clearing and preventing recolonisation by native species. Recovery of native habitat requires further

restoration works.

- Changes in floristic composition that penetrate to distances of 20-45 metres were found in this study, suggesting an insidious, long-term and widespread effect of wide linear clearings. As this clearing was created in the 1950s, recovery from these changes after removal of linear clearings may be a long-term process.

Recommendations for Further Research

- Examine several more transects with differing edge aspects on control and rehabilitation treatments at Palmerston for weed penetration and floristic edge effects.
- Examine similar number of transects along Palmerston highway as a direct comparison of weed penetration and edge effects.
- Analysis of soil seedbank results from selected transects on powerline clearing treatments and highway.

CONTENTS

TERMS OF REFERENCE

ASSESSMENT OF THE RELATIVE ECOLOGICAL CONDITION OF CLEARED INFRASTRUCTURE CORRIDORS WITHIN THE WET TROPICS OF QUEENSLAND WORLD HERITAGE AREA

Purpose of the Contract

The Wet Tropics Management Authority (WTMA) recently produced the report *Wet Tropics Research and Information Needs* (WTMA 2000). This report was designed to take a strategic approach to the identification of the research and information needed to meet the long-term management requirements of the World Heritage Area. An important part of this report was the identification of seven key underlying forces or drivers of pervasive change in the World Heritage Area. From a long-term strategic perspective, it is considered that programs of research dealing with aspects of these Key Forces for Change are vital for future planning and management of the area as management responses will underpin the rate of change shaped by these forces. Two of the identified Key Forces for Change were:

- Infrastructure corridors; and
- Invasive pest species.

Internal fragmentation, caused by linear infrastructure corridors and its array of actual and potential impacts on ecological integrity and evolutionary processes is considered a principal threatening process to World Heritage values. Fragmentation by high voltage power supply infrastructure is of particular concern. The area is dissected by a network of electricity transmission and distribution line routes which were cleared for the construction of lattice towers / poles and for the stringing of conductors. Much of this cleared swathe is still maintained to provide safe clearances between vegetation and energised infrastructure. Access roads are also required for maintenance purposes along the line routes. Presently, 0.22% of the area has been directly impacted by the clearings associated with the combined network of powerlines and roads.

Previous Rainforest CRC research has shown that powerline clearings form an effective barrier to the movement of most non-flying terrestrial and arboreal rainforest fauna. Powerline and road clearings are also the major cause of weed and pest intrusions into forested areas. These weed infestations may also provide an undesirable conduit for fire into otherwise rainforested areas. Recent Rainforest CRC research has also shown that the impact is not confined to the clearing itself, but extends as a band of low integrity forest along its length. Some researchers suggest this effect may extend over 200 metres into the rainforest thereby potentially impacting 12,960 ha of the World Heritage Area.

WTMA recognises that there is an on-going need to manage and maintain powerline and road service corridors to provide safe, reliable and durable electricity and transport infrastructure. However, the maintenance and rehabilitation of the natural integrity of World Heritage values is a key principle for managing the WTWHA. The Authority's focus is on the rehabilitation of disturbed landscapes while developing processes and techniques that minimise environmental impact and permit the reconstruction of stable and self-sustaining ecosystems in the long-term. To this end, Codes of Practice, Best Practice Manuals and Environmental Management Plans have or are being developed with respect to powerline and road maintenance. It is important that methods are developed so that changes resulting from the adoption of these codes and plans can be measured and so that compliance with permit conditions can be monitored.

Overview and Scope

A major requirement in the implementation of these codes and plans is for adaptive management research, which will:

- Test current management practices;
- Provide the baseline data necessary to design robust monitoring programs;
- Provide prescriptions for improved management;
- Provide direct and accountable assessment of the performance of WTMA policies against actual environmental outcomes; and
- Help assess the relative importance of different environmental issues and in the setting of priorities.

Such an emphasis is seen as a means of critically testing and improving our current land management practices while engendering closer collaborative links with infrastructure agencies.

Aims

- To provide a basic spatial inventory to enable an understanding of the distribution of weed species and the relative environmental condition of the WTWHA's infrastructure service corridors and adjoining forested areas;
- To investigate the feasibility of developing a simple, practical and easily implemented system for reporting on the condition of the area and evaluating management activity with respect to infrastructure corridor clearings; and
- To investigate the feasibility of developing monitoring protocols involving standardised techniques for testing management regimes and strategies and for use in compliance monitoring.

Tasks to be Performed

Develop operational methods for monitoring the ecological condition of infrastructure corridors and adjoining rainforests through a combination of field based sampling with GIS, remote sensing and spatial modelling. This is achieved through:

- Employment of a multi-spectral, air borne scanner or other appropriate remote sensing technology to provide data on the baseline state of the major clearings associated with infrastructure corridors
- Mapping and assessing the relative ecological 'condition' of powerline corridors including the identification of areas of weed species infestations such as grasses, trees and shrubs and native tree regrowth
- Developing methods to enable an assessment of the extent of ecological 'edge-effect' intrusions into surrounding forests associated with linear infrastructure clearings

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ABOUT THE AUTHORS

DR MIRIAM GOOSEM

- Bachelor of Science (UQ)
- Master of Science (Qual.) (JCU)
- Doctor of Philosophy (JCU)
- Research Fellow, School of Tropical Environment Studies and Geography, James Cook University, Cairns

Miriam's research interests concern human impacts in tropical rainforest and means of mitigating those impacts. Fragmentation of rainforest areas by clearing and by infrastructure such as roads, highways and powerlines etc. are the current focus, particularly the impacts on wildlife populations of edge effects, linear barrier effects and the introduction of floral and faunal species alien to rainforest habitat. Revegetation to provide connectivity, adapting maintenance procedures and including faunal corridors, road underpasses, overpasses and canopy connectivity when planning new infrastructure are current mitigation strategies under investigation.

PROFESSOR STEPHEN TURTON

- Bachelor of Science (Canterbury)
- Master of Science (Canterbury)
- Doctor of Philosophy (JCU)
- Director, JCU/CSIRO Tropical Landscapes Joint Venture, James Cook University, Cairns

Steve's broad research interests are in tropical rainforest micrometeorology and climatology, and the ecological biogeography of Queensland's Wet Tropics region. His current research also examines diurnal and seasonal surface energetics and carbon budgets for lowland rainforest canopies and ecological impacts of roads and powerline corridors in rainforest environments. Steve leads a Rainforest CRC research program concerned with rainforest access and managing and monitoring associated human impacts.

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We are especially grateful to Dr Steve Goosem and Mr Terry Webb of the Wet Tropics Management Authority for professional advice in relation to this project.

Wet Tropics Management Authority personnel provided access to spatial databases necessary to the completion of this project.

Mr Tom Graham of Powerlink Queensland provided video footage of a number of powerline clearings. This proved very useful in extrapolating ground data to larger areas of corridor. Data concerning locations of power poles and towers within the Wet Tropics bioregion was also supplied.

Mr Mark Sharkey of Ergon Energy supplied similar locational data with respect to power poles and towers.

Dr Stuart Phinn and Mr Alex Held of the Biophysical Remote Sensing Group in the School of Geography, Planning and Architecture at the University of Queensland undertook the supply of fine-scale remote sensing data in the format supplied by the Airborne Data Acquisition and Registration system (ADAR). IKONOS satellite imagery was acquired through Geoimage Pty Ltd, Taringa, Queensland.

Mr Bob Jago provided technical expertise in identification of plants, both weeds in powerline and road clearings, and rainforest flora along transects from the edge of those clearings.

The Rainforest CRC and the School of Tropical Environment Studies and Geography (TESAG) at James Cook University provided infrastructure, academic and technical advice, and administrative assistance where required.

We would also like to thank Mr Craig Harriss, Bachelor of Applied Science Honours student (TESAG) for his major contribution to the analysis of ADAR and IKONOS imagery contained in this report. His hard work and dedication were exemplary. Professor David Gillieson was co-supervisor for Craig's Honours thesis.

ACRONYMS

ADAR .... Airborne Data Acquisition and Registration
CASI .... Compact Airborne Spectrographic Imagery
CCD................... Charged Coupled Device
CIR .... Colour Infra Red
CTR................... Centre for Tropical Restoration
DEM .... Digital Elevation Model
DN .... Digital Numbers
DNR................... Queensland Department of Natural Resources (now Department of Natural Resources, Mines and Water)
EPA .... Queensland Environmental Protection Aency
GIS .... Geographic Information Systems
KAI..................... Kodak Active Interpolation
MADIS .... Multispectral Airborne Digital Imaging System
MAVS .... Multispectral Airborne Video System
NIR .... Near Infra Red
QPWS .... Queensland Parks and Wildlife Service
SMA................... Spectral Mixture Analysis
WTMA .... Wet Tropics Management Authority
WTWHA .... Wet Tropics World Heritage Area

TABLES

FIGURES

1. WEED SURVEYS ALONG HIGHWAYS, ROADS AND POWERLINE CLEARINGS TRAVERSING THE WET TROPICS WORLD HERITAGE AREA

Miriam Goosem

1.1 SUMMARY

The Palmerston (Kareeya-Innisfail) and Chalumbin-Woree powerline clearings and associated road networks, including K-Tree, Maple Creek, Suttie's Gap, Maalan, Bridle Creek, Shoteel Creek tracks and Lake Morris Road were examined for weed infestations and ecological condition using on-ground surveys and aerial video analysis. Major weed infestations recorded for the Palmerston network include Guinea grass, Molasses grass, Signal grass, Bluetop, Lantana and Giant Bramble as well as several other herbaceous weeds. Major weed infestations along the Chalumbin-Woree network included Blue Snakeweed, Paspalum, Lantana, Molasses grass and Signal grass with several other species being common.

Presence of a weed species appears to relate to soil fertility and moisture. There is a considerable overlap in species between the two areas but dominant species vary between the sites. Ecological condition of the Palmerston network was found to be mainly poor, particularly at lower elevations near the Palmerston Highway and Tully Gorge. However in higher elevation sections with dissected topography, where the powerline is swung above the canopy of remnant or regrowth forests, ecological condition in these smaller areas was relatively good. Similarly along the Chalumbin-Woree powerline clearing, ecological condition was relatively good in higher elevation sections with dissected topography, where tower clearings are either restricted in area or swathes are gradually being recolonised by native species. Weed control, particularly of grasses and woody weeds, could aid this recolonisation. Lower elevation sections to the west, which have been subject to past grazing management, are generally swathes of mixed weeds.

Fire and grazing exclusion, weed control and restoration plantings are recommended for the areas of both powerline clearings that are in poor ecological condition. Removal of the Palmerston powerline clearing will aid this goal by allowing taller canopy species to grow. Weed control on the Palmerston road network has been very successful in reducing weed infestations and improving ecological condition of the area and should be continued until canopy connectivity can extend over the roads. Several native species are recommended as showing potential to out-compete weeds in these linear clearings, both naturally and in conjunction with weed control and restoration plantings. It is recommended that one introduced ground orchid species, *Arundina bambusaefolia*, which has recently colonised in one location, be eradicated as soon as possible.

1.2 INTRODUCTION

Effective management of roads and powerline corridors is a major challenge facing the Wet Tropics Management Authority (WTMA) in their effort to achieve the primary goal of protection, conservation, rehabilitation and presentation of the natural resources of the region (WTMA 1995). Many areas of the Wet Tropics World Heritage Area (WTWHA) have been affected by settlement, agricultural practices and other anthropogenic activities in the past and are also dissected by an estimated 1,800 kilometres of roads, highways and powerline corridors (Goosem and Turton 1999).

This linear infrastructure is an integral feature of the modern landscape and one of the most obvious anthropogenic impacts on natural environments; internally fragmenting natural areas into much smaller habitat blocks. Wildlife populations may be subdivided by these linear clearings. Internal fragmentation, caused by infrastructure corridors, and its array of actual and potential impacts on ecological integrity and evolutionary processes, is considered a principal threatening process to natural World Heritage values (WTMA, 2000).

Linear clearings for infrastructure cause a suite of deleterious impacts within the rainforests of the WTWHA. These include:

- Alienation of area that would otherwise form habitat for flora and fauna. Goosem (1997) estimated that about 1,300 hectares have been alienated along 324 kilometres of powerline clearings in the WTWHA, while 608 hectares were utilised in clearings for roads and highways.
- Edge effects are a second impact and consist of a diverse array of ecological changes occurring at and in the vicinity of the abrupt artificial margins of natural habitat with the linear clearing.
- A third impact occurs when faunal movements are restricted (Goosem 2001) or even prevented (Goosem and Marsh 1997) by the 'linear barrier' formed by the clearing.
- Fourthly, fauna alien to the rainforest habitats may intrude along the altered habitat found within the clearing (Goosem and Turton 2000).
- Wildlife mortality in the form of roadkill is another impact of roads as is the penetration of noise and pollutants into the rainforest habitat (Goosem and Turton 1999, 2000).

However, one impact of roads and powerline corridors within the WTWHA that has not been examined in great depth is the extent to which such linear clearings allow the ingress of alien flora i.e. weeds. A major but very broad-scale survey of the status of weeds within the WTWHA was undertaken by Humphries and Stanton (1992), identifying major environmental weeds of concern and providing an idea of their distributions. Werren (2001) has expanded on this study to:

a) Inventory existing weeds, 'sleeper' weeds and plants not presently found in the region that are proven environmental weeds in similar environments elsewhere;
b) Prioritise potential environmental threats;
c) Categorise weeds into management categories of prevention, eradication and control; and to
d) Provide consideration of appropriate management actions.

Werren (2001) identified 504 exotic plants that have established self-maintaining populations within the Wet Tropics bioregion, and performed a preliminary ranking of a sample of fifty-seven Wet Tropics weed species; the 'environmental weed' component was the focus. 'Environmental weeds' are defined as 'introduced species capable of establishing or having a high probability of being able to establish self-sustaining populations by invading native communities or ecosystems and also capable of causing major modifications to species richness, abundance or ecosystem function' (Goosem 1993). Control agents, autecologies and extent of invasion for particular environmental weeds have also been studied (Swarbrick 1993a, 1993b, 1993c, Swarbrick and Skarratt 1994, van Haaren pers. comm., QPWS, DNR on-going).

Although disturbance is a natural feature of dynamic ecosystems, it also facilitates the invasion process by eliminating or reducing the cover and/or vigour of native competitors (Werren 2001). However, most exotic species tend to remain associated with areas of gross human disturbance (Maillet and Lopez-Garcia, 2000), whereas only a few establish in stable natural vegetation. Road verge and powerline corridor maintenance practices including spraying, burning, mowing, grading and removal of overhanging branches provides prime habitat for colonisation by ruderal weeds. Common weeds that occur and may dominate along linear clearings in the WTWHA include Lantana (*Lantana camara*), Giant Bramble (*Rubus alceifolius*), Guinea grass (*Panicum maximum*), Molasses grass (*Melinis minutiflora*), Grader grass (*Themeda quadrivalvis*), Blue-top (*Ageratum* spp.), Blue Snakeweed *(Stachytarpheta* spp.), Guava (*Psidium guajava*), Wild Tobacco (*Solanum mauritianum)* and other *Solanum* spp.

Weeds may have unpredictable flow-on effects that may be extremely damaging to native ecosystems (Werren 2001) e.g. certain weed species, particularly grasses, increase the linear barrier effects of roads and powerline clearings on rainforest wildlife (Goosem and Marsh 1997), whilst others, such as woody weed scrubland, may allow movements of generalist species (Goosem and Turton 2000). Similarly, McFadyen (2000) argues that alien plants displace native flora on which complex native food webs depend, e.g. the exotic species of *Aristolochia* contains toxins fatal to host-specific native butterflies (Werren 2001). Reynolds (1994) found that differences in microclimate underneath the closed canopy of Lantana scrubland may prevent secondary succession of native rainforest species, resulting in self-perpetuating weed fields. Weeds also can penetrate from the rainforest edge to up to seven metres into the forest along roads and powerline corridors. These weeds include *Lantana camara*, *Rubus alceifolius* and *Solanum* spp. (Siegenthaler and Turton, 2000).

The objective of this study was to undertake an initial basic spatial inventory to provide an understanding of the distribution of weed species and relative ecological condition of selected road verges and powerline corridors within the WTWHA. Ecological condition is a relative term used to describe the degree of disturbance of forest components and their function.

1.3 METHODS

1.3.1 Study Sites

Two road and powerline clearing networks were chosen for this study. The Chalumbin-Woree powerline corridor and road network includes the powerline clearing as well as Bridle Creek and Copperlode Dam roads. The Palmerston powerline corridor and road network includes the powerline clearing and the K-Tree, Maple Creek, Sutties Gap, Maalan, Jordan Creek and H Roads.

Chalumbin-Woree Powerline and Road Network

The Chalumbin-Woree powerline corridor traverses the WTWHA from Bridle Creek (near Davies Creek National Park) through to Lake Morris and thence over the escarpment to Woree or White Rock, which are southern suburbs of Cairns. There are two powerlines present along this clearing as far as Lake Morris. The first, on small towers, was installed in the 1960s. This clearing follows the Copperlode Dam road before swinging above the canopy as it descends the escarpment to Woree. During the late 1990s the powerline was upgraded with much larger towers that carry the wires above the tree canopy. This powerline continues to swing above the canopy over the WTWHA following a different route to the escarpment where it descends behind White Rock, which is just south of Woree. The smaller towers remain in place, awaiting decommissioning.

The weed surveys focussed on seven sites surrounding the towers. The new towers have been subject to considerable revegetation of their cleared footprints, undertaken by the Centre for Tropical Restoration, a section of Queensland Parks and Wildlife Service based at

Lake Eacham. Additional incidental surveys were undertaken in the vicinity of Bridle Creek and Shoteel Creek Roads.

Palmerston Powerline and Road Network

The Palmerston (Kareeya-Innisfail) powerline was constructed in the 1950s. It traverses the WTWHA from the Tully Gorge and Kareeya sub-station north towards the Palmerston Highway and is serviced by the H Road, Sutties Gap Road and the Maalan Track. It then turns east towards Innisfail, being accessed from the Jordan Creek and K-tree Roads and from the Palmerston Highway. The weed surveys focussed on sites in the powerline corridor near the Palmerston highway. The towers are accessed from K-tree Road, Suttie's Gap Road, H-Road and the Maalan Track. Surveys were also performed in former forestry clearings and along the verges of those roads, as well as the Maple Creek Road.

1.3.2 Floristic Survey Methods

A well-respected botanist and plant identification expert with many years of experience within the Wet Tropics, Mr Robert Jago, was employed to identify all plant species. Herbarium specimens were prepared for as many species as possible.

Transects

A thirty metre long transect was laid and surveyed to a distance of five metres on either side, resulting in a 10 metre x 30 metre quadrat (Fig. 1.1). The zero metre point of the transect was generally situated under the centre of the towers, with the transect running parallel to the clearing in both directions. Data from both directions were pooled. As maintenance practices within the powerline clearings generally focus in the vicinity of towers and along the tracks, transects centred on the towers contained the greatest diversity of weed species in varying stages of weed succession. In addition, weeds and rainforest species that occurred outside the ten metre wide quadrat but within the clearing were noted, particularly in areas where the vegetation of the clearing varied from the rainforest edge to the centre of the clearing (site of tower). Weed occurrences were classified on a rank scale consisting of:

a) Dominant (dominating the area):
b) Common (not dominant but very common within the area);
c) Occasional (more than two or three occurrences within the 10 metre transect strip, but uncommon); and
d) Rare (one or two occurrences within the transect strip only).

Each thirty metre transect was divided into four sections: 0-5 metres, 5-10 metres, 10-20 metres and 20-30 metres for ease of recording. When other weed species were noticed while traversing the clearing to the transect site, these were recorded as incidental occurrences. This approach resulted in a comprehensive list of species for the 10 m x 30 m quadrats, plus records of other species occurring between the ten metre strip and the rainforest edge but not present within the quadrats, as well as incidental occurrences noted elsewhere in the vicinity. Table 1.1 lists sites surveyed.

Similar transects were surveyed along road and highway verges. However, the width of the clearing in most cases was restricted to five metres on either side of the road, so that additional species were usually not recorded unless they occurred as incidentals beyond the thirty metre distance at either end of the transect.

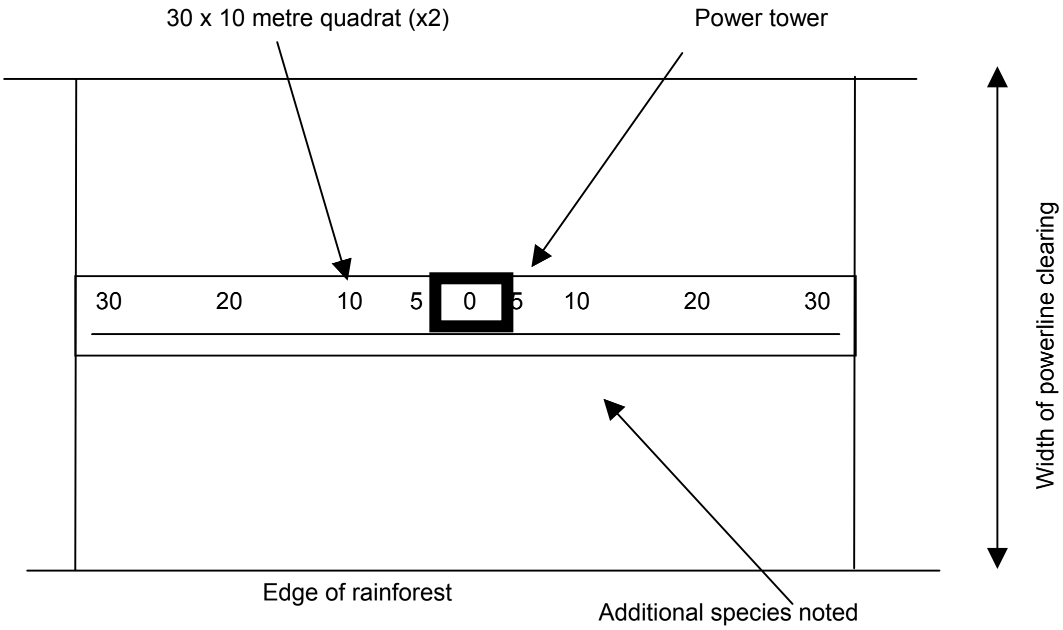


Figure 1.1: Design of the transect surveys.

Percentage Cover by Species

A stratified sampling method was used to obtain an estimate of the composition of leaf area in relatively uniform plots at several sites, with the aim of being able to assess the accuracy of species identity from remote sensing classification (see Section 3). The sites were divided into two or three relatively homogeneous areas large enough to be visible from the air. In each area, three to five quadrats, each one square metre, were examined visually for species content on the basis of leaf area. Each $1m^2$ quadrat had twenty-five cells marked within it to facilitate the estimation. Percentage leaf area in each cell was estimated and the results pooled and averaged for each quadrat. A vertical photograph was taken with the quadrat in place.

1.3.3 Powerline Corridor Video Analysis – Ecological Condition

Powerlink Queensland (Mr Tom Graham) supplied videos taken prior to 2000 during low flights over the powerline corridors under their control. Videos of each corridor were analysed for any large areas of weeds of the species that commonly dominate each corridor, using the field survey data to verify patterns for the dominant species. Additionally, forest linkages across the corridor were noted, together with their apparent quality. It should be noted that this method cannot substitute for field data and is only being used as an adjunct to the field interpretation. In particular, problems remain with interpretation of forest quality from the videos in areas where the plane is flying high above the canopy, especially in rugged regions with extremely deep gullies where the powerline is strung high above the canopy. In such sections, the video interpretation can only conclude that there is apparently a forest connection, assessment of whether this connection is formed by undisturbed rainforest or by weedy regrowth vegetation is impossible. In other areas, it has only been possible to state that the ground cover appears to be grassland, with no dominant species definition, or woody weed shrubland, which may be *Lantana camara, Rubus alceifolius* or a combination of both. Remote sensing data and its potential for assessing weed infestations will be discussed in Section 2.

1.3.4 Data Analysis

Because of variability between the sites, hypothesis testing with the field data is not possible. Rather this is observational data, providing a baseline of weed infestations along the two corridors and road networks in 2001/2002. Species composition analysis was undertaken and a qualitative comparison between the ecological condition within and between corridors is made.

Table 1.1: Powerline clearing and road transects surveyed.

Powerline/ Road Network	Site No.	Power Tower	General Location	GPS Position
Chalumbin-Woree	1	10091	Bridle Creek Road.	351336E 8121985N
	2	10096	Bridle Creek Road	353531E 8121669N
	3	10094	Bridle Creek Road	352551E 8121810N
	4	10109	Copperlode Dam Road	
	5	10108	Copperlode Dam Road	
	6	10104	Shoteel Creek Road	356812E 8122347N
	7	10103	Shoteel Creek Road	356358E 8122398N
Palmerston	8		Powerline crossing 1, K-Tree Road	368996E 8052377N
	9		Powerline, K-tree Road, fossicking field entrance	366786E 8051177N
	10		K-tree Road, Jordan Creek Road turn	366322E 8050542N
	11		K-tree Road, log dump, Creek 1	365573E 8048631N
	12		Maple Creek Road, first major road exit	364601E 8046372N
	13		Maple Creek Road, Creek, first clearing	361893E 8043777N
	14		Maple Creek Road, second major road exit	361607E 8041945N
	15		Maple Creek, Charappa Camp	361607E 8042549N
	16		Powerline, Sutties Gap Road	357957E 8044652N
	17		Maalan Road verge, first trap site	
	18		Maalan Road verge	361757E 8053271N
	19		Maalan Road, log dump	361044E 8053141N
	20		Powerline crossing 1, Maalan Road	360875E 8052605N
	21		Powerline crossing 2, Maalan Road	360042E 8050941N
	22		Powerline crossing 4, Maalan Road	359598E 8050319N
	23		Maalan Road, wide verge, Trap 4	357393E 8053072N
	24		Maalan Road, quarry	

1.4 RESULTS AND DISCUSSION

1.4.1 Weed Species Recorded in Field Surveys of the Powerline Corridor and Road Networks

Chalumbin-Woree Powerline Corridor and Road Network

Table 1.2 provides a list of the weed species identified within the Chalumbin-Woree powerline corridor and road network. The Bridle Creek road follows the powerline corridor, meeting Shoteel Creek Road and continuing onto Lake Morris. The Copperlode Dam road also follows the powerline corridor. Therefore data for the powerline towers presented in Appendix 1.1 includes both road and powerline corridor data. A total of forty-four weed species were recorded in the network.

The weed species that were recorded most consistently along the Chalumbin-Woree powerline corridor were *Stachytarpheta jamaicensis* (blue snakeweed) and *Paspalum paniculatum* (paspalum). *Melinis minutiflora* (molasses grass), *Lantana camara* (lantana), *Mimosa pudica* (sensitive weed), *Polygala paniculata* and *Ageratum conyzoides* (bluetop) also were mostly common or dominant where they occurred and each occurred in at least ten of the twenty-eight sub-sites (four 'distance classes' along each of the seven transects). Figure 1.2 shows that the majority of these species did not completely dominate a sub-site, rather a number of species were common to dominant in different areas of sub-sites, while many were common. Another common weed species that generally dominated where it occurred was *Brachiaria decumbens* (signal grass) (Figure 1.2).

Other weeds recorded less consistently across the sub-sites, but common where they occurred, included *Stylosanthes humilis* (Townsville lucerne), *Urena lobata* (urena burr), *Axonopus compressus* (broadleaf carpet grass), *Rubus alceifolius* (giant bramble), *Scoparia dulcis, Sporobolus africanus* (rat's tail grass) and *Hyptis capitata* (knobweed).

Palmerston Powerline Corridor and Road Network

Table 1.3 provides a list of the weeds encountered within the Palmerston powerline corridor and road network. A total of fifty weed species were encountered. Appendix 1.2 lists all species both native and alien recorded within the network.

Figure 1.3 shows that the weed that most commonly occurs and dominates all else almost everywhere it occurs in the Palmerston powerline clearing and road network is *Panicum maximum* (Guinea grass). Guinea grass forms swathes across the clearing and often leaves only tyre tracks on roads such as Suttie's Gap and Maple Creek Roads.

In four situations, Guinea grass occurs but fails to dominate.

- The first occurs in areas where the Department of Natural Resources has undertaken weed control along the road network and at present herbaceous weeds (particularly *Ageratum conyzoides*, bluetop) and natives are dominating. However, Guinea grass is starting to return in these areas and will again dominate unless these control measures are continued.
- The second is in parts of the powerline clearing where the previously dominant Guinea grass is being gradually out-competed by *Lantana camara* (lantana), due to the reduced frequency of fires in the powerline clearing in recent years.
- The third situation is where *Melinis minutiflora* (molasses grass) out-competes Guinea grass; this appears to be related to the soils drying out in areas such as old powerline track cuttings or slopes.

- The fourth occurs under the powerline towers and along the powerline tracks, where regular track maintenance by grading favours *Brachiaria decumbens* (signal grass).

Other weeds that dominate in certain situations include *Ageratum conyzoides* (bluetop) and *Crassocephalum crepidiodes* (thickhead or fathead), particularly where weed control has been undertaken or where grading and clearing have disturbed the ground. Herbaceous weeds, and in particular bluetop, appear to form the first stage of weed succession in this area. *Brachiaria decumbens* (signal grass) is very obvious in less recently disturbed areas such as under and around the power towers and tracks, thereby seeming to form a second stage in weed succession. *Melinis minutiflora* (molasses grass) also dominates large areas, due to its ability to out-compete Guinea grass in areas that dry out quickly, such as steep banks, slopes and ridges that receive no shade during the day. These two species (Guinea and molasses grass) appear to be the third stage in succession in sunny cleared areas.

In shaded areas on the edges of the clearing adjacent to the rainforest, *Lantana camara* dominates (Figure 1.3). *Rubus alceifolius* often occurs with the Lantana along the edges. In the past, the shaded, damper rainforest edge was the main stronghold of these two woody weeds that tend to prevent regeneration of native rainforest species. However, as the powerline clearing is now no longer subject to regular fires, in some areas, principally in gullies and lower slopes, but more recently also further up the slopes, lantana has spread all the way across the clearing, gradually outcompeting the Guinea grass. Thus Lantana may be considered a final stage of weed succession where fires have been eliminated and shading for part of the day allows its establishment.

Polygala paniculata is very common in the majority of sub-sites but its small size and growth form does not allow it to dominate. Other common herbaceous weeds are *Mitracarpus hirtus* and *Emilia sonchifolia*. One weed species found along the South Johnstone road network, near the disused Charappa Creek forestry camp, is a South-east Asian ground orchid species, *Arundina bambusaefolia*. Specific recommendations for this particular weed infestation are found below (Section 1.4.3).

Comparison of Powerline and Road Networks

Figure 1.4 demonstrates that while there is considerable overlap of common weed species in the two linear clearing networks, there are also several species that occur or are common in only one network e.g. the most common weed in the Chalumbin-Woree area, *Stachytarpheta jamaicensis* was not recorded at Palmerston. Likewise the second most common weed in the Chalumbin-Woree area, *Paspalum paniculatum* is extremely unusual in the records from Palmerston. In contrast, *Panicum maximum*, the dominant species at Palmerston was relatively uncommon along the Chalumbin-Woree network. *Crassocephalum crepidioides* is another species common at Palmerston and absent along the Chalumbin-Woree network. The conspecifics *Paspalum paniculatum* and *P. scrobiculatum* appear to replace each other in the different soil and moisture conditions of the two powerline clearing and road networks. *Ageratum conyzoides, Brachiaria decumbens, Melinis minutiflora, Lantana camara, Rubus alceifolius, Polygala paniculata* and *Mimosa pudica* are common in both areas. This separation of weed species between areas may be related to soil fertility and moisture. The fertile basalt soils and higher rainfall of the Palmerston region contrast with the nutrient-depauperate granitic and metamorphic soils, and the slightly lower rainfall, of the Chalumbin-Woree area. The age of the powerline clearings may be another differential factor.

Table 1.2: Weed species recorded in the Chalumbin-Woree powerline clearing and road network.

Species Name	Common Name	Family	Life Form	No. Sub-Sites. (Total 28)	Common Abund'. Category
**Ageratum conyzoides*	Bluetop	Asteraceae	Herb	10	C-D
**Arundo donax*			Grass	1	R
**Axonopus compressus*	Broadleaf carpet grass	Poaceae	Grass	6	C
**Axonopus fissifolius*	Narrowleaf carpet grass	Poaceae	Grass	2	C
**Bidens pilosa*	Cobbler's pegs	Asteraceae	Herb	1	O
**Brachiaria decumbens*	Signal grass	Poaceae	Grass	9	D
**Citrus limon*	Lemon tree	Rutaceae	Tree	1	R
**Conyza leucantha*		Asteraceae	Herb	2	C
**Crotalaria goreensis*	Gamba pea	Fabaceae	Herb	1	O
**Crotalaria lanceolata*	Rattlepod	Fabaceae	Herb	1	O
**Cynodon dactylon*	Green couch	Poaceae	Grass	1	R
**Cyperus aromaticus*	Navua sedge	Cyperaceae	Herb	3	C-D
**Emilia sonchifolia*	Emilia	Asteraceae	Herb	1	R
**Eupatorium catarium*	Praxelis	Asteraceae	Shrub	4	O
**Euphorbia hirta*					
**Hyptis capitata*	Knobweed	Lamiaceae	Herb	5	C
**Hyptis suaveolens*		Lamiaceae	Herb	2	C
**Indigofera suffruticosa*		Fabaceae		2	O
**Lantana camara camara*	Lantana	Verbenaceae	Shrub	13	C
**Macroptilium atropurpureum*	Siratro	Fabaceae	Herb	4	O
**Melinis minutiflora*	Molasses grass	Poaceae	Grass	13	C-D
**Melinis repens*	Red natal grass	Poaceae	Grass	2	O
**Mimosa pudica*	Sensitive weed	Mimosaceae	Herb	11	C
**Mitracarpus hirtus*		Rubiaceae	Herb	1	O
**Panicum maximum*	Guinea grass	Poaceae	Grass	3	C
**Paspalum conjugatum*	Paspalum	Poaceae	Grass	1	C
**Paspalum paniculatum*	Paspalum	Poaceae	Grass	17	C
**Passiflora edulis*	Edible passionfruit	Passifloraceae	Vine	1	R
**Passiflora foetida*	Stinking passionfruit	Passifloraceae	Vine	1	O
**Polygala paniculata*		Polygalaceae	Herb	11	C
**Centratherum punctatum* var. *punctatum*		Asteraceae	Herb	1	C
**Richardia brasiliensis*		Rubiaceae		2	O/C
**Rubus alceifolius*	Giant bramble	Rosaceae	Vine	6	C
**Scoparia dulcis*		Scrophulariaceae		6	C
**Sida rhombifolia*		Malvaceae	Shrub	5	O
**Solanum mauritianum*	Tobacco bush	Solanaceae	Shrub	3	R
**Solanum torvum*	Thorn apple	Solanaceae	Shrub	1	+
**Spermacoce latifolia*		Rubiaceae		1	O
**Sporobolus jacquemontii*	Rats-tail grass	Poaceae	Grass	5	C

Species Name	Common Name	Family	Life Form	No. Sub-Sites. (Total 28)	Common Abund'. Category
**Stachytarpheta jamaicensis*	Blue snakeweed	Verbenaceae	Herb	22	C-D
**Stylosanthes humilis*	Townsville lucerne	Fabaceae	Herb	7	C
**Tagetes minuta*	Stinking roger	Asteraceae	Herb	1	+
**Tristemma mauritianum*		Melastomataceae	Shrub	4	C
**Urena lobata*	Urena burr	Malvaceae	Shrub	**7**	**C**

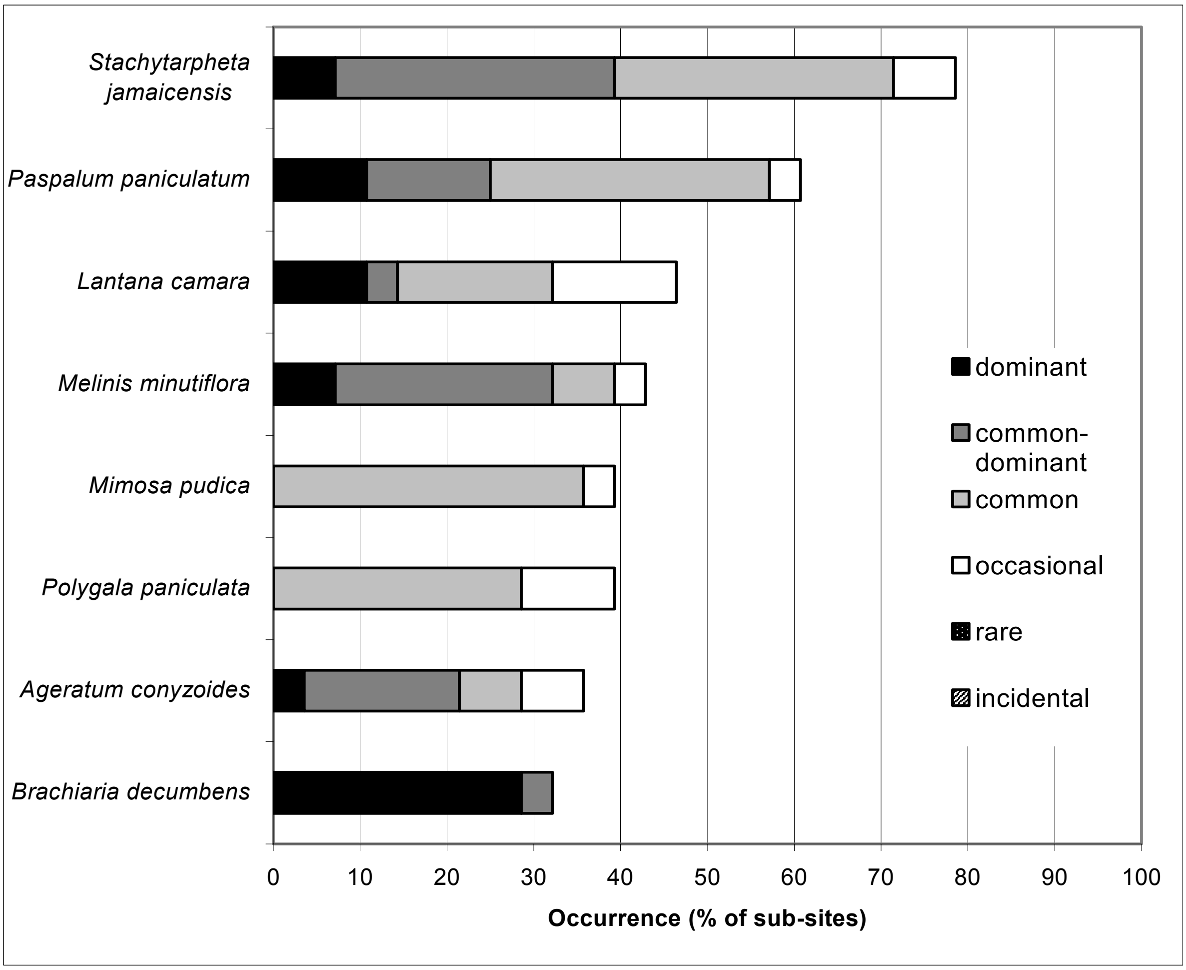


Figure 1.2: Abundance categories of common species found within the Chalumbin-Woree powerline corridor and road network. Species dominating sub-sites are few, although many are common or common-to-dominant within sub-sites.

Table 1.3: Weed species recorded in Palmerston powerline clearing and road network.

Species Name	Common Name	Family	Life Form	No. Sub-sites (Total 68)	Common Abund' Category
**Ageratum conyzoides*	Bluetop	Asteraceae	Herb	46	C
**Arundina bambusaefolia*		Orchidaceae	Orchid	1	+
**Axonopus compressus*	Broadleaf carpet grass	Poaceae	Grass	1	R
**Axonopus fissifolius*	Narrowleaf carpet grass	Poaceae	Grass	3	R
**Bidens pilosa*	Cobbler's pegs	Asteraceae	Herb	2	+
**Brachiaria decumbens*	Signal grass	Poaceae	Grass	31	D
**Brachiaria mutica*	Para grass	Poaceae	Grass	1	O
**Calyptocarpus vialis*	Little Synedrella weed	Asteraceae	Herb	5	O
**Centrosema pubescens*	Centro	Fabaceae	Herb	1	R
**Conyza leucantha*		Asteraceae	Herb	4	C
**Crassocephalum crepidioides*	Thickhead	Asteraceae	Herb	21	C
**Crotalaria lanceolata*	Rattlepod	Fabaceae	Herb	11	O
**Crotalaria pallida*	Streaked rattlepod	Fabaceae	Herb	4	+
**Cyperus aromaticus*	Navua sedge	Cyperaceae	Herb	7	O
**Desmodium intortum*	Desmodium	Fabaceae	Herb	5	R/O
**Desmodium uncinatum*	Desmodium	Fabaceae	Herb		
**Dichrocephala integrifolia*		Asteraceae	Herb	2	O
**Echinochloa colona*	Awnless barnyard grass	Poaceae	Grass	1	R
**Eleusine indica*	Crowsfoot grass	Poaceae	Grass	6	R/O
**Emilia sonchifolia*	Emilia	Asteraceae	Herb	12	R
**Erechtites valerianifolia*	Brazilian fireweed	Asteraceae	Herb	6	O
**Hyptis capitata*	Knobweed	Lamiaceae	Herb	2	O/+
**Ipomoea indica*	Morning glory	Convolvulaceae	Vine	2	O
**Lantana camara camara*	Lantana	Verbenaceae	Shrub	21	D
**Macroptilium atropurpureum*	Siratro	Fabaceae	Herb	2	C/+
**Melinis minutiflora*	Molasses grass	Poaceae	Grass	18	D
**Mimosa pudica*	Sensitive weed	Mimosaceae	Herb	7	C
**Mitracarpus hirtus*		Rubiaceae	Herb	15	O/C
**Oxalis corniculata*	Wood sorrel	Oxalidaceae	Herb	7	O
**Panicum maximum*	Guinea grass	Poaceae	Grass	60	D
**Paspalum conjugatum*	Paspalum	Poaceae	Grass	1	R
**Paspalum paniculatum*	Paspalum	Poaceae	Grass	1	R
**Passiflora edulis*	Edible passionfruit	Passifloraceae	Vine	1	R
**Phyllanthus amarus*		Euphorbiaceae		10	O
**Polygala paniculata*		Polygalaceae	Herb	40	C
**Richardia brasiliensis*		Asteraceae	Herb	1	R
**Rubus alceifolius*	Giant bramble	Rosaceae	Vine	12	C
**Scoparia dulcis*		Scrophulariaceae		1	R

Species Name	Common Name	Family	Life Form	No. Sub-sites (Total 68)	Common Abund' Category
**Setaria sphacelata*	Pigeongrass	Poaceae	Grass	3	R
**Sida rhombifolia*		Malvaceae	Shrub	6	O
**Sigesbeckia orientalis*		Asteraceae	Herb	6	O
**Solanum americanum*		Solanaceae	Shrub	5	O
**Solanum mauritianum*	Tobacco bush	Solanaceae	Shrub	3	R
**Solanum torvum*	Thorn apple	Solanaceae	Shrub	1	+
**Spermacoce latifolia*		Rubiaceae		4	+
**Sporobolus jacquemontii*	Rats-tail grass	Poaceae	Grass	5	R
**Stylosanthes humilis*	Townsville lucerne	Fabaceae	Herb	4	O
**Synedrella nodiflora*	Cinderella weed	Asteraceae	Herb	3	O
**Triumfetta rhomboidea*		Tiliaceae	Herb	1	R
**Urena lobata*	Urena burr	Malvaceae	Shrub	2	R

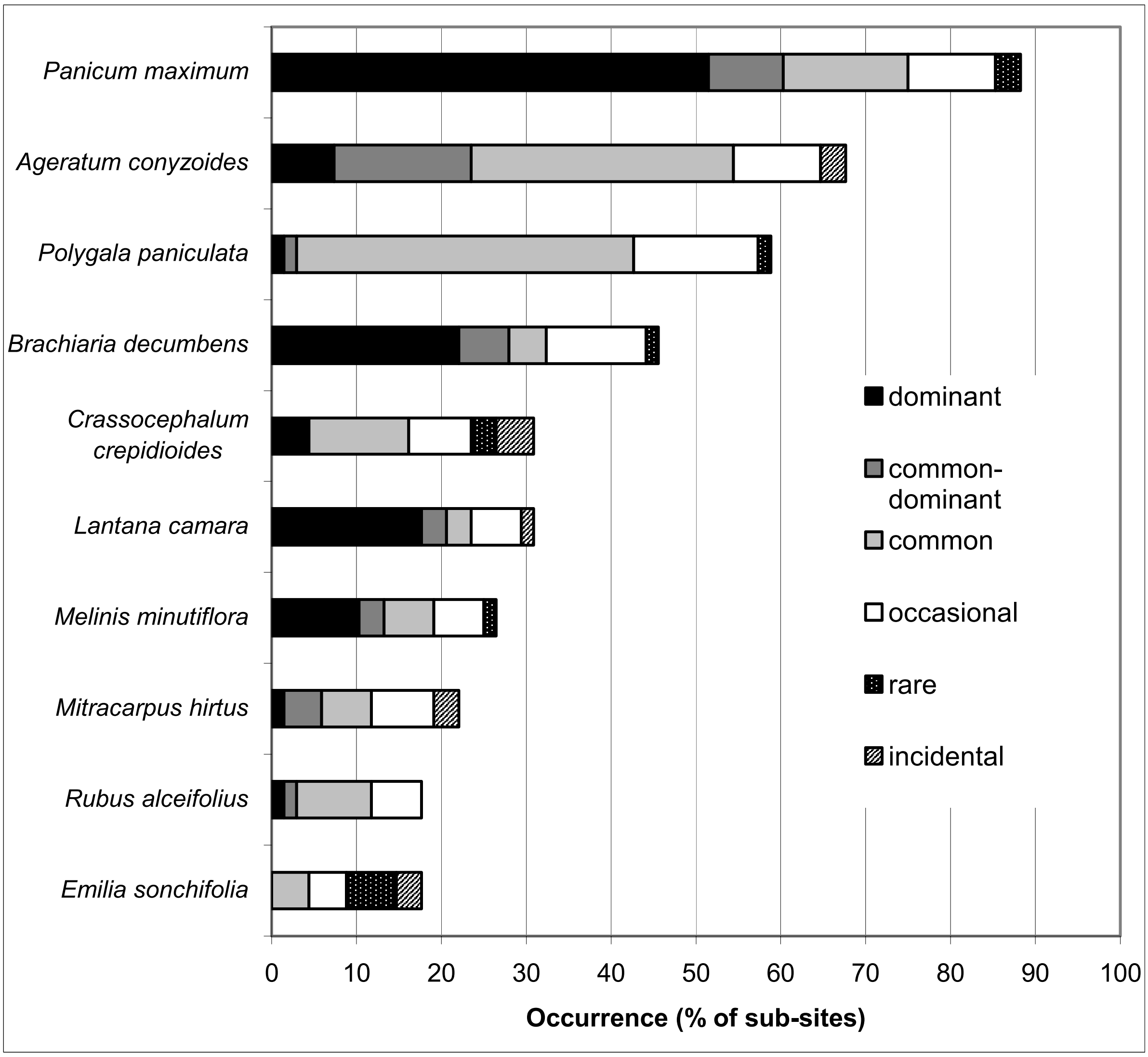


Figure 1.3: Abundance categories of common species found within the Palmerston powerline corridor and road network. Several species dominate sub-sites where they are found and many are common or common-to-dominant within sub-sites.

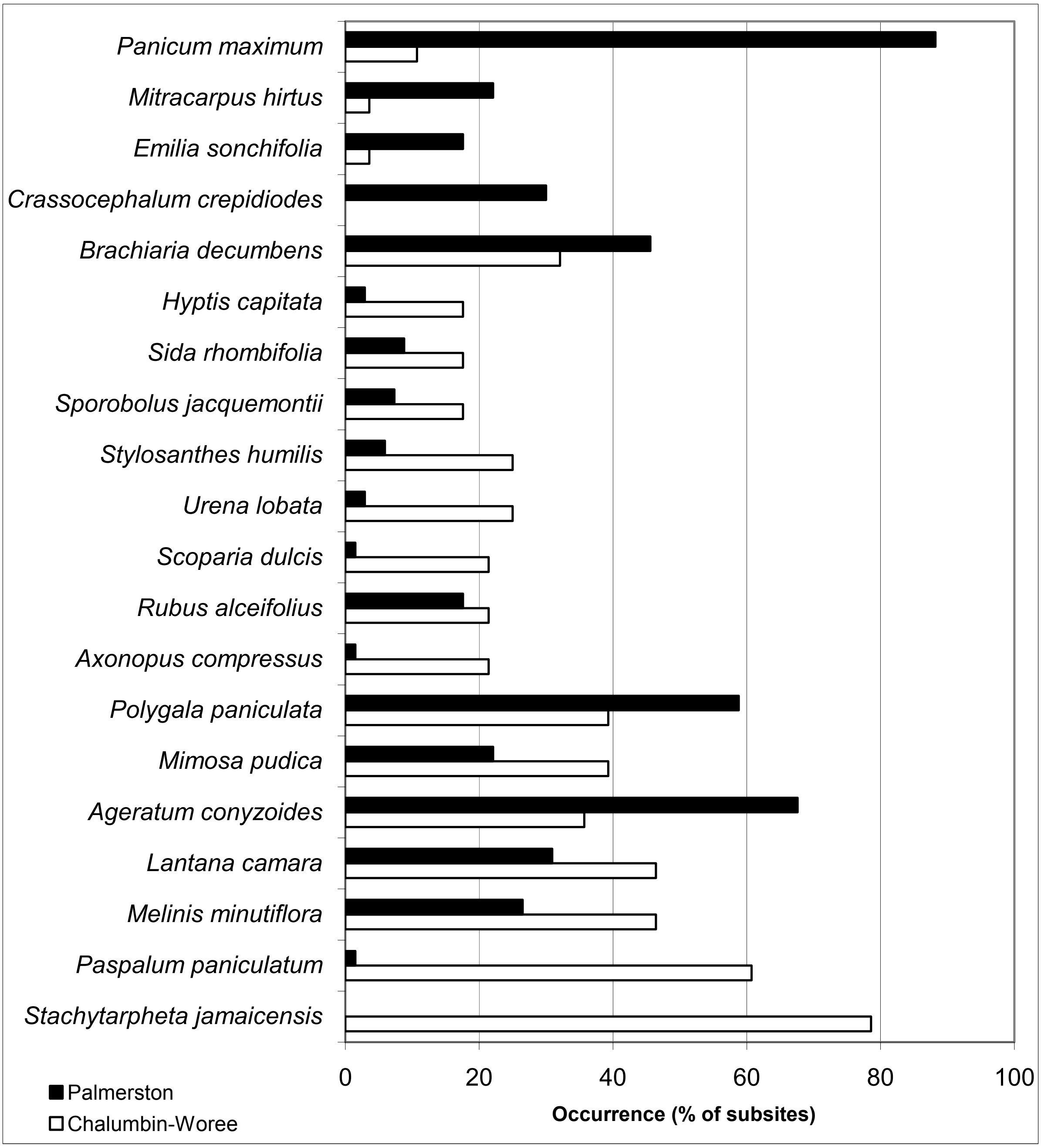


Figure 1.4: Occurrence of most common weed species on the Palmerston and Chalumbin-Woree powerline and road networks.

1.4.2 Native Species Occurrence in Weedy Areas of the Powerline and Road Networks

Chalumbin-Woree Powerline and Road Network

Of the native species occurring within the weedy sites chosen in the Chalumbin-Woree powerline clearing and road network, none were very common. Table 1.4 shows the most common species and their frequency of occurrence in various dominance categories. Few of these species show potential to replace and out-compete weeds. The exceptions to these are the groundcover species *Dicranopteris linearis, Lycopodiella cernua* and *Gahnia sieberiana* which occur in the wetter, eastern areas towards Lake Morris, while in the drier areas to the west, *Themeda triandra* and *Imperata cylindrica* (blady grass) are competitive. Several canopy species have established in certain areas, whilst elsewhere they have been planted by the Centre for Tropical Restoration. These include *Acacia simsii, Alphitonia petriei, Acacia celsa* and *Omalanthus novo-guineensis*.

Where these groundcover and taller species are not already established, restoration works appear to require the approach taken by CTR e.g. clearing the area, weed control and re-planting with native species. However, the groundcover species mentioned may form an alternative planting strategy following weed control in areas where low-growing species are necessary to avoid interfering with powerlines or towers. Similarly shrubs such as *Acacia simmsii* in drier areas and *Melastome affine* in wetter sections should prove useful.

Palmerston Powerline and Road Network

Similarly to the Chalumbin-Woree clearing, of the native species occurring within the weedy sites chosen in the Palmerston powerline clearing and road network, few were very common. Table 1.5 shows the most common species and their frequency of occurrence in various dominance categories. Very few of these show potential to replace and out-compete weeds.

However, in certain situations, several native species appear very useful. Where the Department of Natural Resources has undertaken weed control along road verges, native species, including the grasses *Oplismenus compositus and O. hirtellus,* have become dominant, though it is unlikely that they could out-compete weed grass species, except in areas of shade, as they are adapted to the low light regimes of small rainforest gaps. Maintenance along road verges of these low-growing species that enhance rather than restrict the presentation of World Heritage values of the rainforest, would require maintenance of a high degree of canopy closure above the road to provide the necessary shade. Another low-growing native species particularly useful along road verges for reasons of visitor appreciation is the attractive herb *Pollia macrophylla*. This herb occurs in wetter areas and once established, does appear to be able to out-compete the weed grasses, provided that a reasonable amount of shade is maintained by canopy overhangs.

On road banks in less fertile areas the groundcover species *Dicranopteris linearis, Lycopodiella cernua* and *Gahnia sieberiana* are capable of maintaining an embankment covered in native species that is attractive due to their ferny or sedge foliage. Again their survival is aided by canopy overhangs that prevent establishment of light-requiring weed species such as *Melinis minutiflora* (molasses grass). The ferns *Blechnum orientale, Pteridium esculentum* and *Christella dentata* as well as several tree fern species (*Cyathea* spp.) are also useful in this regard, in areas with greater light penetration. Low shrubs such as *Otanthera bracteata* also have potential for partly shaded areas of the powerline clearing.

Canopy species have not had much opportunity to establish due to the self-perpetuating weed succession present in the powerline clearing and along the roads with wider verges. In previously cleared gullies of the powerline clearing tree ferns form a canopy in some areas. Weed control along the road verges has not yet resulted in canopy species becoming established, other than the occasional seedling, particularly of *Omalanthus novo-guineensis,* although the native grasses and herbs have out-competed the weeds as mentioned above. Continuation of this weed control should be a high priority. It appears that to establish native canopy species more pro-active restoration works are required, such as that undertaken in three sections of the powerline clearing by the Centre for Tropical Restoration (see Section 4). The three species planted in February 2000, *Acacia celsa, Elaeocarpus grandis* and *Alphitonia petriei* are growing extremely quickly and have already established an open canopy that shades out the majority of weeds.

Table 1.4: More common native species occurring within the chosen weedy areas of the Chalumbin-Woree powerline and road network. Table shows the number of sub-sites where a species was found in each occurrence category.

Species	Dominant	Common-Dominant	Common	Occasional	Rare	Incidental
Acacia celsa			2	7	3	
Acacia simsii			4	3		
Alphitonia petriei			1	2	10	
Alstonia muelleriana			5	1	3	
Dicranopteris linearis	1	4	2	1		
Gahnia sieberiana		3	4	1		
Imperata cylindrica		4	3	2		
Lycopodiella cernua	1	3	2	1		
Lygodium reticulatum		1	4	1	1	
Melastoma affine			4		1	
Omalanthus novo-guineensis			2	4		
Parsonsia latifolia			5	2	1	
Rubus moluccanus	1		1	3		
Themeda triandra	4					

Table 1.5: More common native species occurring within the chosen weedy areas of the Palmerston powerline and road network. Table shows the number of sub-sites where a species was found in each occurrence category.

Species	Dominant	Common-Dominant	Common	Occasional	Rare	Incidental
Blechnum orientale			1	5	1	
Centella asiatica		4	13	1		
Christella dentata			2	5	1	
Dicranopteris linearis	2	2	1	2		
Imperata cylindrica			3	4	1	
Lycopodiella cernua		2	10	1		
Otanthera bracteata	1	2		2	1	
Omalanthus novo-guineensis	1			5	4	1
Oplismenus compositus		2	1			
Oplismenus hirtellus		1				
Pollia macrophylla		3	1			
Rubus moluccanus			1	5		
Rubus probus			2	5		1
Pteridium esculentum			4			

1.4.3 *Arundina bambusaefolia* (Bamboo Orchid) – A New Weed of the Wet Tropics World Heritage Area

The Bamboo Orchid was found on a road cutting in the South Johnstone Road network, near an old clearing for the Charappa Forestry Camp. This species has not been collected in the Wet Tropics prior to this, although Mr Rigel Jensen did note it approximately two years ago at this location. The species is a native of the South-east Asian to Himalayan region and is recognised as being able to naturalise in many tropical countries. It has been found on old lava flows in Hawaii and on lava bluffs near volcanic activity. It is also found wild in Fiji and is considered an escapee from cultivation in Puerto Rico. However, seeds and plants are readily available on the Internet, as it appears to be a popular garden plant.

Bruce Gray, the recognised orchid expert in North Queensland (CSIRO Tropical Forest Research Centre, Atherton), has not seen this species naturalised in the Wet Tropics, but knows it from cultivation, mainly in the coastal lowlands. However, it is cultivated less frequently on the Atherton Tablelands but has been observed in a garden in Millaa Millaa (Bob Jago, pers. comm.).

The Bamboo Orchid is a large, terrestrial plant with cane-like stems 1.5 - 2.5 metres tall and up to 1.5 centimetres in diameter. The leaves are borne in two ranks and are narrowly oblong and grass-like, they are twelve to thirty centimetres long and 1.6 - 2.5 centimetres across. The simple, terminal inflorescence is fifteen to thirty centimetres long and bears many flowers that bloom in succession for two to three days.

The flowers found along the Suttie's Gap road (Figure 1.5) are rose-purple or white and a few centimetres across, the lip is darker than the sepals and petals, they are often veined purple and have a yellow patch at the base. The species blooms all year and one plant bears many flower spikes.

Arundina bambusaefolia prefers bright sunlight and plenty of water but tolerates a wide range of conditions, being particularly prominent as a weed of hillsides, banks and road cuttings. It is capable of vegetatively reproducing; when the tall canes fall and touch the ground they may take root. As this is the only known occurrence of this exotic species that has demonstrated weedy characteristics in other tropical areas, there is a good opportunity to control the infestation before it is transferred to other sites.

Bruce Gray (pers. comm.) recommends that it should be removed from the site and the location monitored for several years, as seed may have been set during the two years that it has been known to occur at this site (Rigel Jensen, pers. comm.).

Figure 1.5: *Arundina bambusaefolia* flower.

Figure 1.6: Growth form of *Arundina bambusaefolia.*

Bob Jago believes that the plants may have seeded.

There are many individual plants present along the road cutting for approximately fifty metres, suggesting that the species is at least vegetatively reproducing and very probably seeding also.

Removal of the plant should only require one vehicle with several people and equipment to allow safe climbing of the road cutting and the digging out of the plants. Replacement with native ferns such as *Dicranopteris linearis* or tree ferns would be preferable, to prevent colonisation by alternative weeds.

Figure 1.7: *Arundina bambusaefolia* on a road cutting west of Charappa Creek forestry camp clearing.

1.4.4 Aerial Video Analysis of Powerline Clearings

Ecological condition of the Palmerston and the Chalumbin-Woree powerline clearings was assessed using aerial videography, noting the presence of large areas of weeds and the quality of forest linkages across the clearings In several cases along the Palmerston powerline, especially when descending the escarpment to the Tully Gorge and for the majority of the Chalumbin-Woree line, the plane was flying high above the clearing or the clearing was in shadow, this made interpretation difficult. The height of the new towers along the Chalumbin-Woree line also necessitated relatively high flight paths. Interpretation was supplemented by knowledge of the sites where the weed survey was undertaken. However, this method can only supplement existing knowledge.

Palmerston Powerline Clearing

The lower section of the Palmerston powerline clearing (from the Palmerston Highway to the K-Tree Road and along the Jordan Goldfields Track) exists mainly as a grassy swathe dominated by Guinea grass, molasses grass and signal grass (Figure 1.8). In recent times the exclusion of fire has allowed lantana to spread across the clearing, particularly on slopes near gullies and drainage lines, where shading during part of the day reduces the competitiveness of the grasses. Lantana and giant bramble tend to form impenetrable thickets on the edge of the clearing; this is the source for the spread of the woody weeds across the clearing. In deeper gullies, rainforest regrowth occurs, often edged with tree ferns. Narrow strips of regrowth can also be found in shallower gullies, this having occurred only over the past 10 years, again a function of the reduction in fires. However, for several spans in this lower section, rainforested connections remain along deep creek lines, probably having never been completely cleared. These occur twice near the K-Tree Road and more commonly near the Jordan Goldfields Track. Additionally, along the Jordan Goldfields track section, several regrowth gullies that were present as thin strips ten years ago have been strengthened by further growth of the forest to form excellent connections for faunal movements.

The higher sections of the powerline clearing near the Jordan Goldfields Track and the Maalan Track are more varied. Guinea and molasses grass swathes with lantana/bramble edges remain dominant, particularly along shorter spans and ridgelines. In several places, shade characteristics due to differing aspects has allowed lantana to again out-compete the grasses and stretch across the clearing (Figure 1.9). Additionally, several major creeks and their tributaries cross the clearing and these are associated with long rainforest connections. Regrowth is a feature in shallower gullies, but shadows in the video image caused difficulty in determination of the quality of these connections.

The section along the West Palmerston Track between the last crossing of the Maalan Track and Sutties Gap Road has a number of rainforest connections or regrowth gullies associated with the South Johnstone River and its tributaries. Each forested connection appears to be fringed with lantana, while grassy swathes predominate on slopes to the towers. However flight height restricted interpretation. Grassy areas occur on the riverbank itself.

Figure 1.8: Lower section of Palmerston powerline clearing illustrating swathes of molasses grass (purple flowers), signal grass (bright green in foreground) and Guinea grass (taller pale green in foreground). Note small amounts of regrowth in gullies in middle distance.

Figure 1.9: Upper section of Palmerston powerline clearing illustrating a Guinea grass swathe and areas where Lantana is expanding through the grass in the centre of the clearing.

The pattern of forested connections fringed with woody weeds and grassy swathes near the towers continues down the H Road section of the powerline, although grassy swathes predominate where the line follows a ridge and has shorter spans. Further south on the H Road, tower footprints become smaller grassy clearings and the forested connections are the dominant feature. Along the escarpment of the Tully Gorge, the majority of tower footprints are small with long forested connections separating them. Although the height of the plane over the area where the powerline leaves the major escarpment makes interpretation difficult, it is likely that the clearing has regrowth and weeds with narrower forested gullies. At Cochable Creek, grasses infest the creek banks and islands, these grassy swathes become dominant except in steep sections and along the riverbanks where lantana and regrowth predominate as the line crosses the Tully River. The Tully Gorge, the Tully Gorge Road and the powerline clearing are dominated by grassy swathes, except in small gullies leading to the Tully River and along the riverbanks.

In summary, the general ecological condition of the Palmerston powerline clearing is extremely poor, being dominated by grassy swathes and lantana. In sections, particularly along the H Road and the Tully Gorge escarpment, and to a lesser extent along parts of the Maalan Track and West Palmerston Track, long forested connections where the powerline swings above the canopy, together with the small tower footprints leads to a relatively good ecological condition rating. However, even in these sections, weeds infest the tower sites. The lower elevation sections near the Palmerston highway, K-Tree Track, Jordan Goldfields Track and the Tully River are mostly in extremely poor condition. However, there has been a change in ecological condition since fires were excluded over the past few years. In some cases that has resulted in one weed type (woody) overtaking another (grass), but in others it has allowed regrowth forests along gullies to grow taller and the extent of these regrowth patches has increased, thus improving ecological condition.

Chalumbin-Woree Powerline Clearing

The lower elevation swathes of the Chalumbin-Woree powerline clearing, where Bridle Creek runs parallel to the clearing, are mostly heavily weed-infested. The adjacent forest is relatively dry and the dryness is reflected in the clearing vegetation that consists mainly of grasses, including the native species *Themeda triandra* and *Imperata cylindrica,* as well as weeds such as molasses grass and paspalum. Dense thickets of lantana commonly occur while herbaceous weeds such as blue snakeweed, bluetop, knobweed and sensitive weed are common everywhere. Riparian vegetation along Bridle Creek forms the main forest connections.

Figure 1.10: Chalumbin-Woree lower elevation swathes of grass and blue snakeweed.

As the powerline climbs, wet-adapted grasses such as Signal and Carpet grass take over, while the herbaceous weeds, particularly Blue Snakeweed and Bluetop, remain common, with lantana still forming dense thickets. Forested connections become more common with clearings around the towers reducing in size and weeds therefore becoming less dominant.

The powerline climbs quickly in the vicinity of the Clohessy River and its tributaries, with the line mainly swinging above the canopy and tower footprints small. Weeds comprise mainly signal and molasses grasses.

Once the Shoteel Creek Road rejoins the clearing, it again becomes a swathe of grass and herbaceous weeds near the powerline towers, with woody weeds and regrowth down the slopes, often with native ferns, sedges and rainforest pioneers interspersed. Long forested connections still occur in the gullies that form the headwaters of Shoteel Creek and Freshwater Creek.

Figure 1.11: As the powerline climbs, forested connections become more common; clearings around towers are still dominated by grasses adapted to wetter habitats and woody weeds.

Near Copperlode Dam, weeds are prevalent around the water's edge as well as in the clearing, carpark and tracks associated with the kiosk. The clearing generally has lower regrowth including native ferns, sedges and pioneers but woody weeds including giant bramble and lantana are still prevalent on road embankments with weedy grasses occurring in the vicinity of towers and hillcrests. Forested gullies that form rainforested connections commonly occur at the headwaters of Freshwater Creek's tributaries. Low regrowth, with woody weed thickets, native ferns and pioneers, occurs where the clearing follows the main ridge. Weeds are particularly prevalent where the clearing reaches the escarpment to descend. The majority of towers on the descent of the escarpment are situated in old fire scarred grassland on the foothills behind Cairns suburbs.

In summary, the Chalumbin-Woree powerline corridor has sections in relatively poor condition, particularly at the drier end towards Bridle Creek where lantana and herbaceous weeds as well as weedy grasses are dominant or common. At higher elevations, the powerline swings above the canopy in many areas, resulting in smaller weed fields with some native regrowth that are mainly associated with towers, and to a lesser extent the slopes adjacent to towers. The Lake Morris Road, Copperlode Dam and the kiosk provide opportunities for woody weeds and grasses on the eastern end of the powerline clearing, with power towers surrounded by a mixture of herbaceous, grassy and woody weeds as well as native ferns, sedges and pioneer rainforest trees. Swathes in the eastern section where the line does not swing above the canopy tend to be more native regrowth and herbaceous weeds rather than grasses. As the powerlines descend toward the coast, the towers are mainly situated in existing clearings that are often fire scars from cane fire escapes.

1.4.5 Characteristics of Major Weeds Found Along Road and Powerline Networks

Many of the species mentioned above can be associated with the six major impacts of exotic plant species in the tropical environment of Hawaii that were listed by Smith (1989). Examples are:

1. Physical displacement of native species (all weeds);
2. Formation of monotypic stands resulting in biodiversity loss and devastating effects on survival of endemic species with limited ranges and small population sizes (e.g. *Lantana camara, Rubus alceifolius, Melinus minutiflora, Panicum maximum*);
3. Changing fire characteristics, particularly promotion of fire by exotic pasture grasses (e.g. *Panicum maximum*);
4. Alteration of soil-water regimes;
5. Alteration of soil nutrient status by nitrogen-fixing legumes (e.g. *Macroptilium atropurpureum*, not a problem at Palmerston); and
6. Promotion of mutually beneficial interactions between feral animals and weeds (e.g. *Rubus alceifolius*)(Werren 2001).

Werren (2001) evaluated a group of exotic terrestrial plant species within the Wet Tropics bioregion according to a number of risk criteria that included existing species posing major management problems as well as the plants' habitat and life form. Informal functional groups and examples found in the powerline corridors comprised:

a) Herbaceous, shrubby plants that invade relatively slowly but that may dominate or replace the natural herb/shrub layer of more open communities (e.g. *Stachytarpheta*, *Hyptis* spp.);
b) Graminoids and herbaceous species that spread rapidly or more extensively, thereby replacing the herb layer with a monospecific stand and seriously inhibiting recruitment of

tree and shrub layers (e.g. *Panicum maximum, Melinis minutiflora* and other introduced pasture grasses), also promoting highly modified fire regimes;

c) Scramblers and climbers that have spread widely and become integrated into natural communities (e.g. *Passiflora* spp.,*)* that exert at least intermittent competition and can form dense mats to adversely affect the growth of native species;

d) Shrubs and small trees that form dense stands preventing other herbaceous and woody growth (e.g. *Lantana camara, Rubus alceifolius)*;

e) Trees invading slowly forming 'sleeper weeds' in the early stages of invasion or being inconspicuous (e.g. *Mangifera indica)*;

f) Trees that spread rapidly by wind-borne or small animal (especially bird) dispersal that can form dense stands (e.g. *Solanum mauritianum);*

g) Miscellaneous species that have adverse interactions with native species

Of the fifty terrestrial weed species assessed by Werren (2001) in a trial weed risk assessment system, nine were found within the two powerline clearings examined in this study. Two of these, Guinea grass, *Panicum maximum*, and Para grass, *Brachiaria mutica*, were judged as forming part of the eleven-strong top risk cohort, that display extremely aggressive weedy tendencies within the Wet Tropics bioregion. They greatly impair ecosystem function and are considered 'transformer species' that change the character, condition, form or nature of a natural ecosystem over a substantial area (Richardson *et al*. 2000). Therefore the Palmerston powerline clearing, particularly at lower elevations, would be considered to have greatly impaired ecosystem function due to the presence of swathes of Guinea grass. It should be noted that molasses grass, *Melinis minutiflora*, was not one of the weeds assessed, but would be expected to fall within the same group.

Mango, *Mangifera indica*, was a species ranked in the second worst group (Werren 2001). Although not found in any of our transects, Mango trees were observed near Bridle Creek and may be expected to spread through the mediation of feral pigs and fruit bats that eat the fruit and drop the seeds later further afield. In the next group, two herbaceous species common in the Chalumbin-Woree network were found, Snakeweed, *Stachytarpheta* spp. and Praxelis, *Eupatorium catarium*. These are widespread species found in disturbed areas. A fourth group of species considered either of less serious environmental risk or less pervasive, include Knobweed, *Hyptis* spp., Navua sedge, *Cyperus aromaticus*, and Stinking Passionfruit, *Passiflora foetida.*

Lantana, *Lantana camara*, is considered a weed of national significance. It was not assessed in the trial weed risk assessment system undertaken by Werren (2001), but would be expected to rate very highly due to its potential to alter substantial areas and impair ecosystem function. Again the Palmerston clearing harbours major infestations of this weed, whilst the Chalumbin-Woree clearing is less affected but still has relatively large areas where lantana dominates.

'Sleeper weeds' are those invasive plants that have naturalised in a region but have not yet increased their population size exponentially (Groves 1999). While not currently considered a problem, they may be in the early phases of an explosive invasion (Werren 2001). Species listed by Space (2001) as invasive in Pacific Island ecosystems may also constitute 'sleeper weeds'. Those found in the two powerline and road networks include Cobbler's pegs, *Bidens pilosa*, Knobweed, *Hyptis capitata*, *Hyptis suaveolens*, Siratro, *Macroptilium atropurpureum*, Red Natal grass, *Melinis repens*, Sensitive weed, *Mimosa pudica*, Paspalum, *Paspalum conjugatum, Paspalum paniculatum,* Edible Passionfruit, *Passiflora edulis*, Stinking Passionfruit, *Passiflora foetida*, Giant Bramble, *Rubus alceifolius*, Tobacco Bush, *Solanum mauritianum*, Thorn Apple, *Solanum torvum* and Urena Burr, *Urena lobata.*

The weeds of the powerline and road networks assessed have a variety of characteristics that predispose them either to the formation of large infestations that alter the ecosystem and are self-perpetuating, or to form mixtures with other weeds and/or natives. Many may be 'sleeper weeds' that may have the potential to increase population size exponentially in the future. Several have the potential to colonise within the rainforest and the rainforest edge as well as the cleared areas.

1.5 CONCLUSION – ECOLOGICAL CONDITION OF POWERLINE AND ROAD NETWORKS

The differences in weed composition and ecological condition observed along both the Palmerston powerline clearing and road network and the Chalumbin-Woree powerline clearing and road network are linked to the substrate and topography of each powerline clearing and to past and present construction and maintenance procedures. Where topography is deeply incised with deep creeks and high crests, clearing for powerline construction was limited or avoided. In these areas the powerlines swing above the majority of the canopy, retaining connectivity of forests (either remnant or regrowth) below the line, and leaving only relatively small clearings around the towers to be infested by weeds. Such deeply-incised topography is found along the escarpments crossed by both of the powerline clearings, in particular where granites and metamorphic substrates occur. This has resulted in excellent connectivity where clearing did not occur and relatively good connectivity where regrowth has occurred. Where the topography is relatively flat, swathe clearing was used for construction and these areas are generally in poor condition.

Burning of the lower sections of the Palmerston powerline clearing encouraged self-perpetuating grassy swathes that currently, in the absence of fire, are partially being overtaken by woody weeds. Where restoration works have been undertaken, rainforest species establish quickly to form a weed-excluding tree canopy. Further restoration works centred on gullies in large weedy swathes should continue to subdivide the weed areas and encourage adjacent natural regeneration. The advantage of these restoration works is that they aim to allow faunal movements, reduce linear barrier effects and reduce the movements of alien species along the weedy swathes of the clearing. In certain areas where fires have been excluded in recent times, rainforest species, including *Cardwellia sublimis* as well as other rainforest pioneers have been able to colonise the clearing. This is particularly true of gully areas. However, this recolonisation in gullies is limited by the degree of infestation of lantana and bramble already present. Encouragement of such natural regeneration may be improved by woody weed control.

The dominance of grass and woody weeds along the lower Palmerston clearing has caused the ecological condition of that section of the World Heritage Area to be identified as the worst of all areas assessed in this study. Areas of the Palmerston road network that have not been subject to weed control are similarly infested with swathes of grass and herbaceous weeds. In contrast, where weed control has been undertaken, the emphasis has shifted from swathes of grass to herbaceous weeds and natives. This situation causes a great improvement in ecological condition, reducing linear barrier effects for fauna and greatly improving presentation values for tourists. Encouraging canopy connections above the road would maintain this improvement without the need for herbicide controls. Until this canopy closure can be achieved, continuation of the weed control measures in areas where weeds are presently reduced and extension of those measures into those areas where control has not yet been undertaken, is considered a high priority.

Grazing along the western sections of the Chalumbin-Woree powerline corridor has encouraged a self-perpetuating weedy swathe. Although cattle are not currently in evidence, weeds remain diverse. Some regrowth species are beginning to colonise, and areas of native grasses including *Themeda triandra* and *Imperata cylindrica* occur, however swathes of blue snakeweed, lantana, molasses grass, signal grass, paspalum, bluetop and mixed herbaceous weeds are dominant. Areas of restoration revegetation may help to subdivide these areas and increase recolonisation by native species. Weed control similar to that undertaken in the Palmerston road network may also encourage the recolonisation of native species but would require maintenance to prevent weed swathe re-establishment.

Areas of the Chalumbin-Woree powerline clearing in the vicinity of the Lake Morris Road vary from good condition, where the powerline swings above the canopy between crests of hills, through to large areas dominanted by weeds. However, native ferns, sedges and pioneers have established in many areas and weed control of areas of grass, lantana and bramble may encourage expansion of these low swathes of native species. These low native swathes appear ideal in reducing many of the impacts of linear infrastructure, whilst not impinging on safety aspects for the power distributors.

1.6 RECOMMENDATIONS

Similar examination of other powerline clearings and road networks within the WTWHA, including the Creb Track and powerline clearing, Mt Lewis Road, Rex Range and powerline clearing, Kuranda Range Road, Black Mountain Road and the Gillies Highway is recommended. The ecological condition of southern linear infrastructure such as the Paluma Road, Bluewater Road, Kirrama Road and Tully Falls Road and the associated powerline clearings is relatively unknown.

1.7 MANAGEMENT IMPLICATIONS

- Areas of powerline clearing that were totally cleared and then subjected to fire or grazing for maintenance purposes remain the areas in worst ecological condition.
- Exclusion of fire from the Palmerston powerline network has allowed some expansion of natural regeneration, but in many areas the absence of fire has allowed the expansion of woody weeds which now require control and possibly restoration work to prevent their establishment at the top of a weed succession within the clearing.
- Weed control along the Palmerston road network undertaken by EPA South Johnstone has been extremely successful in improving the ecological condition of the area and reducing the impacts of weeds but does require continued maintenance over several years whilst canopy connectivity is established.
- The removal of trees and branches from above unsealed roads should be avoided as this decreases canopy connectivity. Increased connectivity is necessary for reducing weed infestations and thus the requirement for herbicide control.
- Removal of the new weed species, *Arundina bambusaefolia*, which was found along the South Johnstone road network, should be undertaken as soon as possible, as elimination of this weed is currently achievable.
- Encouragement of the extension of swathes of low native species to replace weedy swathes using selective weed control along the Chalumbin-Woree powerline corridor, particularly at higher elevations, and along the Lake Morris Road, should result in excellent gains in ecological condition whilst retaining safety aspects crucial to the power distributors.
- Grazing should be excluded from powerline clearings due to the potential of livestock to spread weeds and contribute to maintenance of weed fields.
- Species of ferns, tree ferns, sedges and low shrubs have been suggested as alternatives to exotic grasses for stabilisation of road banks.

- Ensure that future clearing of swathes is totally rejected. When powerline are swung above the canopy on high towers with natural vegetation clearing restricted to tower footprints only, the impacts of new powerlines or powerline upgrades on weed establishment will be reduced
- Although parts of the Palmerston powerline clearing are currently in poor ecological condition, restoration work across the clearing, such as that undertaken by the Centre for Tropical Restoration, and extension of the natural regeneration in gullies is improving this situation gradually. Further restoration works could speed this recovery. As this is an area of high biological diversity, vegetation complexity and the habitat of many species of rare and threatened fauna and flora, it is considered a high priority for restoration. Removal of the powerline infrastructure will aid in the recovery by allowing further restoration works as well as the natural regeneration to proceed without concerns for safety.
- Weed control and restoration work, together with the exclusion of livestock, is required in the western sections of the Chalumbin-Woree powerline and road network, to improve the ecological condition of the area.

2. POTENTIAL OF REMOTE SENSING IN THE MONITORING OF WEED INFESTATIONS ALONG POWERLINE CORRIDORS

Craig Harriss and David Gillieson

2.1 SUMMARY

The Chalumbin-Woree powerline corridor was examined in detail at seven locations. Percentage vegetation cover was measured and spectral reflectance data of weed species was collected in the field using a “Cropscan” Multispectral Radiometer. Imagery of the powerline corridor was acquired at two different spatial scales. One source was Ikonos multispectral satellite at four-metre resolution and the other was from an Airborne Data Acquisition and Registration (ADAR) system at approximately one metre ground resolution. This study examined the general criteria needed for quantitative ground measurements of reflectance to be used in classifying the spectral differences of weed species. The specific focus was the determination of the spatial, spectral and radiometric resolution required to detect the fractional quantity of each weed species at the sub-pixel level using "Spectral Mixture Analysis" (SMA).

Field measurements of the percent cover of weed species showed that within each square metre, one to three main species were present suggesting that SMA was a viable technique for determining the quantity of weed fractions in imagery at one metre spatial resolution. Signatures were made from the spectral reflectance measurements and found to be statistically separable.

To relate field spectral responses to the imagery an empirical calibration was employed, avoiding complex atmospheric corrections. However difficulty was experienced with calibration of the ADAR imagery due to an inherent interpolation algorithm in the camera's output.

The Spectral Mixture Analysis was found to be unsuitable as a classifier of the ADAR imagery because of poor camera performance. The spatial resolution of the Ikonos imagery was unsuitable for SMA, as there are only four spectral bands to unmix the contents of each 4 metre x 4 metre area on the ground.

There is definite potential to discriminate individual weed species using their spectral signatures. However, vegetation reflectance patterns are broad and the variability within a species is much higher than apparent differences between species. An image classifier that considers the variance in vegetation reflectance is required, together with a sensor with the spectral and radiometric qualities of the Ikonos satellite imagery but with the higher spatial resolution of an airborne camera ($1m^2$). Either a four camera airborne system giving a spatial resolution of $1m^2$ or a 4-band multispectral satellite sensor with two metre resolution (available 2005) can be expected to be far more successful than the imagery examined in this study.

2.2 INTRODUCTION

In the wet tropical zone of Queensland, the World Heritage Convention has protected much of the publicly owned tropical rainforest from logging and clearing, but other more insidious threats remain. Roads and electricity supply corridors create linear barriers through natural areas, fragmenting the WTWHA. Weed invasions along these corridors (see Section 1) contribute to fragmentation effects by competition with native species (shading, allelopathy), and inducing disturbances such as fire, edge effects (see Section 3) or the influx of generalist species. Thus, infrastructure corridors and invasive pest species have been identified as priority areas of research effort in the Wet Tropics World Heritage Area (WTMA 2000).

In addition to the significant threats posed by fragmentation, several invasive weed species, which are in the higher categories of significance for Weeds of the Wet Tropics Bio-region (Werren 2001), occur in the linear infrastructure corridors that traverse the World Heritage Area. WTMA (1999) identified a need to develop less field-intensive methods for the detection of invasions of new weed species, and to predict expansion of existing weed problems. Good information on the density and location of weeds is essential to monitor the effectiveness of control programs and management strategies (Lamb 2000). Ground surveys over large areas are labour intensive, costly and in the WTWHA, difficult to undertake during wet seasons. Remote sensing has the potential to provide a practical and cost-effective monitoring tool both for threats such as weed incursion or for the success of rehabilitation. It could give timely, up-to-date information on the distribution and abundance of weeds over wide areas, especially where seasonally wet roads prevent continuous access to some locations. Remote sensing has the capability to discern small patches at a local scale of square metres as well as surveying on broad scales of square kilometres. The ability of a Geographic Information System (GIS) to integrate remote sensing data also allows development of predictive modelling. Such a powerful tool could assist in monitoring the spread of an aggressive weed such as Pond apple (*Annona glabra*), and in design of control strategies.

2.3 POTENTIAL OF REMOTE SENSING AS A MONITORING TOOL FOR WEEDS – LITERATURE REVIEW

2.3.1 Introduction

Limited use and development of remote sensing in rainforest environments has occurred in Australia (Phinn *et al.* 2000). One reason for this could be due to the fact that rainforests are located in mountainous areas with rugged topography and frequent cloudy weather. Much of the groundwork in developing remote sensing as a useful tool has occurred in comparatively flat areas of temperate or semi-arid regions with consistently clear skies (Schetselaar and Rencz 1997; Hindle 1998; Lewis *et al.* 2000). Most quantitative work on plant material has been for agricultural crops that predominantly have uniform low canopies (McNairn *et al.* 2001; Nutter *et al.* 2001).

One difficulty, which is exacerbated by mountain environments, is relating one remotely sensed image to another image captured at a different time. An essential requirement of this is an adjustment of the levels of light recorded in each image, to a standard surface of known reflectance (calibration), while at the same time, accounting for all the variations in light levels arising from seasonal, view angle and atmospheric differences. The calibration of an image can be a difficult and complex task but can be avoided if one limits analysis to just spatial changes, rather than subtle spectral changes (Adams *et al.* 1995). Thus, remote sensing has been used for monitoring land clearing, but less frequently applied to detecting small changes in forest type.

2.3.2 Using Remotely-Sensed Imagery to Determine Canopy Composition

Satellite imagery is widely used to map broad vegetation or land use classes. However the highly complex mix of canopy types in rainforests presents difficulties when standard classification techniques are used on coarse resolution. To overcome similar problems in other environments, sub-pixel component analysis has been used with varying success for tasks such as arid-zone vegetation mapping (Lewis 1998) and agricultural weeds surveys

(Chewings *et al.* 2000, Hindle 1998). It shows promise for the mapping of forests in Australia (Dibley *et al.* 1998), and in recognition of its growing importance, several new versions of GIS packages have included modules for this new technique (often called "Linear Unmixing").

2.3.3 Spectral Component Analysis

Spectral component analysis is suited to the situation where the resolution of an image (e.g. a Landsat scene with a ground resolution of 25 metres) is larger than the size of the features of interest e.g. a patch of weeds.

Spectral component analysis can determine the proportions of each cover type or canopy species in each pixel, but only after three requirements are met:

1. Determination of the spectral reflectance characteristics of the canopy species occurring in each pixel;
2. Calibrated imagery; and
3. Imagery that has an equal or greater number of bands of information than the number of distinct canopy types occurring in each pixel.

The last requirement can be met by reducing the size of the ground resolution element (pixel) so that fewer species are present within it or by obtaining a larger number of bands in the imagery (the rationale behind hyperspectral imagery).

2.3.4 Measurements of Spectral Reflectance of Species

Spectral reflectance characteristics of individual species can be measured in the field with a hand held radiometer. Sampling the reflectance of plants *in situ* takes into account the reflectance of other components such as shade and bark, just as occurs in remotely sensed imagery. The spectral signal received by a sensor (whether it is near the canopy or above the atmosphere) is a mix of different components like leaves, flowers, stems, understorey, and is affected by shadow within the canopy (Dury *et al.* 2000). For instance, short grass has less shade within its canopy than thick long grass which, in turn, has less than a rainforest. Skidmore and Schmidt (1998) suggest that canopy structure and soil background are two criteria that can alter reflectance.

Remote sensing systems are designed to sample these spectral responses of Earth surfaces in several bands, so that enough information is obtained to distinguish one kind of surface from another (Richards 1993). Common Earth surfaces such as leaves, soil, water, rock, bark and pavements all reflect different parts of the spectrum differently. The reflectance of a surface can be expressed as a ratio or a percentage of the quantity of light incident on that surface. A graph can represent the reflectivity response of a surface by showing percentage of incident light reflected at different wavelengths, as in Figure 2.1.

The reflective properties of minerals and vegetation have been studied in depth. Leaves are interesting in that the reflective properties change with the loss of moisture and variation in pigments such as chlorophyll. Chlorophyll (a) and (b) are important in photosynthesis, they absorb light at particular wavelengths in the red and blue regions of the spectrum (Curran 1985). This selective absorption gives leaves their green colour because comparatively more green light is reflected, as shown in Figure 2.2. Green leaves vary in the thickness of their composite layers leading to further variation in the quantity of light absorbed, transmitted and reflected. The cell walls and numerous air spaces in the mesophyll of a moist green leaf (Curran 1985) are responsible for the high reflectivity in the Near Infra Red (NIR) region of the spectrum (at wavelengths greater than 700nm), which is invisible to the human eye. Dry leaves have lost their moisture and thus the structure responsible for the high NIR reflectivity of green leaves. The NIR end of the spectrum therefore makes a useful diagnostic feature in remotely sensed imagery for maturation or drying out of vegetation.

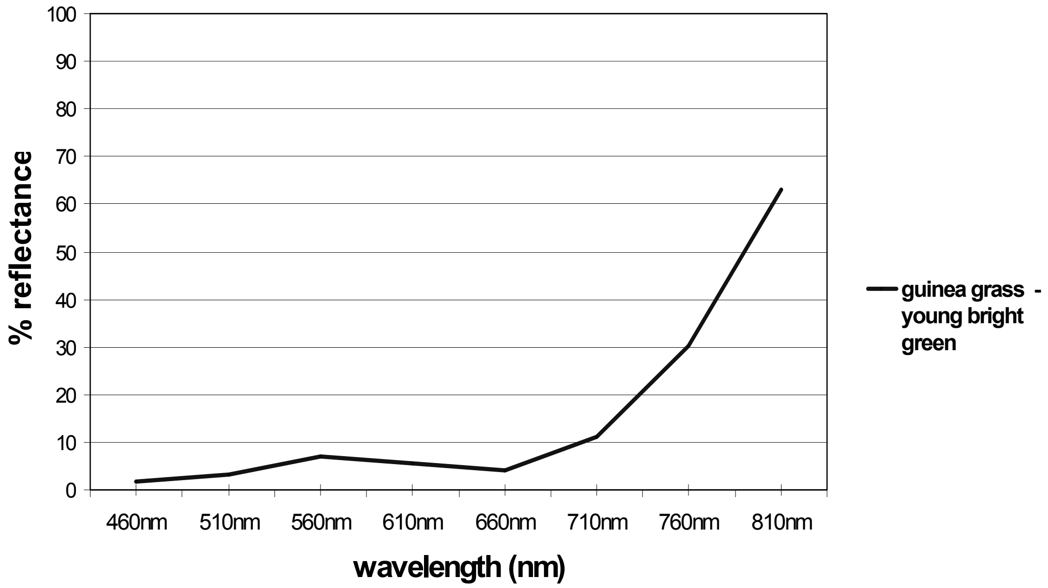


Figure 2.1: An example of typical reflectance of green vegetation, Guinea Grass (*Panicum maximum*).

Finding a way to discriminate plants, or in this case weeds, by their spectral reflectivity response requires dealing with three main issues:

1) Genuine differences between species in their spectral reflectivity response;
2) Genuine variation within a species in its spectral response; and
3) Uncertainty due to the external condition at the time of sampling such as lighting or variation in sampling methodology

Point (1) is a straightforward problem and, given a fine enough resolution, is considered statistically solvable. Several studies have investigated different features of plant spectral response to find the best diagnostic method of differentiating between species. Some of the relevant findings in the literature are summarised below.

Asner and Lobell (2000) suggest that features of plant spectra that are least variable within species but distinct between species are the most desirable for discrimination between plant spectral signatures. Skidmore and Schmidt (1998) found that for eight species of grass there were more pairs of significantly different reflectances in the red region at 650nm (550-680nm) and NIR region at 1300nm than at 800nm in NIR region. Differences were found in the NIR (800 nm) but were not statistically significant because of the greater variances in this region.

Kumar and Skidmore (1998) compared reflectance spectra of ten *Eucalyptus* species in the field. While some species could be differentiated easily over a wide range of wavelengths, others showed differences only at certain positions, and others showed no differences at all. Reflectance values at 550nm, 630nm, 800nm and red edge features seem to be the best locations for discrimination of eucalypts. Nutter *et al.* (2001) also used field methods to correlate soyabean yield and nematode infestation using "Cropscan" reflectance, airphoto images and satellite images (Landsat 7). Percentage reflectance at 810nm had the best relationship with nematode infestation explaining fifty-two percent of the variation in population densities.

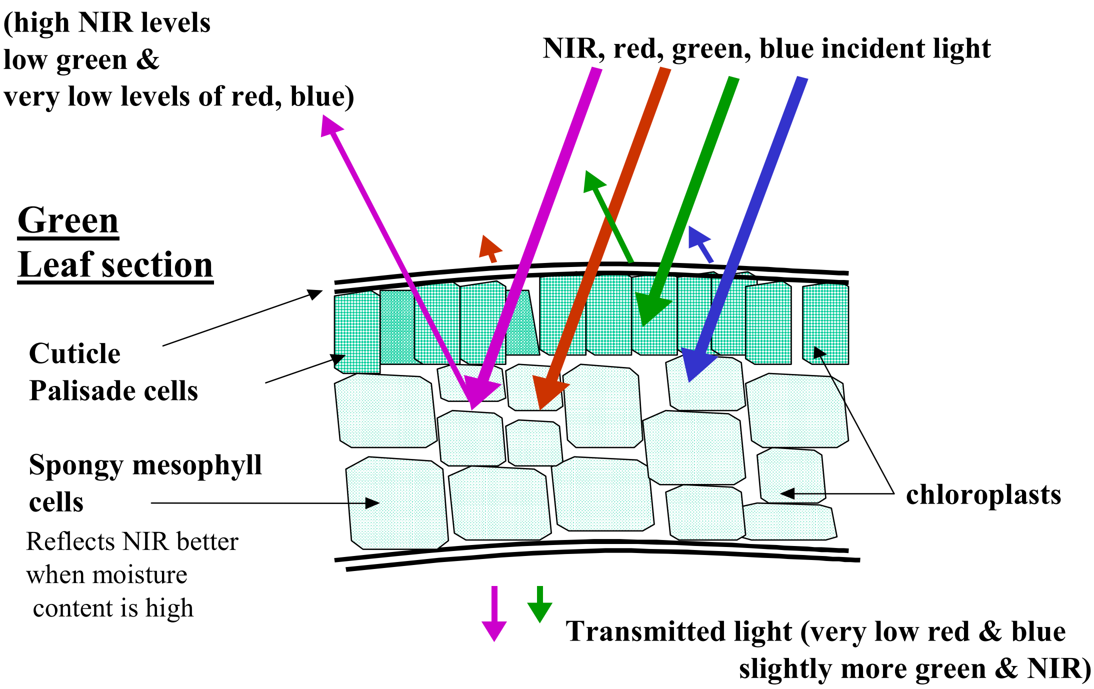


Figure 2.2: Leaf section showing interaction of visible and near infrared light.

The position of the steep rise in reflectance of green leaves in the NIR region is known as the "red edge position". Curran *et al.* (1998) and Datt (2000) found that the position of this 'red edge' correlated with the chlorophyll and carotenoid content of leaves.

Farrand *et al.* (1994) suggest that "apparent" reflectance is dependent not only on the mixture and the composition of surface materials but also on the physical condition of the surface and its orientation to the sun (point c above). Thus while low reflectance may be due to the low reflectance of a surface, it also may be affected by poor orientation or lighting (i.e. shade). Sun angle, sensor angle, topography, aspect and leaf angle (and the change in its orientation during the course of a day) interact in complex geometric ways. All of these factors can influence the amount of shade the sensor "sees" (Curran 1985).

McGowen (1998) highlights how environmental and seasonal variation in weed species can cause their spectral signatures to vary over time (*i.e.* point 2 above). Environmental variation such as in soil moisture status or poor drainage may affect the density of plants and alter the purity of their spectral reflectance. Seasonal differences, such as distinct colouring of flower heads (e.g. molasses grass, *Melinis minutiflora*), may be useful in discriminating a weed from its surrounding vegetation and soil spectra. However, these differences may also be a confounding factor in the Wet Tropics area because altitudinal and climatic gradients affect the timing of events such as flowering and seed set. It may therefore be useful to represent a species by 2, 3 or 4 different signatures (or a mixture of these), which represent distinct stages of growth.

2.3.5 Calibrating an Image

A simple, robust calibration technique that corrects for atmospheric absorption and scatter, called the "empirical line method," has been used successfully in many studies (Roberts *et al.* 1993; Farrand *et al.* 1994; Adams *et al.* 1995; Lewis 1998; Edirisinghe *et al.* 1999 and Sabol *et al.* 2002). It uses a linear regression between field spectral data and the image spectral values to define the relationship between them for each band.

2.3.6 Spectral Component Analysis of the Image

Spectral mixture analysis is a way of identifying which cover classes are present in a pixel and estimating their relative contribution to the mixed pixel (Settle and Drake 1993; Adams *et al.* 1995). The unmixing algorithm is mathematically simple, assuming an additive combination of the spectra of the cover classes.

With an equation for each band of imagery, fractions can be solved simultaneously for up to as many classes as there are bands of imagery. Thus to find the fractions of a large number of signatures, a large number of spectral bands are needed, e.g. Landsat TM covers seven bands. Thus, proportions of up to seven signatures (ideally, seven species) can be "unmixed". Hyperspectral imagery, which covers 128 to 212 bands, has been used in many studies for spectral mixture analysis (eg, Anstee *et al.* 2000; Chewings *et al.*, 2000; Hermann *et al.* 2000; Lewis *et al.* 2000).

The pixel "unmixing" algorithm examines every pixel for the best combination of signatures. It produces a map for each signature showing its proportion in each pixel. From these maps it is theoretically possible to calculate a quantitative measure of the total area occupied by each signature or ground cover type.

From this review of the literature it seems that if spectral component analysis could be successfully applied, two aspects of remotely sensed weed surveys could be addressed simultaneously:

1. The difficulty of obtaining fine scale imagery with high enough resolution to detect individual clumps of a weed species; and
2. A quantitative measure of the proportion of each species could be made with greater accuracy than with standard classifiers.

2.4 RESEARCH QUESTIONS

The research questions investigated in this study are:

1. Can multi-spectral satellite or airborne imagery discriminate individual weed species and if so what spatial resolution is needed?
2. Is it possible to determine the fractional quantity of each weed species at the sub-pixel level using "Spectral Mixture Analysis", and if so what conditions are best for doing this?
3. Which sensor is likely to provide the best overall result for the WTWHA?

2.5 METHODS

2.5.1 Study Sites

The focus of this study is seven sites surrounding towers in the Chalumbin-Woree powerline corridor. The corridor passes through World Heritage listed rainforest, from Bridle Creek (near Davies Creek), to Woree, a suburb of Cairns. Figure 2.3 shows a colour satellite image of the study area. Percentage cover was measured and spectral reflectance data of weed species was collected using a hand-held radiometer. Imagery of the powerline corridor was acquired at two different spatial scales. One source was Ikonos multispectral satellite at four metre resolution and the other was from an Airborne Data Acquisition and Registration (ADAR), system at approximately one metre ground resolution (Figure 2.4).

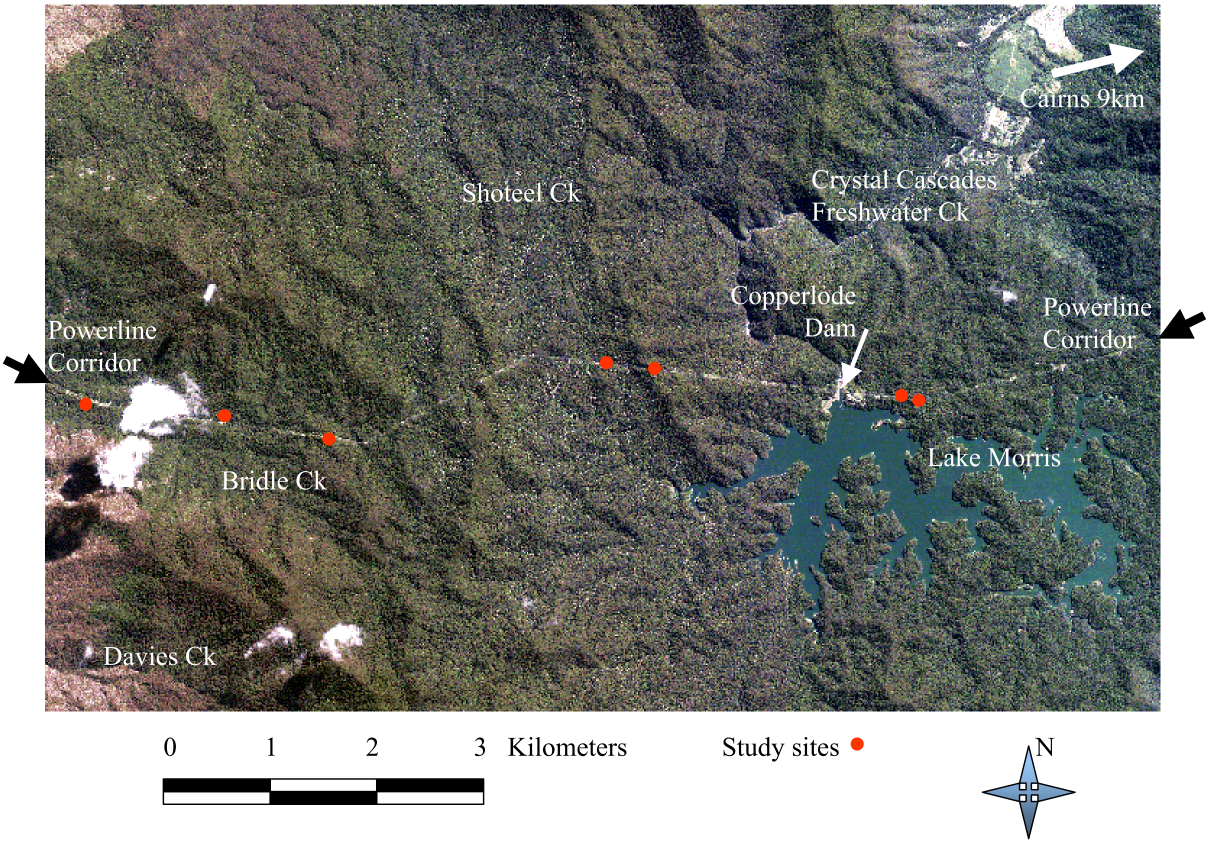


Figure 2.3: Ikonos satellite image of the study area showing the powerline towers within the study sites as red dots.

2.5.2 Floristic Survey Methods

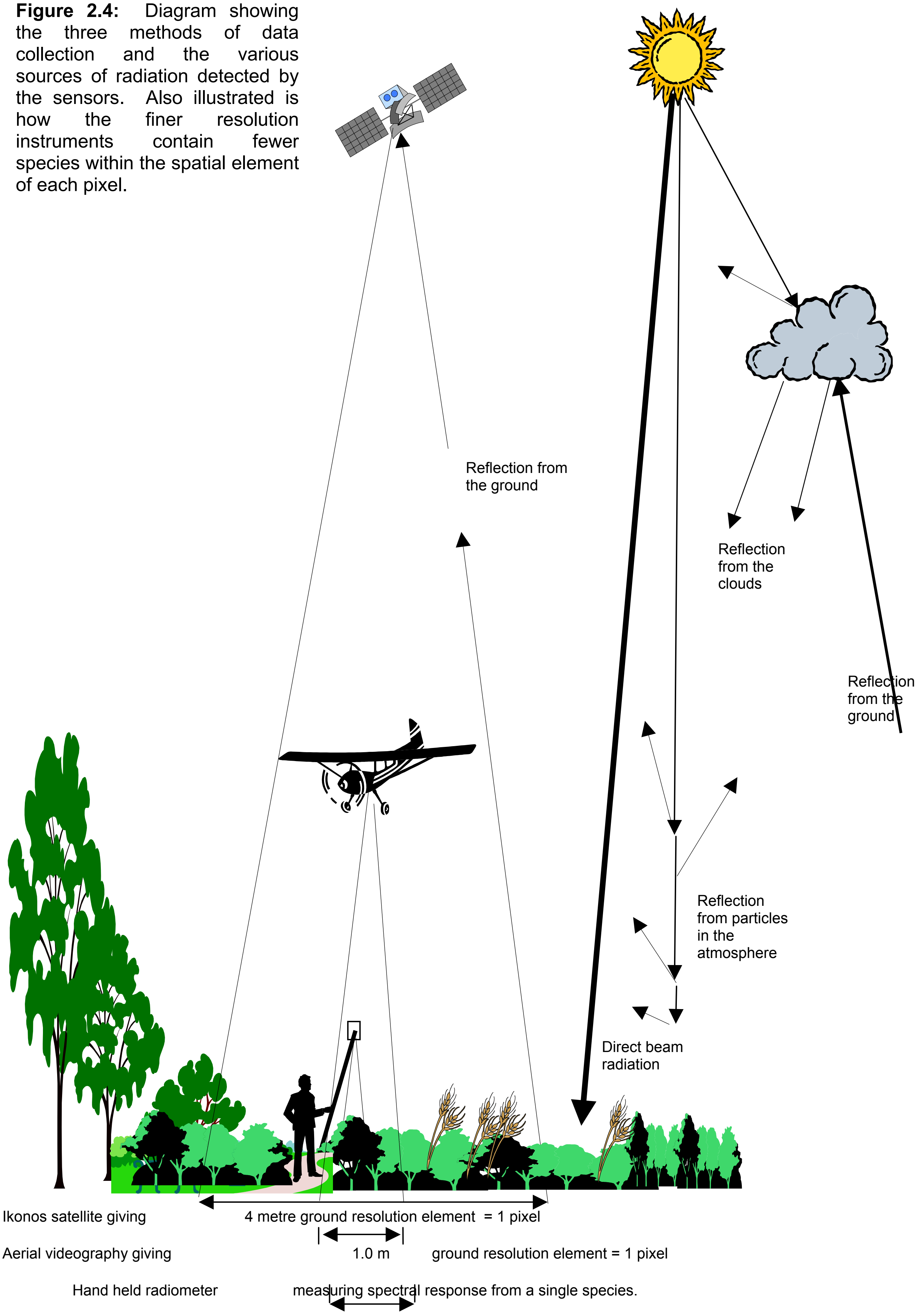
Three sets of field data were collected:

1. Weed and rainforest species present at each site
2. Percentage cover by weed and rainforest species
3. Spectral reflectance recordings of weed species.

Transects

Mr. Robert Jago, a well-respected botanist with many years experience in the Wet Tropics, was employed to identify all plants at each site. Along a sixty metre transect at each site all plants located within five metres each side of the line were identified.

Figure 2.4: Diagram showing the three methods of data collection and the various sources of radiation detected by the sensors. Also illustrated is how the finer resolution instruments contain fewer species within the spatial element of each pixel.



Percentage Cover

Species composition was estimated in several relatively homogeneous areas of the sites. This was used to assess the accuracy of the species identification in the classification of the satellite and airborne imagery (ground truthing). The sites were divided into two or three relatively homogeneous areas assumed to be large enough to be visible from the air. In each area, three to five quadrats, each one square metre, were examined visually for species content. Assessment was based on the percentage of leaf area of each species.

2.5.3 Field Reflectance Measurements

Spectral reflectivity measurements were collected in the field with a hand-held radiometer ("Cropscan" Multispectral Radiometer) and analysed to develop spectral classes to be identified in the imagery. The sensor measures the level of radiation from above and below simultaneously in eight discrete, narrow bandwidths (Figure 2.5).

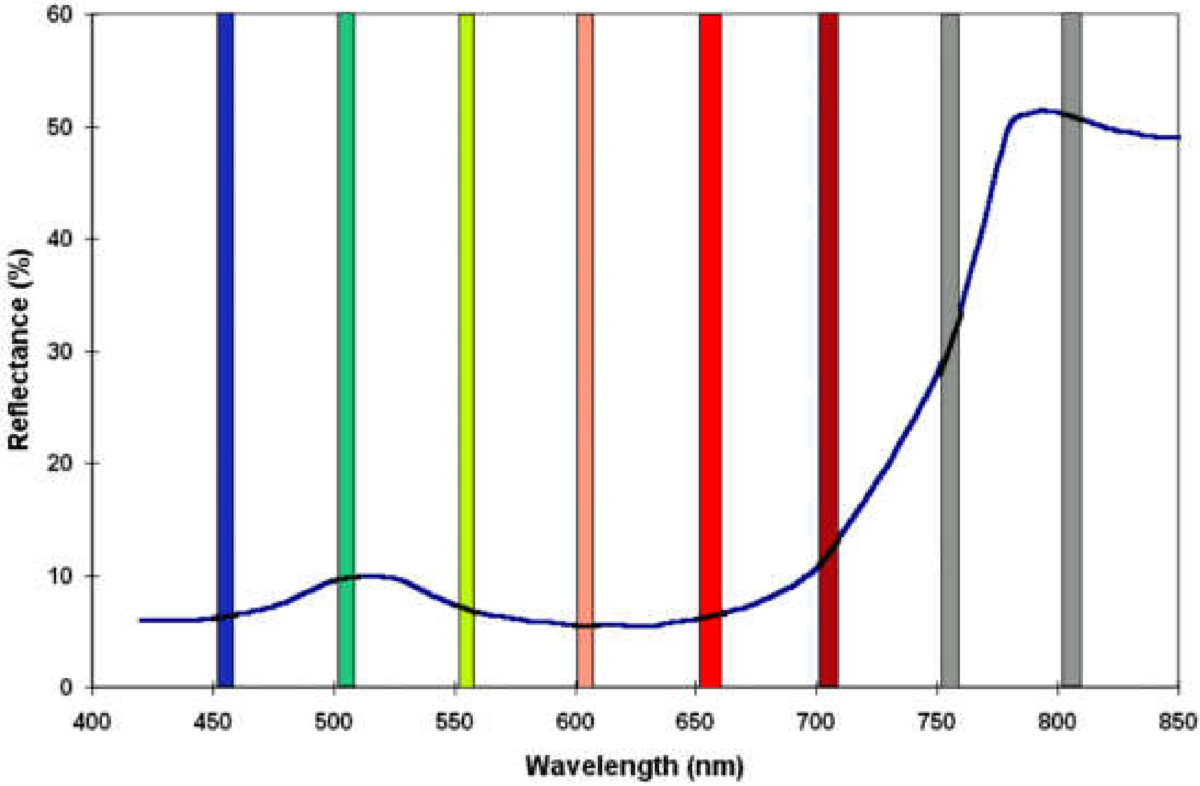


Figure 2.5: "Cropscan" Multi-Spectral Radiometer band positions showing also a typical reflectance curve of green vegetation. Source Cropscan MSR at (http://www.cropscan.com).

2.5.4 Data Analysis

Percentage reflectance for each sample was graphed to gain a visual appreciation of variability of the reflectance curves of different species. Each species showed a wide variation in reflectance that, in most cases, appeared larger than the apparent differences between species. The data was entered into a GIS to organise it into groups of spectral classes (using a cluster analysis). The classes obtained were further subdivided into groups containing samples of a single species. The validity of these groups as distinct spectral classes was tested statistically using discriminant analysis and further refined. "Signatures" for classifying the imagery were made from the resultant spectral classes. The signatures were tested for their separability using a divergence indicator. Both the ADAR and the Ikonos imagery were calibrated and classified using the signatures described.

2.6 RESULTS

2.6.1 Species Present in Transects

Weed species recorded on the transects are compiled in Appendix 1.1. There were two hundred and twenty-seven species identified within the ten metre wide quadrats along the thirty metre transects, but most of these occurred in small numbers. A number of rainforest pioneer tree species were present as well as many shrubs, herbs, ferns and vines. There were forty-four weed species identified and six out of seven sites had one or more weeds as the dominant class of vegetation (Table 2.1).

Table 2.1: Summary of dominant or common weeds found adjacent to transects at sites on Chalumbin-Woree powerline corridor. Weeds were not dominant near the transect at Tower 10108.

Weed Species	Site Tower No.						
	10091	10094	10096	10103	10104	10108	10109
Ageratum conyzoides	x		x	x			x
Axonopus compressus	x		x				x
Axonopus fissifolius					x		
Brachiaria decumbens		x	x	x			
Cyperus aromaticus							x
Hyptis capitata				x			
Lantana camara	x	x	x	x			
Melinis minutiflora	x	x	x	x	x		x
Mimosa pudica	x	x	x	x	x		x
Paspalum paniculatum	x		x	x	x		x
Rubus alceifolius				x	x		
Sporobolus jacquemontii			x		x		x
Stachytarpheta jamaicensis	x	x	x	x	x		x

2.6.2 Percentage Cover Measurements

Despite the large number of species found in the powerline corridors, within the area represented by one pixel in the ADAR imagery (1.0 m^2) there were typically one to three dominant species and generally no more than five species per pixel. No quadrat had more than four species with greater than five percent cover. Therefore the capacity of spectral unmixing techniques to examine the proportion of a weed species in a mixed pixel is not exceeded for three bands of imagery at one metre resolution (i.e. the resolution of the ADAR imagery).

2.6.3 Spectral Reflectivity

The unsupervised classification procedure in IDRISI produced twenty-eight groups of spectral classes from a total of nine hundren and thirty samples. Thirteen groups contained more than four samples of weeds, and the larger groups contained a number of different species. Figure 2.6 provides the mean spectral reflectance curve of the largest twelve groups and Table 2.2 lists the majority of the species in each group.

Signature Clusters

Signatures for each group were created that conformed to the bands used in the ADAR and Ikonos imagery. After creating signatures the separability of every pair was tested with a divergence score. A score of two thousand indicates complete signature separability (obtained in forty-seven percent of signature pairs) while a score between 1200 -1500 suggests separability is less likely, and a score less than one thousand suggests it is unlikely (Stow *et al.* 2000). The majority (seventy-seven percent) of signature pairs earned scores of 1900 or more, and are thus likely to be able to be separately identified when classifying an image.

2.6.4 ADAR Imagery Results

The focus of the study was to investigate the use of field reflectance measurements to classify remotely sensed imagery. The imagery came from an Airborne Data Acquisition and Registration system (ADAR) designed and manufactured by Positive Systems Inc. (http://www.possys.com). The basis of these images is a Kodak digital camera (DCS460) mounted on a small aeroplane and connected to ancillaries such as a controlling terminal, a GPS and a facility to store the digital images as they are captured. Imagery was supplied by the Biophysical Remote Sensing Group at the University of Queensland. The ADAR system is capable of producing high resolution images of the Earth's surface in colour or colour infra red (CIR).

The resolution can be 0.5 - 2.0 metre pixels, depending on the flying height. Each image is 3064 x 2040 pixels. The spectral response for CIR imagery is given in Figure 2.7; note the positions of each band. Instead of recording light levels in the blue region (~450nm) the sensor records the near infra red light, which is highly reflected by green vegetation. Figure 2.7 indicates that the spectral responses of each sensor overlap, allowing a broad range of wavelengths to reach each sensor. Compared to a satellite sensor, the bands of which are well separated in wavelength, the ADAR camera's reduced purity of signal decreases its sensitivity to fine spectral features. This does not matter to the human eye but fine spectral resolution is an important criterion for detecting subtle reflectance features (Anstee *et al.* 2000; Stow *et al.* 2000).

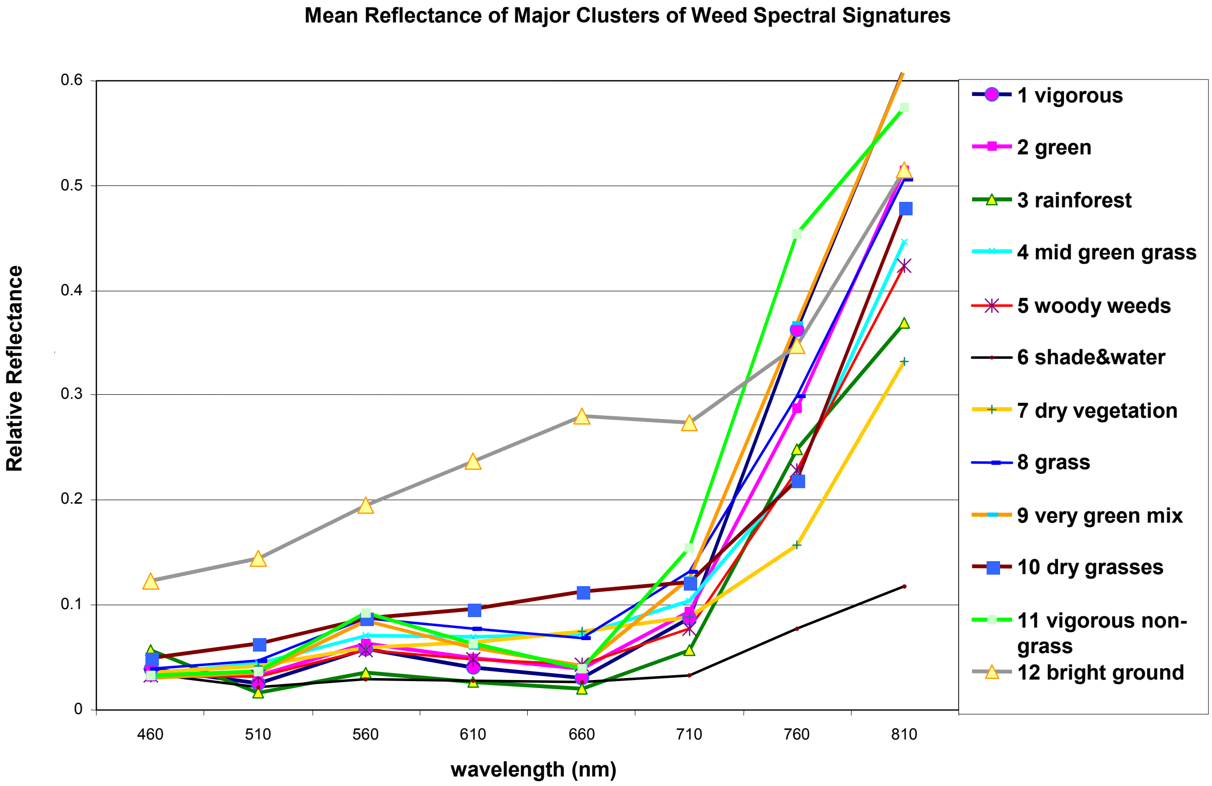


Figure 2.6: Mean reflectance of major spectral clusters of weeds

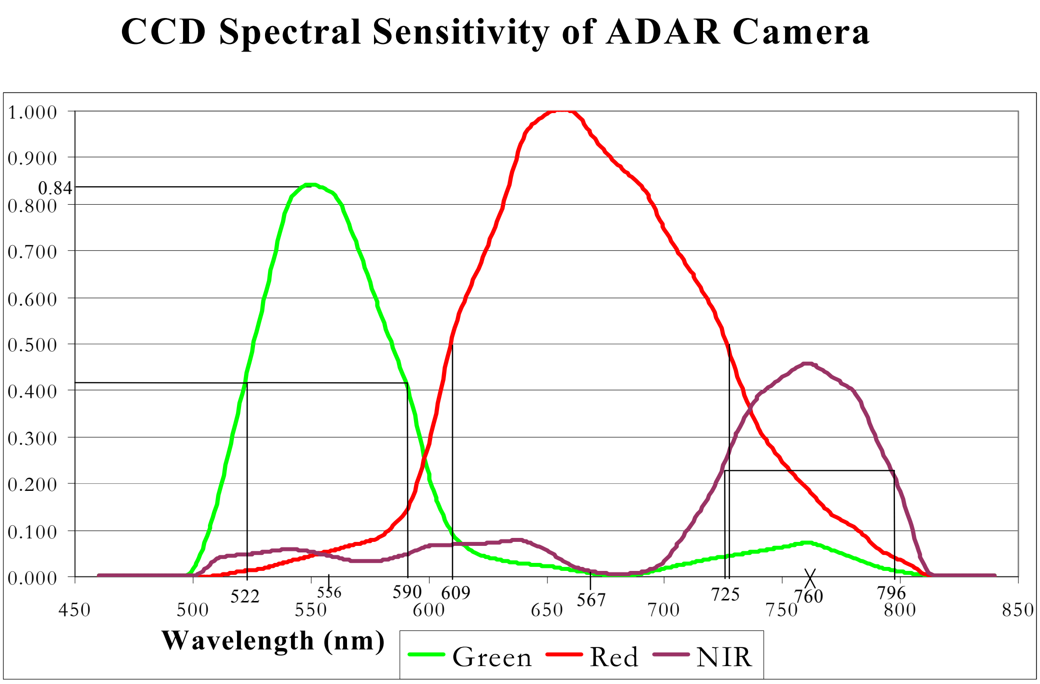


Figure 2.7: CCD spectral sensitivity of ADAR camera. Source: Phinn pers.comm.

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Table 2.2: Summarised species composition represented by each cluster.

Species/Surface Type	No. of samples	Species/Surface Type	No. of Samples	Species/Surface Type	No. of Samples	Species/Surface Type	No. of samples
Cluster 1 – Vigorous	**146**	**Cluster 3 – Rainforest**	**117**	**Cluster 7 – Dry vegetation**	**55**	**Cluster 10 – Dry grass**	**33**
Lantana	41	Rainforest	81	*Themeda triandra,*	10	Blady grass	9
Guinea grass	10	Lantana	22	Dry grass	7	Guinea grass – dry	6
Rainforest	9	Other - 9 types	14	Bare ground	6	Dry grass	4
Rubus spp.	9	**Cluster 4 – Mid-green grass**	**92**	Lycopodiella, mostly dry	6	Small bush	3
Singapore daisy	8	Molasses grass	20	Molasses grass, dry	6	Themeda, dry	3
Solanum spp.	8	Guinea grass	13	Blady grass	**5**	Bare ground	3
Commersonia (flowering)	6	*Lycopodiella cernua*	9	Gahnia sieberiana	4	Other - 3 types	5
Other – 18 types	55	Themeda *spp.*	8	Other - 6 types	11	**Cluster 11 – Vigorous non-grass**	**31**
Cluster 2 – Green	**141**	Dicranopteris -green	5	**Cluster 8 – Grass**	54	Rubus	8
Guinea grass	26	*Paspalum paniculatum*	5	*Paspalum paniculatum*	**13**	*Solanum* spp.	7
Molasses grass	10	Bracken fern	4	Guinea grass	11	Ageratum - no flower, green	4
Paspalum paniculatum	10	*Oplismenus* spp.	4	*Dicranopteris linearis*	8	Ginger,Large	3
Lantana – most flowering	9	Sedge	4	*Gahnia sieberiana*	5	Other - 6 types	9
Omalanthus	8	Other - 11 types	20	Other - 9 types	17	**Cluster 12 – Bare ground (1)**	**14**
Rainforest	8	**Cluster 5 – Woody weeds**	**85**	**Cluster 9 – Very green mix**	**53**	Bare ground/road	14
Ageratum, flowering	7	Guinea grass	25	*Dicranopteris linearis*	9	**Cluster 13 – Water/bitumen, dark surfaces**	**13**
Rubus spp.	7	Blue snakeweed	10	*Rubus* spp	9	**Cluster 14 – Bright Surfaces**	7
Acacia spp.	6	Lantana	10		7	Dicranopteris	5
Melastoma affine	6	Rainforest	5	Ageratum - full flower, no flower	4	Other - 2 types	**2**
Bracken fern	5	Other – 15 types	35	*Solanum* spp	4	**Cluster 15 – Dry Grass**	**6**
Dicranopteris linearis	5	**Cluster 6 – Shade/Water**	**59**	Other – 13 types	20	Dry grass – various	51
Other – 16 types	34	Water, river/dam	22			Bitumen	1
		Shade	19			Cluster 16, 17, 20, 21 – Bare ground	14
		Other – 7 types	18			**Cluster 22, 23, 24, 25 26, 27, Vegetation, various**	8

Calibration

The image (Figure 2.8) must be calibrated in order to use the signatures made from the field reflectance measurements of weed species. The calibration process expresses the imagery values in the same units or terms as the data from the hand held radiometer.

The reflectance measurements of specific locations within the image were regressed against the numerical value (digital number) of their corresponding pixels for each band. The resulting line of best fit was curvilinear and not the linear relationship defined in previous studies (Farrand *et al.* 1994; Edirisinghe *et al.* 1999). Therefore field reflectances were log-transformed to give a linear relationship to the values in the image (Harriss 2002).

Classification

An unsupervised classification indicates the maximum number of classes possible given the spectral space of the image. It does not use any field radiometer data to create these classes. As an example, using unsupervised classification for the site near Powerline Tower no.10103 (Figure 2.9), twenty-two spectral classes were found. However, there is likely to be difficulty in separating some signatures, eg, spectral cluster “2” has membership both on the road and in the forest.

A supervised classification technique using the radiometer field signatures to classify the calibrated image of the same site (Figure 2.10) showed an allocation of only seventeen out of the original sixty-eight classes. The areas of interest to this study, the road verge and the clearing around the tower, belonged to only two classes, shown in pink and blue-green. This suggests two possibilities:

(a) That the calibration of the image did not bring the pixel values, at those locations, within the ranges of most of the signatures; or

(b) That there was insufficient spectral differentiation in the image in those areas of interest.

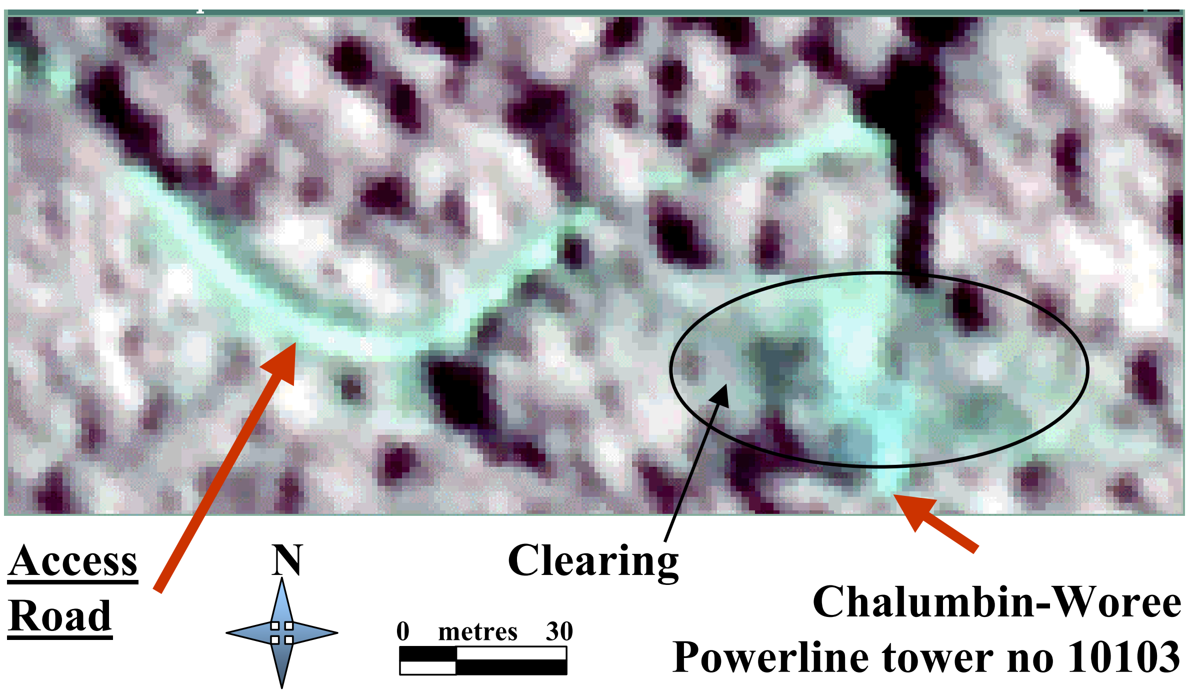


Figure 2.8: ADAR image showing one of the study sites on the Chalumbin-Woree powerline corridor near Powerline Tower no.10103.

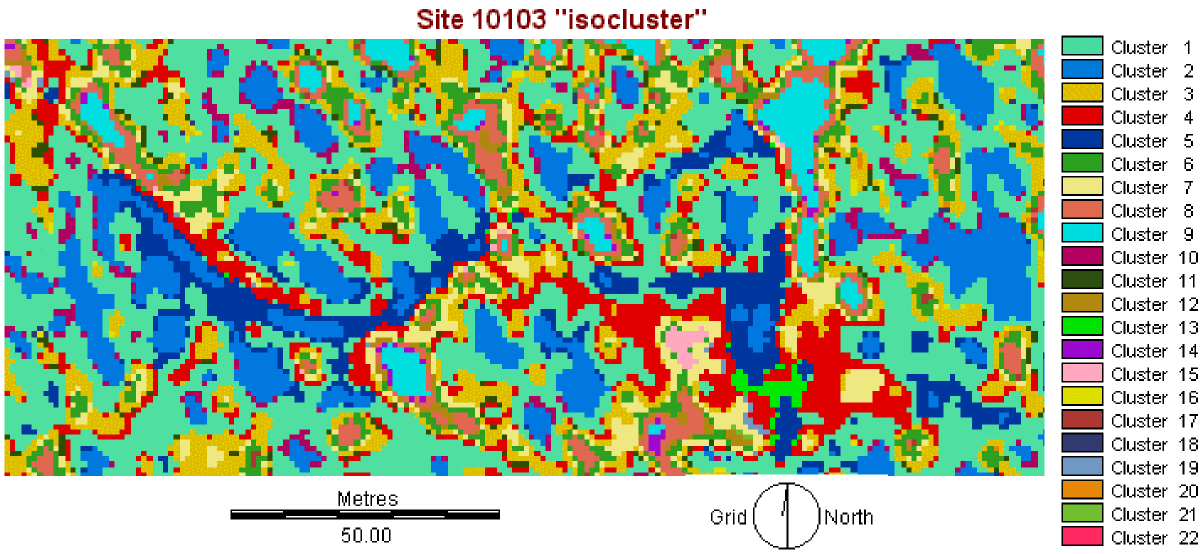


Figure 2.9: Unsupervised classification of the image around powerline tower No. 10103. The spectral class of shade is in light blue, while dark blue is situated on the road and part of the clearing. Red delineates the clearing and the road edge while bright green is possibly the legs of the tower.

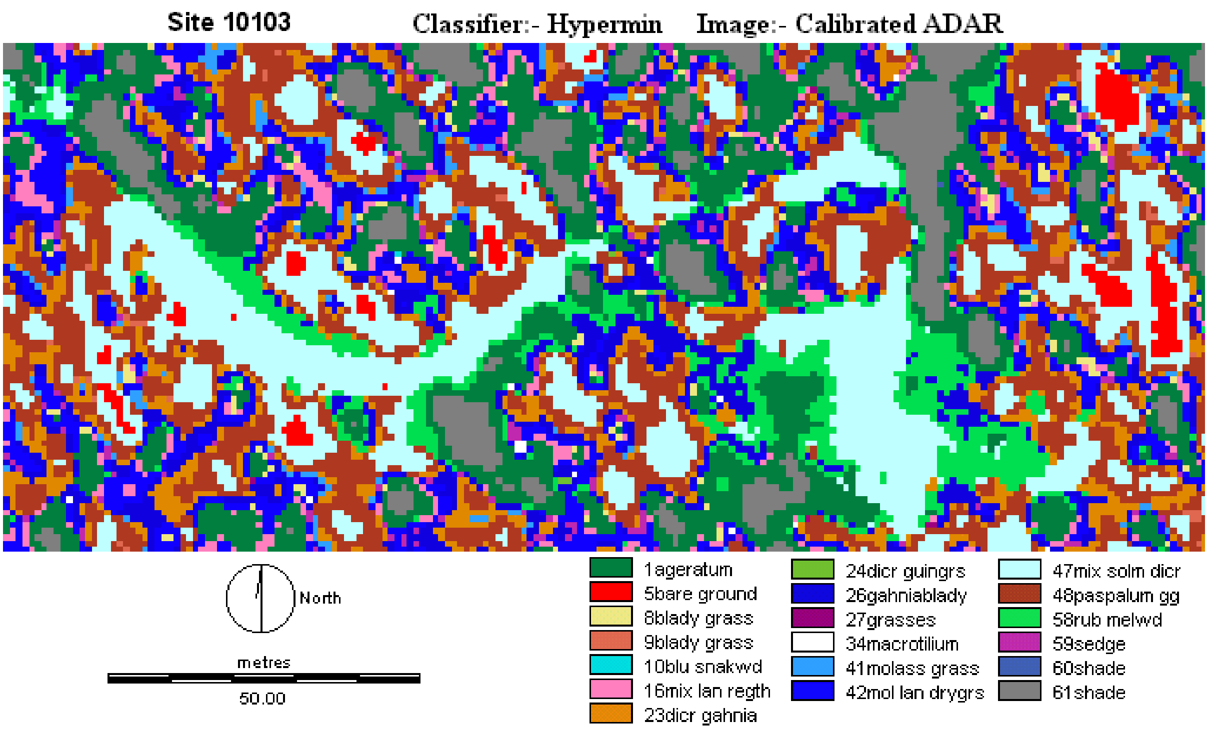


Figure 2.10: A supervised classification with minimum-distance measure using the group of 68 signatures derived from the field data by SPSS discriminant analysis.

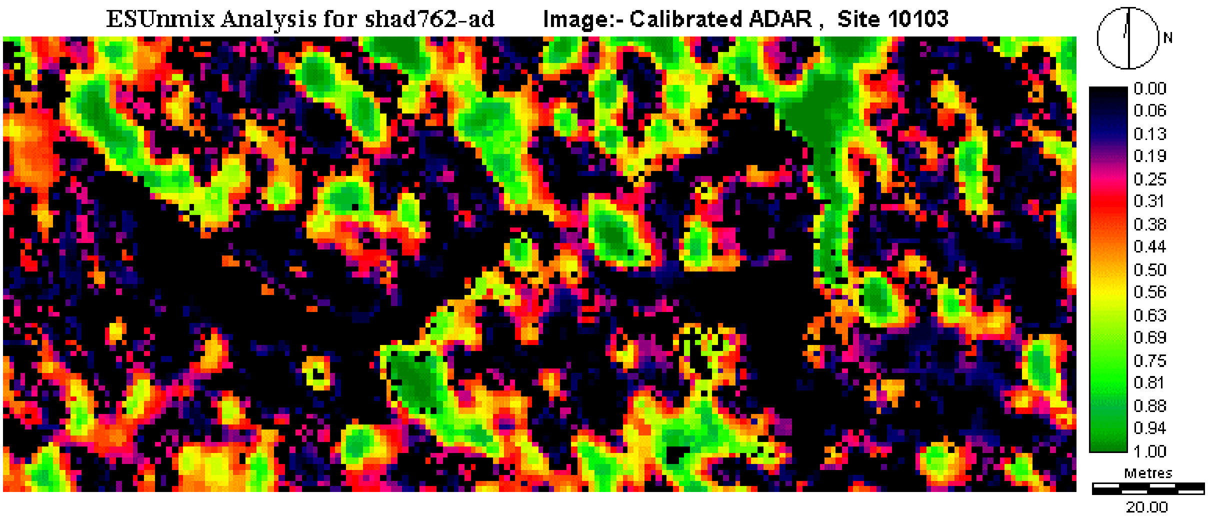


Figure 2.11: Unmixed fractional map of shade class. A pixel coloured dark green in this image indicates an estimated 90% to 100% shade.

Spectral Mixture Analysis

Figure 2.11 shows the fraction of one signature (shade) in each pixel of the image while Figure 2.12 shows the fraction of a signature that is itself a mixture (containing mostly *Rubus*). The members of the mixed group "14" were present along the road to some extent as found in Figure 2.12, but a large number of images generated by this procedure were blank or meaningless. The way each signature represents a spectral class, and the way the spectral components mix to form the overall reflectance of a pixel needs further examination and development of theory.

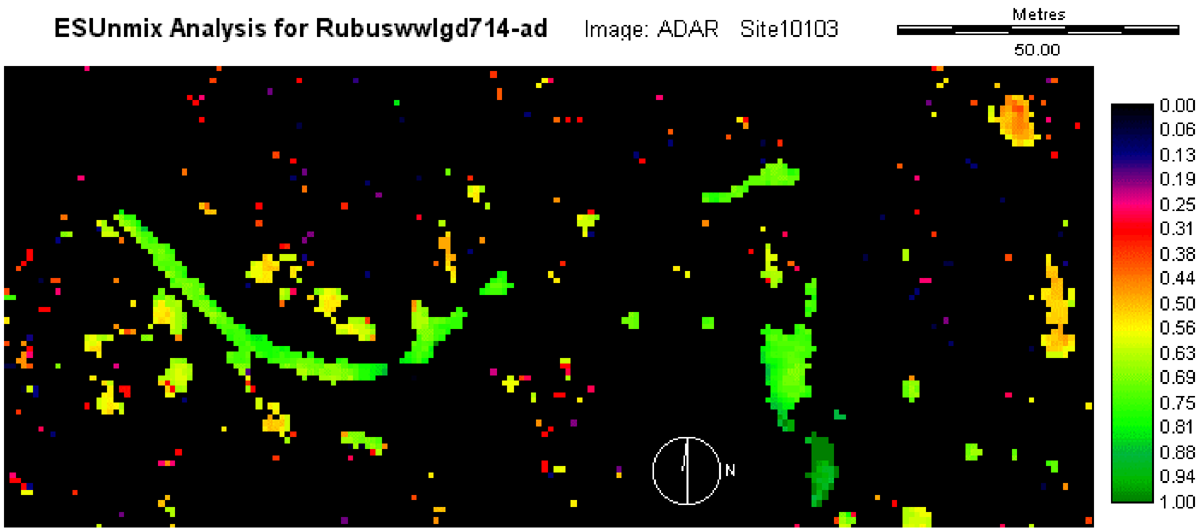


Figure 2.12: Fraction of group 14, which is a mixture of mostly *Rubus, Dicranopteris, Alpinia* spp and *Panicum*.

2.6.5 Ikonos Satellite Imagery Results

A similar set of procedures was undertaken for the Ikonos satellite imagery. The Ikonos satellite was launched in 1999 and provides high resolution imagery in four bands, blue, green, red and near infra-red (Figure 2.13). The ground resolution element, which equates to a pixel, is 4m x 4m, and the instrument sensitivity is high, recording in two thousand and forty-eight grey levels as opposed to the two hundren and fifty-six levels (dn) of the aerial imagery (Lillesand and Kiefer 2000). Its accuracy for mapping purposes is excellent (Fraser 2000). The imagery is expensive at present but is expected to become less so with time and competition from other suppliers such as Orbimage.

Calibration

The imagery was calibrated using the empirical line method, however, unlike the ADAR images, the empirical relationships were linear as expected from the literature.

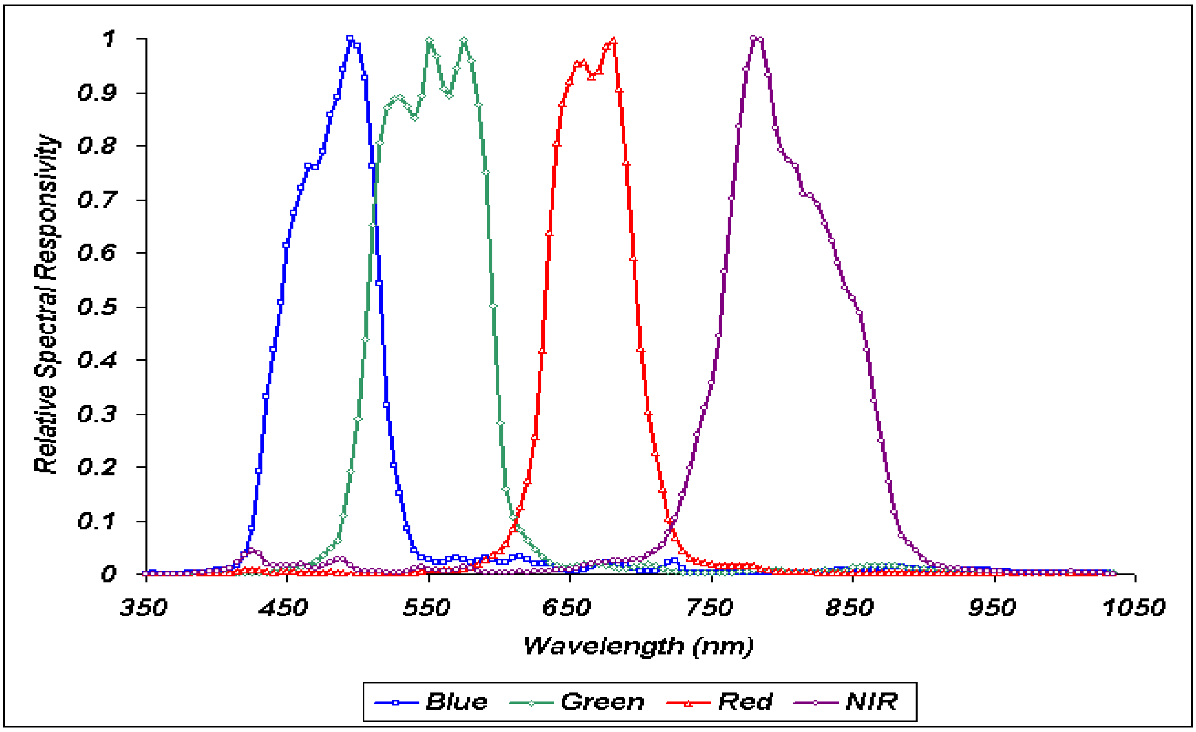


Figure 2.13: Ikonos spectral response for 4m bands: source spaceimaging.com. Note that there is much less overlap between bands compared to the ADAR spectral response and the sensitivity levels are equal across the four bands.

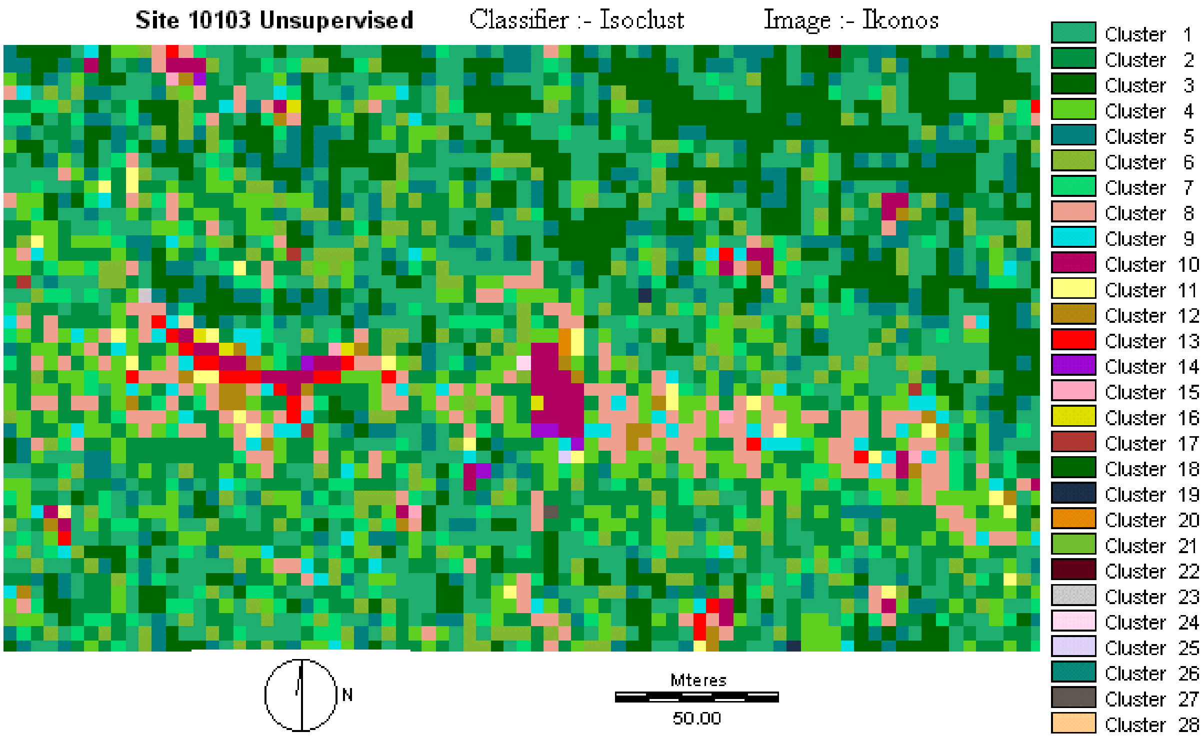


Figure 2.14: Unsupervised classification of the site around tower 10103, showing clusters of pixels with similar values (clusters 1-13 >20 pixels, clusters 14-28 <7 pixels).

Classification and Spectral Mixture Analysis

An unsupervised (clustering) classification of the same site near tower 10103 (Figure 2.14) shows that in the area of interest (the clearing and road verge) many spectral classes can be detected. In fact more spectral classes were discernible in this imagery than in the ADAR imagery, which is surprising given that each pixel covers an area sixteen times larger. It suggests a potential to detect a variety of weed species

Supervised Classification and Spectral Mixture Analysis showed similar results to the ADAR imagery except that in general, more classes were obtained in the Ikonos imagery.

2.7 DISCUSSION

The percentage cover results showed that one to three species dominated an area the same size as the spatial resolution of the aerial imagery. Other species occurred in very low proportions. Although the samples were chosen in reasonably homogeneous areas, this spatial resolution of the field data to one metre matches the spatial resolution of the ADAR imagery. Therefore spectral mixture analysis of the ADAR imagery should be capable of analysing the cover types in at least some areas of the powerline clearing, provided that spectral separation is satisfactory and that variations within species and external conditions can be controlled.

Weeds dominated the powerline corridor in most places, however, the species list from the transects (Appendix 1.1) included only one species found in the categories of serious significance (one or two) of the fifty-seven classified by Werren (2001), out of the five hundred and four exotic plants with self-maintaining populations recognised in the WTWHA (Werren 2001). However, almost four hundred and fifty species remain to be examined by this classification, so other serious weeds may be present. Guinea grass (*Panicum* *maximum*) falls into the second group, mainly due to its aggressive characteristics and potential to impair ecosystem function as a 'transformer species' (Werren 2001). However, Guinea grass was only found commonly in a few subsites of the transects and is not the dominant feature that it is in other powerline and road networks, such as the Palmerston area (see Section 1).

Analysis is required of a number of interactions and effects such as sun / leaf angle, shading etc. on the field spectral responses of weeds to enable full understanding of the variation that is due to species difference alone. There is a wide variation of the spectral response within a species that can overlap the variation seen in other species. For accurate results in classification of imagery, a method that allows for the wide variation in plant reflectivity response must be incorporated. The mean value is clearly inadequate for representing the variance without first trying to define what a representative sample of the species is or its separate stages of growth.

There is adequate power in many statistical processes to be able to separate small differences in spectral signatures but GIS image processing software is limited to a resolution of two hundred and fifty-six levels of information (eight bit) for many processes.

2.7.1 ADAR Imagery

The ADAR imagery showed only a few spectral classes in the cleared areas. This suggests that either the number of spectral classes in the clearing was limited to relatively few or the imagery did not represent the range of reflectances actually present in this area. The brighter areas in the images (the powerline clearing and road) were close to saturation levels for the camera (255 dn) and this could explain the loss of detail, especially when considering the analysis of the camera's performance by Dean *et al.* (2000). Their assessment was that quantitative analysis of colour, or colour infra red imagery (CIR) of vegetation with this camera is not reliable above sixty-seven percent of the maximum range in the green and red bands (*ie.* 170 dn). The ADAR imagery for the seven sites of this study had maximum digital numbers (dn) of 188 to 255 in the red bands. Similarly in the green bands the maximum dn ranged from 236 to 255. This is clearly outside the reliable range for both red and green bands as described by Dean *et al.* (2000).

The camera's unsatisfactory performance can also explain the difficulty found with the calibration of the ADAR imagery, and why the unconventional logarithmic transformation was needed to achieve calibration. Dean *et al.* (2000) found that Kodak`s Active Interpolation (KAI) algorithm (that produces the digital image) includes edge enhancement, increased contrast and spectral response fall-off that varies with wavelength and scene composition. These may be good features for photo-journalism but are undesirable for remote sensing especially for quantitative analysis applications such as extracting reflectance information. The interpolation of colours from neighbouring pixels defeats the purpose of high spatial resolution. Thus successful "unmixing" of the component reflectances of a pixel is compromised.

Accuracy of the calibration process is critical to the success of classifying with field spectral measurements. The image in Figure 2.11 shows a reasonable result for the "shade" class, but the "bare ground" class is positioned where there is rainforest, suggesting either a calibration inaccuracy, or an inadequate separation of the signatures used.

The unmixing algorithm used in this study requires very accurate calibration because it uses only the mean value in signature files to determine the mixture of components in the pixel. The best fit is simply the one with the smallest error. However, it takes no account of the spread in the spectral response pattern of the cover type. This can work well in cases where the surfaces are comprised mostly of non-photosynthetic materials such as in arid areas or for detection of certain chemical absorption phenomena associated with particular minerals (Atkinson *et al.* 1997). But vegetation response patterns are broad and led Asner and Lobell (2000) to say that "broad variations in endmembers often leads to a wide range of plausible cover fraction results". Therefore it is "desirable to establish features of the spectrum that display the least variability while remaining distinct". An alternative classifier such as "Fuzzy C-means" might tolerate high variance in the signature yet still produce a plausible result.

An additional problem with green vegetation is that the NIR wavelengths are highly reflective and the multiple reflections within a canopy amount to non-linear mixing of the spectral components. Bastin (1997) and Small (2001) mention this difficulty and Borel and Gerstl (1994) have actually modelled nonlinear mixing.

2.7.2 Ikonos Satellite Imagery

Many of the above comments apply also to the Ikonos Satellite Imagery. Supervised Classification and Spectral Mixture Analysis showed similar results to the ADAR imagery except that in general, more classes were obtained in the cleared areas with the Ikonos imagery. This improvement could be attributed to having one more band of information available in the Ikonos imagery but it is more likely that it is a reflection of the higher quality of instrument in the satellite. Full exploitation of the greater sensitivity of the Ikonos imagery (requiring improved GIS software) will enable even better discernment of subtle spectral differences in vegetation.

The satellite passes the Equator at 10.30am each day so imagery of North Queensland (shortly before 10.30 am) has some shading due to morning sun angles and effects of undulations in the canopy. Ideally, any imagery used for quantitative assessment should be corrected for illumination effects (McDonald *et al.* 2000; Shepherd and Dymond 2000) due to topographical aspect and sun angle. This procedure was considered beyond the scope of this project and would require a fine scale digital elevation model (DEM), but offers potential for better results.

2.8 CONCLUSION

Technical challenges facing the development of a methodology to use remote sensing and image interpretation in Wet Tropics vegetation monitoring can be summarised as concerns with spatial, spectral and radiometric resolution.

2.8.1 Spatial Resolution

The percentage cover measurements showed that there are mostly one to three, or sometimes four, dominant weed species in a one square metre quadrat on the Chalumbin-Woree powerline corridor. This suggests that a one metre spatial resolution with three bands of imagery would be the minimum necessary to unmix spectral components in homogenous areas. The one metre spatial resolution of the ADAR imagery in three bands is therefore theoretically adequate. The spatial resolution of the Ikonos satellite is much coarser than the patch size of most weeds (except possibly *Lantana, Panicum, Themeda* and *Melinis*). Spectral Mixture Analysis is difficult to apply when there are more spectral classes contributing to a mixed pixel than bands of imagery. Resolution coarser than one to two metres is likely to be inadequate for mapping individual weed species. Thus, Landsat ETM+ imagery (twenty-five metre cells) is unlikely to be productive using this approach except where the patch size of a weed species is greater than 0.1hectare.

2.8.2 Spectral Resolution

To discriminate one species of weed from another requires a feature that is distinct between species, but constant within an individual species. This study has examined the reflectance at eight locations in the light spectrum and found that the ranges within a species are large compared to the differences between species. The solution to this conundrum is to characterise the reflectance of a species across all eight bands simultaneously whilst accounting for or minimising the other variables. Achieving this requires more data than was obtained by this study. However, this study was valuable in highlighting the range of issues involved.

Good spectral reflectance information about weeds may require:

a) Measurement of the full cycles of reflectivity as they change with the seasons (phenological cycles measured around the year at the same sites);
b) Measurement at a consistent time of day, or investigation of time of day and its effect on reflectivity with regards to geometry of sun / leaf / sensor angles and diurnal moisture change in the leaf tissues; and
c) Understanding of instrument variables such as calibration, and performance with respect to light conditions or height above the canopy.

The basis of image calibration is that a relationship, preferably linear, can be found between measurements of field reflectance and the brightness levels measured by airborne or satellite sensors (Niemann *et al.* 2001). This assumption was shown to be incorrect for the ADAR data. The problem was probably due to the adjustment of exposure levels and to the nature of the Charged Coupled Device (CCD) in the camera when it is used in colour mode (gathering data in three colours rather than in monochrome) (Dean *et al.* 2000). However, the satellite data did show a linear relationship to field spectral measurements. Better quality signatures, image calibration and spatial resolution would confirm the linear relationship for the Ikonos satellite.

2.8.3 Radiometric Resolution

The analysis of the field spectral data showed that there is definite potential for developing reliable signatures for spectral classes of weeds from field data. The novel technique of entering the field data into a GIS and image interpretation program is an excellent way to begin the process of finding existing spectral classes. The clustering procedure in IDRISI looks for true clusters (Richards 1993; Eastman 1999) in the data but the statistical resolution was limited by eight-bit data processing (eight bit data has only two hundred and fifty-six values and cannot therefore represent real numbers with greater than three significant figures). Subsequent statistical analysis showed that finer division of spectral classes to near species level was justifiable, and that the real number of signatures developed from these was divergent enough to be separable in ninety-eight percent of pair-wise combinations. Many of the classification routines in IDRISI require eight-bit images and therefore do not take advantage of the high radiometric resolution available with the latest satellite capabilities. This problem of radiometric resolution is shared by many remote sensing and GIS packages at present.

The unmixing routine in IDRISI does, however, use real numbers. This classifier has a fundamental assumption that the spectral response of a surface can be represented by a mean value. It takes no account of the variation of reflectance seen in vegetation. An additional problem with spectral component analysis is the assumption that the reflectance of a pixel is a simple addition of the reflectance of the components within the ground resolution element. Green vegetation is highly reflective in NIR wavelengths and likely to bounce or reflect more than once within a plant canopy thereby losing more energy through absorption and transmission, degrading the distinctive spectral characteristics of particular plants (Borel and Gerstl 1994; Bastin 1997; Small 2001).

The choice of bands in the various sensors is important. Bands that show the features of the plant spectra that are least variable while still distinct are the most desirable (Asner and Lobell, 2000). This study did not examine the advantages and disadvantages of different bands, but the "Cropscan" MSR produced readings at 810nm that were very sensitive to small changes in calibration of the instrument. They were also highly variable, a fact noted in other studies (Skidmore and Schmidt, 1998). There is no doubt that the analysis of many, narrow, more discrete bands (with no overlap), gives the user greater power of spectral discrimination (Curran 1985; Anstee *et al.* 2000; Lillesand and Kiefer 2000). Asner and Lobell (2000) found that moderate bandwidths (20-30nm) were optimal since wider bandwidths confused some classes and smaller bandwidths were subject to high frequency noise.

2.8.4 ADAR (Airborne) Imagery

The performance of the ADAR imagery was disappointing despite its excellent spatial resolution. The overlapping bands and the fact that the colour is produced by interpolation (averaging the dn in each band over ten pixels or so) means that quantitative analysis is imprecise. The response is not linear above sixty-seven percent saturation (ie above 170 dn). These problems can only be overcome by the use of a separate camera or separate image for each band.

2.8.5 Ikonos Satellite Imagery

The high radiometric resolution (11 bit) of the Ikonos satellite produced high quality data. The four discrete bands of Ikonos positioned right across the range of wavelengths expected to be most informative for vegetation studies gave good spectral coverage. However it may be more effective to use field reflectance at 760nm when analysing Ikonos imagery, since it is not as variable as reflectance at 810nm. The imagery should also be corrected for illumination effects using a Digital Elevation Model (DEM).

2.8.6 Hyperspectral Data

Perhaps the ideal imagery for discriminating weeds would be something like Compact Airborne Spectrographic Imagery (CASI) (Lewis 1998) that has eight to twenty bands each 20-40 nm in width but with eleven bit radiometric resolution and one metre spatial resolution. The Multi Spectral Airborne Video System (MAVS) (Edirisinghe *et al.* 1999) that uses four cameras, each with a narrow band pass filter, would be a vast improvement on the ADAR system for quantitative analysis. The Multispectral Airborne Digital Imaging System (MADIS) system operated by Charles Sturt University has similar specifications.

2.9 RECOMMENDATIONS

- The "Cropscan" MSR should be tested under standardised conditions.
- Further work needs to be done to better characterise the spectral responses of weeds.
- To effectively estimate proportions of land cover such as clumps of weeds from imagery requires:
  - Calibrated imagery;
  - Suitable band widths (20 – 30 nm) in the appropriate areas of the spectrum;
  - A high spatial resolution (0.5 – 2 m) that contains few spectral components;

  - Correction for illumination effects; and
  - Processing with classifiers that allow for the variation seen in the spectral response patterns of vegetation.
- Alternative image interpretation software is required with the ability to handle twelve -bit data and real numbers to take advantage of the high dynamic range of the latest satellite data and to be able to discriminate the subtle differences in vegetation signatures. Another feature that would reduce time and effort is signature portability (*i.e.* signatures that can be used on multiple images and in a variety of classifiers).
- Classifiers that allow for variance in a signature should be investigated, e.g. "Fuzzy C-means" or "Artificial Neural Networks" (Atkinson *et al.* 1997) may be more effective at classifying vegetation than Linear Unmixing.
- Large targets such as tarpaulins should be set out whenever imagery is captured for quantitative analysis. Spectral reflectance measurements taken of the targets at the time of flying enables calibration to be carried out accurately, which is important for relating field measurements to the imagery.
- Imagery for quantitative analysis should not be captured with a digital camera unless it is part of a multi-camera array or is fitted with a wheel-filter to enable the camera to be used in monochrome mode (King 1995). It is strongly recommended that an appreciation of these matters is gained before acquiring airborne imagery. The journal articles by King (1995) and Dean *et al.* (2000) should therefore be read.
- Regular usage of airborne imagery will require the ability to "set up and go" quickly due to the lack of cloudless periods in the Wet Tropics that last more than a few days and the inability to safely predict when these will occur. Ultra-light aircraft or drones (computer or radio controlled pilot-less aircraft) may provide a more timely means for the monitoring of environmental weeds. Alternatively use of the Ergon Energy maintenance helicopter to capture imagery may also be a possibility.
- Future work on the spectral response of weeds should be directed at measuring the seasonal variations for each species by establishing permanent plots for regular monitoring. More data is needed for each species. A clustering routine in a GIS that looks for true shoulders or peaks in spectral data should then be used to find spectral groups on a species by species basis.

2.10 MANAGEMENT IMPLICATIONS

Analysis of the ground data showed that identifying weeds to a species level is possible but requires more research and suitable imagery for its application. The ADAR has appropriate spatial resolution of one metre but cannot be recommended for quantitative analysis. A system that has narrow and discrete bandwidths would have vastly improved performance. There is also an unpredictable cost with ADAR imagery of waiting for good weather or being able to fly at short notice when clouds clear.

Ikonos satellite imagery has excellent radiometric resolution, and accurately located cloud free images can be ordered, which is very convenient. However, four metre spatial resolution is probably too coarse for accurate identification of weed infestations. Similar imagery at two metre resolution will be available in three years or so, improving the potential of satellite imagery for this application.

Hyperspectral imagery may be ideal for discriminating weeds. Systems such as Compact Airborne Spectrographic Imagery (CASI) that uses many narrow bands, 11 bit radiometric resolution and one metre spatial resolution may be the best available. Alternatively, the Multi Spectral Airborne Video System (MAVS) that uses four cameras, each with narrow bands, or the Multispectral Airborne Digital Imaging System (MADIS) would offer better spectral resolution than ADAR.

3. WEED PENETRATION, EDGE EFFECTS AND REHABILITATION STRATEGY SUCCESS IN WEEDY SWATHES OF THE PALMERSTON POWERLINE CLEARING

Miriam Goosem and Robert Jago

3.1 SUMMARY

This study has shown that the rainforest restoration plantings across the Palmerston powerline clearing that were undertaken by the Centre for Tropical Restoration (QPWS) in 2000, using three framework species, has demonstrated early success. Grasses, which include molasses grass *(Melinis minutiflora*) and Guinea grass *(Panicum maximum*),that can help to maintain a grassy swathe by promoting fires and by preventing the germination of native rainforest species, have been reduced or almost eliminated under the low relatively open canopy that is now present. These grasses dominate in the clearing at sites that have not been rehabilitated, together with woody weeds such as Lantana (*Lantana camara*) and Giant Bramble (*Rubus alceifolius*). Herbaceous species, including Bluetop (*Ageratum conyzoides*) and Thickhead (*Crassocephalum crepidiodes*), have replaced the grasses in the ground cover where light penetrates but are also gradually being eliminated as the canopy spreads. As yet, very little recruitment of rainforest species was recorded in these early stages of growth.

Edge-induced changes in floristic composition were shown to penetrate the rainforest to a distance of between three and seven metres from the rainforest edge, with a few weeds present in this edge zone. Early successional stage rainforest species appeared more prevalent in this band, whereas a slight trend suggested that late successional species may be more common further inside the rainforest. However more data are required to confirm these results. Hierarchical agglomerative classification and ordination techniques both demonstrated that floristic composition was altered further into the rainforest to distances between twenty and forty-five metres. These alterations suggest a more insidious, longer-term and more widespread effect of wide linear clearings on floristic composition. Such changes could have a flow-on effect to other flora and fauna of the rainforest. The distance from the edge where these changes can be recognised suggests that a larger area of habitat within the Wet Tropics World Heritage Area may be floristically altered due to linear clearings through the rainforest than was previously thought. Further data will clarify these results.

3.2 INTRODUCTION

In Section 1, the distribution of weeds within the Palmerston powerline corridor was described. Weeds may also penetrate the rainforest, generally only to short distances (Siegenthaler *et al.,* 2000). Penetration of alien flora constitutes one type of edge effect. Edge effects are a diverse array of ecological changes occurring at and in the vicinity of the abrupt artificial margins of natural habitat and the linear clearing. Edge effects comprise both abiotic and biotic changes. On rainforest edges, abiotic edge effects can include elevated wind speed, turbulence and vorticity (Laurance 1997) and changes in microclimate. Increased solar penetration during the day and reradiation at night result in greater diurnal air and soil temperature fluctuation than found under the interior forest canopy (Murcia 1995). Consequent increases in vapour pressure deficit and evaporation occur while relative humidity and available soil moisture decrease (Turton and Freiburger 1997). Biotic edge effects can be direct changes in abundance and distribution of species caused by these changes in physical conditions. Indirect biotic effects arising from the direct changes in floristic and faunal species composition can include variations in species interactions such as predation, competition, herbivory and seed dispersal.

Laurance (1991b) showed that edges of rainforest fragments had greater canopy and subcanopy damage and increased abundances of woody lianes, climbing rattans and other disturbance-adapted plants. Such forest disturbance was discernible to distances of two hundred to five hundred metres. By comparing species richness and abundance of weeds, colonising plant species and rainforest core species in rainforest remnants of NSW, Fox *et al.* (1997) were able to delineate edge dimensions in terms of the changes in community composition of each of these groups. They observed a decrease in rainforest core species towards the edge with a concomitant increase in weeds and colonisers. However, grazing was prevalent in these remnants, creating a greater weed load than might otherwise be expected (Fox *et al.* 1997). Siegenthaler *et al.* (2000) demonstrated edge effects in floristic composition and vegetation structure along the Palmerston powerline clearing and an associated road, penetrating into the rainforest to distances of at least thirty metres for some factors and dependent on the width of the clearing. Canopy openness was increased at the rainforest edge, as were weeds and pioneer species. Weeds were found to penetrate to a distance of three metres from the edge (Siegenthaler *et al.,* 2000). Sapling and seedling abundances were elevated to greater distances, suggesting greater disturbance at the edge. Seedlings (probably of rainforest rather than disturbance species) were also more abundant further into the forest (thirty to one hundred metres).

Although 'edge effects' on floristic composition and vegetation structure have been examined previously, there has been no comparison of powerline corridors, highways and narrow roads and rehabilitation success has yet to be examined. One objective of this study was to examine the success of rehabilitation plantings in prevention of weed germination. A second objective was to compare the penetration of weeds and weed seeds into the forest from powerline corridors with and without rehabilitation plantings, as well as from highway and narrow road edges. The third objective was to examine edge effects in vegetation floristic composition at these three treatments.

3.3 METHODS

3.3.1 Study Sites

In 1999 / 2000, three 60 metre x 50 metre sites in the lower section of the Palmerston powerline corridor were prepared for restoration plantings by the Centre for Tropical Restoration (Dellow 2000); these sites are more than two hundred metres apart. In preparation, the sites were twice slashed for weeds (September and November 1999), one pig trap was installed at each site (October 1999) and glyphosate was applied using a 'Weedbug' (December 1999 and February 2000). Three rainforest species, *Acacia celsa, Alphitonia petriei* and *Elaeocarpus grandis* were planted in February 2000 at three metre spacings in rows perpendicular to the powerline clearing. These three species were chosen to provide a framework for later direct seeding trials under the canopy they establish. Three control sites where woody weed or grassy swathe occurred in the clearing were established at a distance of at least fifty metres from each of the rehabilitation sites.

The rainforest vegetation of the area comprises Complex Mesophyll Vine Forest (Type 1a *sensu* Tracey 1982). The canopy is uneven with a height ranging from twenty-five to thirty-five metres. Vegetation within the powerline clearing at the control sites consists either of a grassy swathe of *Panicum maximum* (Guinea grass), *Melinis minutiflora* (Molasses grass) and occasional *Brachiaria decumbens* (signal grass) as well as herbaceous weeds with occasional rainforest pioneer species establishing. Woody weeds including *Lantana camara* (Lantana) and *Rubus alceifolius* (wild raspberry) often occur along the edge and are, in places, out-competing the exotic grasses to form an almost complete woody weed swathe across the clearing (see Section 1).

3.3.2 Floristic Survey Methods

Mr Robert Jago, a well-respected botanist and plant identification expert with many years of experience within the Wet Tropics was employed to identify all plant species present. Surveys of four transects were undertaken in June 2002. Unfortunately, Mr Jago will not be available for further work in this project but Mr Rigel Jensen, another plant identification expert has continued with identifications. The height of the rehabilitation site canopy is shown in Figures 3.1 and 3.2.

Transects

Each of the six sites included two by one hundred metre long line transects, one on either side of the clearing, that were laid perpendicular to the linear clearing from a zero point at five metres inside the clearing to a distance of one hundred metres into the rainforest (Siegenthaler and Turton 2000). Ten data sampling points were established at the following intervals along the line transects: 0, 5 (rainforest edge), 8, 12, 16, 20, 25, 30, 50 and 100 metres. Additionally, three or four sampling points (depending on clearing width at the transect) were established along the same transect into the powerline clearing at five metre intervals (i.e -5, -10, -15 and -20 metres).

Quadrats

At each sampling point in a circular quadrat of one metre radius, all vegetation was surveyed for all species in five size classes:

a) Canopy and emergents (trees reaching the canopy);
b) Subcanopy (trees not reaching the canopy but forming a layered subcanopy beneath it);
c) Understorey (saplings and shrubs >1 metre in height not reaching the subcanopy);
d) Groundcover (seedlings and shrubs <1 metre in height);
e) Vines (lianes and rattans climbing toward or into the subcanopy and canopy); and
f) Epiphytes (ephiphytic ferns and orchids and hemiepiphytes such as aroids).

Additionally, all species of understorey size or greater as well as dominant groundcovers were surveyed in circular quadrats of five metres radius from each sampling point. The larger sampling area resulted in a more comprehensive coverage of species reaching understorey height in the vicinity.

Species occurrences were classified on an ordinal scale consisting of:

a) Dominant (dominating the area):
b) Common (not dominant but very common within the area);
c) Occasional (at least two occurrences within the 1m quadrat or three occurrences within the 5m quadrat, but uncommon); and
d) Rare (one occurrence within the 1 m quadrat or 1-2 occurrences within the 5 m quadrat)

Figure 3.1: Height of rehabilitation plot canopy in May 2002.
Photograph taken at a distance to allow comparison with the forest edge.

Figure 3.2: Height of rehabilitation plot canopy in May 2002.
Photograph reveals height of trees relative to person height.

Classification of Species into Disturbance Indicators and Successional Stages

Species were classified into groups on the basis of successional stage (Goosem and Tucker 1995, Tucker and Murphy 1997, Tucker 2001), using ecological descriptions from Hyland and Whiffin (1993) and Hyland *et al*. (1999) for species not listed elsewhere, to determine successional stage similarity to cogenerics. Successional stage groupings were:

a) Weeds (exotic species), e.g. *Panicum maximum, Lantana camara, Ageratum conyzoides*;
b) Early successional stage or pioneer rainforest species, e.g. *Breynia stipitata, Omalanthus novoguineensis, Maclura cochinchinensis, Rubus probus, Glochidion harveyanum;*
c) Intermediate successional stage rainforest species, e.g. *Mischocarpus stipitatus,*
d) Late successional stage rainforest species, e.g. *Argyrodendron peralatum, Desmos goezeanus, Sloanea mcbrydei, Syzygium cormiflorum*.

However many species are considered to belong to two or more of these groups (Tucker and Murphy 1997, Tucker 2001):

a) Early to intermediate, e.g. *Darlingia darlingiana, Flagellaria indica, Dysoxylum muelleri, Guioa lasioneura, Oplismenus hirtellus, Polyscias australiana, Sarcopteryx martyana*;
b) Intermediate to late, e.g. *Alpinia modesta, Carronia protensa, Castanospermum australe, Cryptocarya mackinnoniana, Dysoxylum papuanum, Flindersia bourjotiana, Haplostichanthus* sp.*, Helicia nortoniana, Litsea leefeana, Melodinus australis, Pitiviasta haplophyllus, Raphidophora australasica, Tetrasynandra laxiflora, Toechima erythrocarpum, Xanthophyllum octandrum;*
c) Early to intermediate to late, e.g. *Asplenium australasicum, Cardwellia sublimis, Chionanthus ramiflora, Ichnocarpus frutescens, Melicope vitiflora, Piper novaehollandiae.*

Those species included in two or more groups are depicted graphically in the combined class. If a species belongs to an early to intermediate stage it was included in the early successional disturbance indicator class (see Figure 3.3). Likewise if a species belongs to an intermediate to late successional stage, it was included in the late successional class when graphing disturbance indicators.

3.3.3 Soil Seed Bank

Three replicate soil samples were randomly chosen within each circular quadrat of one metre radius. Any large leaf litter was removed from the soil; the soil was then sampled in a twenty-centimetre square to a depth of five centimetres. These samples were pooled, mixed, and subsampled by quartering with one random subsample chosen, resulting in a final 1500cm^3 sample. Samples were transferred to a greenhouse and placed on coarse blotting paper to prevent soil loss within free draining seed germination trays. Trays were kept moist by twice-daily watering.

All seedlings were counted, identified and removed after twenty-eight days. Any unidentifiable individuals were potted into larger tubes to permit later identification. The soil surface was then disturbed to a depth of one centimetre to encourage further germination. Seedlings were again counted, identified, removed and soil disturbed at fifty-six and eighty-four days when no further germination was recorded.

3.3.4 Data Analysis

Species lists were compiled for each quadrat size at each sampling point. Species composition was examined for successional stage for each quadrat. Data for both the one metre and five metre radius quadrats (incorporating data from the one metre radius quadrats) were analysed by SPSS Version 10.0. Non-metric multi-dimensional scaling ordinations were performed for each transect using presence / absence data and binary Euclidean distance as the measure of separation of quadrats. Ordination in both two-dimensional and three-dimensional spaces was performed. Dimension coordinate data were back-correlated with species data to determine the major contributors to each dimension. Hierarchical agglomerative clustering analysis was also performed with the presence / absence data for each transect using binary Euclidean distance as the measure of separation and Ward's minimum variance clustering method. Finally, quadrat data for all transects were classified using hierarchical agglomerative clustering.

3.4 RESULTS AND DISCUSSION

A total of two hundred and four plant species were identified within the quadrats along the four transects within the Palmerston powerline clearing and adjacent rainforest that has been examined thus far (Appendix 2.1). Data collection on transects within the powerline clearing and along the highway continued using Mr Rigel Jensen to identify plant species. Appendix 2.2 provides a list of all species found within each quadrat of one metre radius and each quadrat of five-metre radius.

3.4.1 Penetration of Weeds and Disturbance Indicators

Of the two hundred and four species recorded along the four transects, sixteen were exotic (weed) species. The great majority of exotic species were found within the corridor (Figure 3.3a, Figure 3.4). Weed species were dominant in the clearing (-20 – 0 metres) but barely penetrated the rainforest edge, only three or four species were recorded in rainforest edge quadrats (five metre sample) at the control site and one or two at the rehabilitation site edge. Weed species that were dominant within quadrats in the clearing include *Panicum maximum* (Guinea grass), *Melinis minutiflora* (molasses grass), *Lantana camara* (lantana), *Rubus alceifolius* (wild raspberry) and *Ageratum conyzoides* (blue top). One species (*Rubus alceifolius*) penetrated as far as the eight metre quadrat (three metres from the edge) at the control sites (n = two transects per treatment).

Numbers of weed species were reduced in almost all quadrats within the clearing at the rehabilitation sites (Appendix 2.2). This was mainly due to a shift away from grassy weeds such as *Panicum maximum* (Guinea grass), *Melinis minutiflora* (molasses grass) and *Brachiaria decumbens* (signal grass). The abundance of weeds was dramatically reduced, particularly the grasses, with herbaceous weeds such as *Ageratum conyzoides* (blue top) and *Crassocephalum crepidiodes* (thickhead) becoming more common.

This shift in weed species present and their abundance is related directly to the ability of these herbaceous species to out-compete the previously dominant grasses in the greater shade that is provided by the low canopy of the rehabilitation plantings. Eventually, the expansion of the canopy towards closure should completely prevent the germination of these herbaceous species, as is happening directly under each tree where light is more limited.

This canopy expansion should also result in the recruitment of rainforest species below the canopy (Goosem and Tucker 1995, Lamb *et al*. 1997, Tucker and Murphy 1997). Restoration is already achieving some of its objectives by preventing germination of fire promoting grass species such as Molasses grass and Guinea grass (Wallmer 1994, Werren 2001). These fire-promoting grasses have contributed to the self-sustaining grassy swathe within the powerline clearing but have now been reduced, at least in these small areas. In recent history, fires were an annual occurrence within the lower elevations of this linear clearing (personal observation). The presence of these firebreaks should also reduce the likelihood of fires in between the rehabilitation sites.

Although vines are expected to be more common in the disturbed areas of the edge, this was not true of numbers of vine species which tended to be relatively uniform throughout the rainforest sections of the transects (Figure 3.3c). Vine abundance may show a different trend, although the majority of vine species recorded along these transects come from the later successional stages (Appendix 2.1). Abundance of vines was examined when further data were collected in an Honours in Applied Science project (Mr Neil Maver), completed in November 2002.

Early successional stage rainforest species were more common near the edge (Figure 3.3b while those occurring within the clearing at the rehabilitation sites were predominantly the planted trees. However, because several species can occur in early, intermediate and late successional stages, the early species (a combination of early, early to intermediate and early to intermediate to late species) are still relatively common even ninety-five metres into the forest. This is particularly true of one rehabilitation site where the one hundred metre quadrat occurs near a creek which is an area of greater natural disturbance.

Numbers of later successional stage rainforest species tend to increase from the edge to the interior (Figure 3.3d). However much more data are required to determine whether this trend translates to statistical differences. Further transect data are required to analyse this trend.

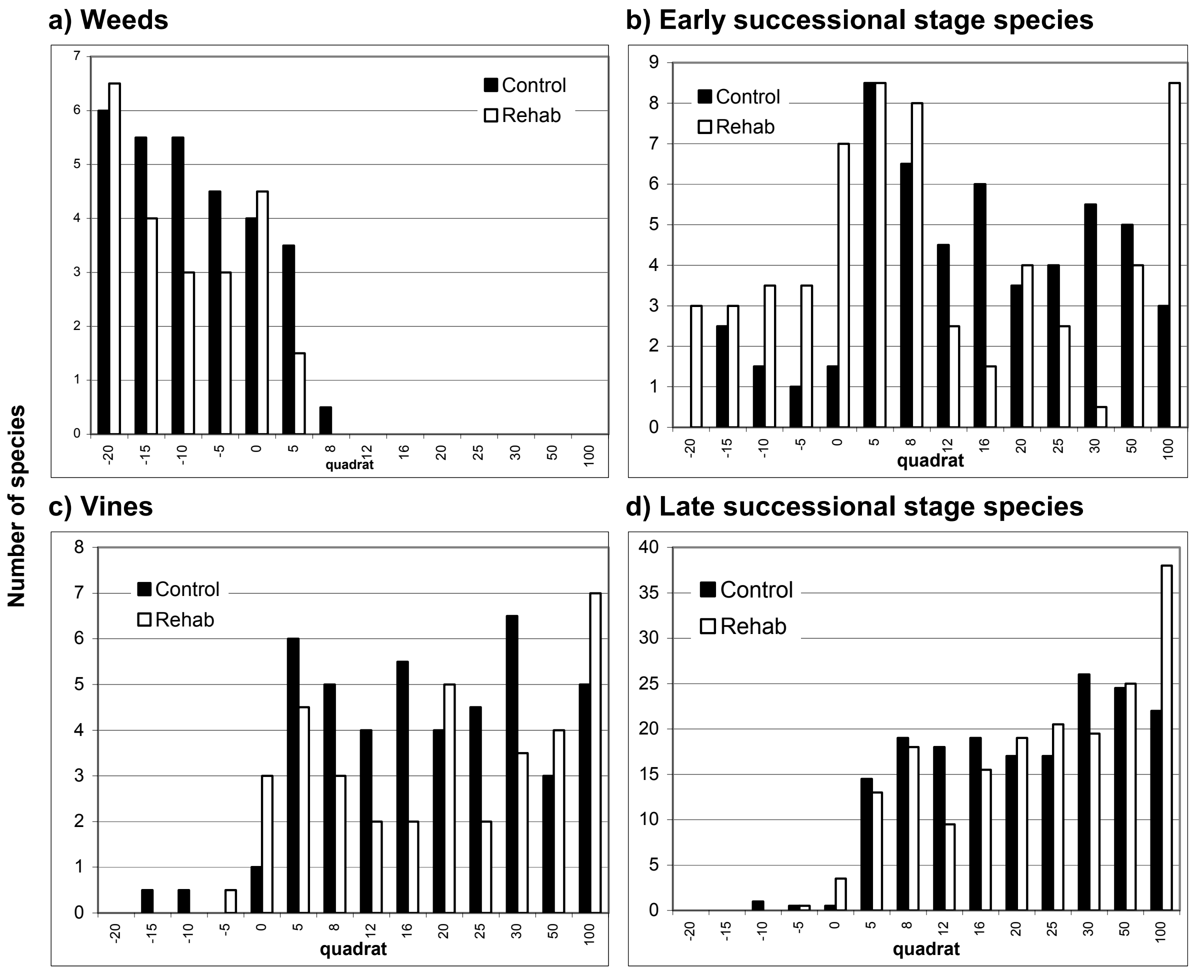


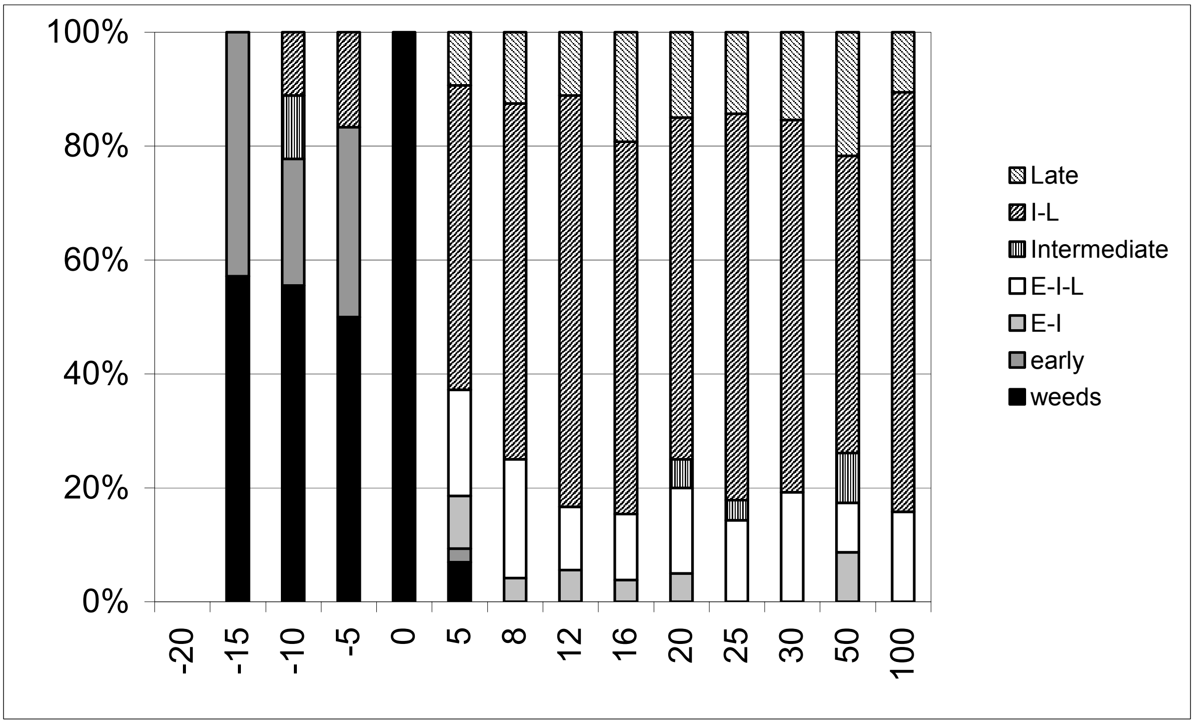
Figure 3.3: Mean numbers of species of weeds, vines, early and late successional species in quadrats along control and rehabilitation site transects.

3.4.2 Edge Effects in Floristic Composition

Edge effects in floristic composition were demonstrated both at control and rehabilitation sites (Figure 3.4, 3.5). The percentage of early, early to intermediate and early to intermediate to late species was elevated in the vicinity of the rainforest edge (five metre quadrat) in terms of number of species and abundance. Once inside the rainforest, the vast majority of species and individuals come from the intermediate to late or late categories (Figures 3.4, 3.5). Figure 3.5 demonstrates the percentage abundance of species in each of the successional stage classifications by weighting dominant species as twenty, common as ten, occasional as three and rare as one. The dominance of weeds in the clearing is obvious, as is their lack of penetration into the rainforest.

Species were not weighted with respect to their dominance of the canopy, but only with respect to their numerical dominance, percentage cover estimates were not obtained. The success of rehabilitation sites in providing canopy cover of rainforest species is not demonstrated in Figure 3.5, as only one of each planted tree species could occur within the five metre circular quadrat and therefore they were considered rare. However, the reduction in weed abundance is impressive and can be seen in the reduction of dominance of *Panicum maximum* (Guinea grass), *Melinis minutiflora* (molasses grass) and *Ageratum conyzoides* (blue top) to merely common or occasional in favour of more shade-tolerant species including native species.

a) Control Site 1



b) Rehabilitation Site 2

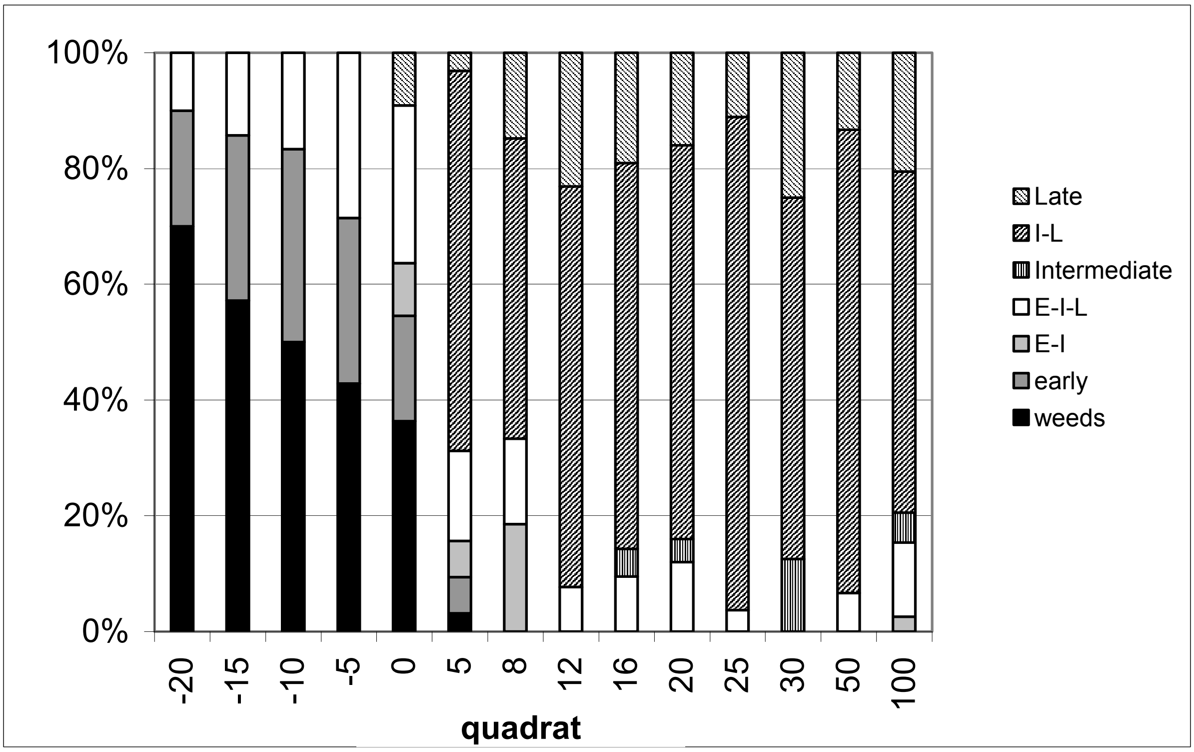
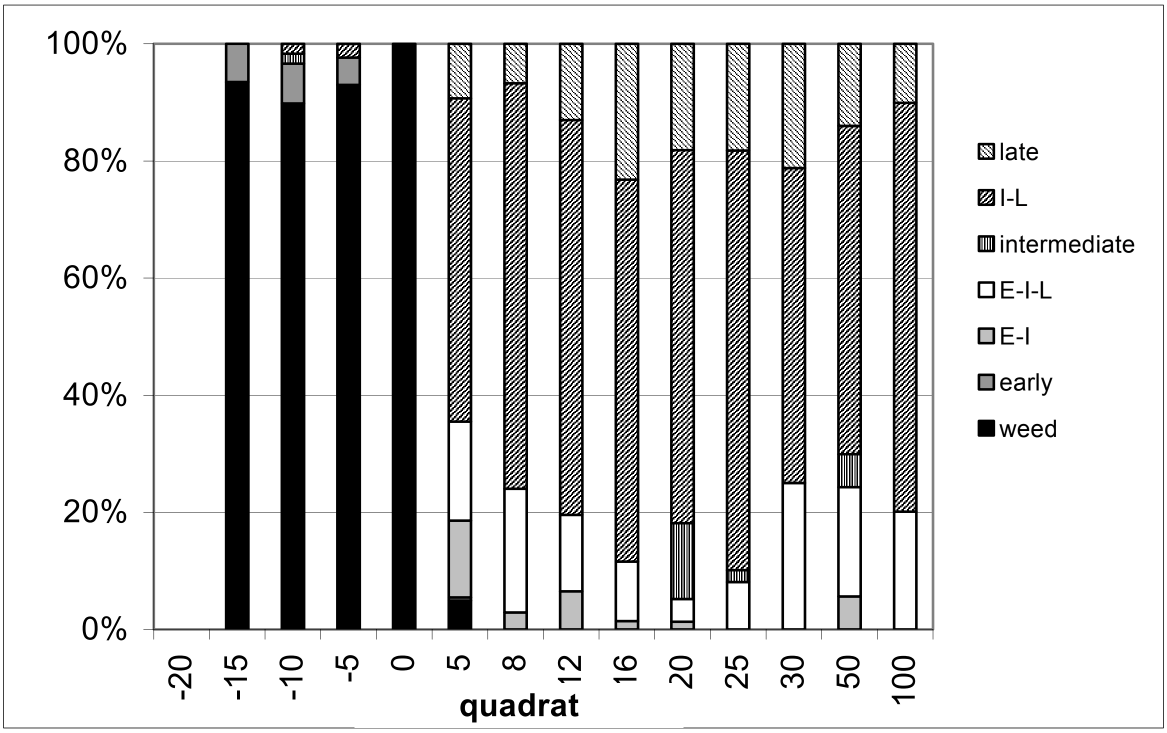


Figure 3.4: Percentage of species number in each successional stage found in each quadrat of 5m radius. Species are classified as occurring as weeds or in early (E), intermediate (I) and late (L) successional stages (Tucker and Murphy, 1995; Tucker 2002).

a) Control Site 1



b) Rehabilitation Site 2

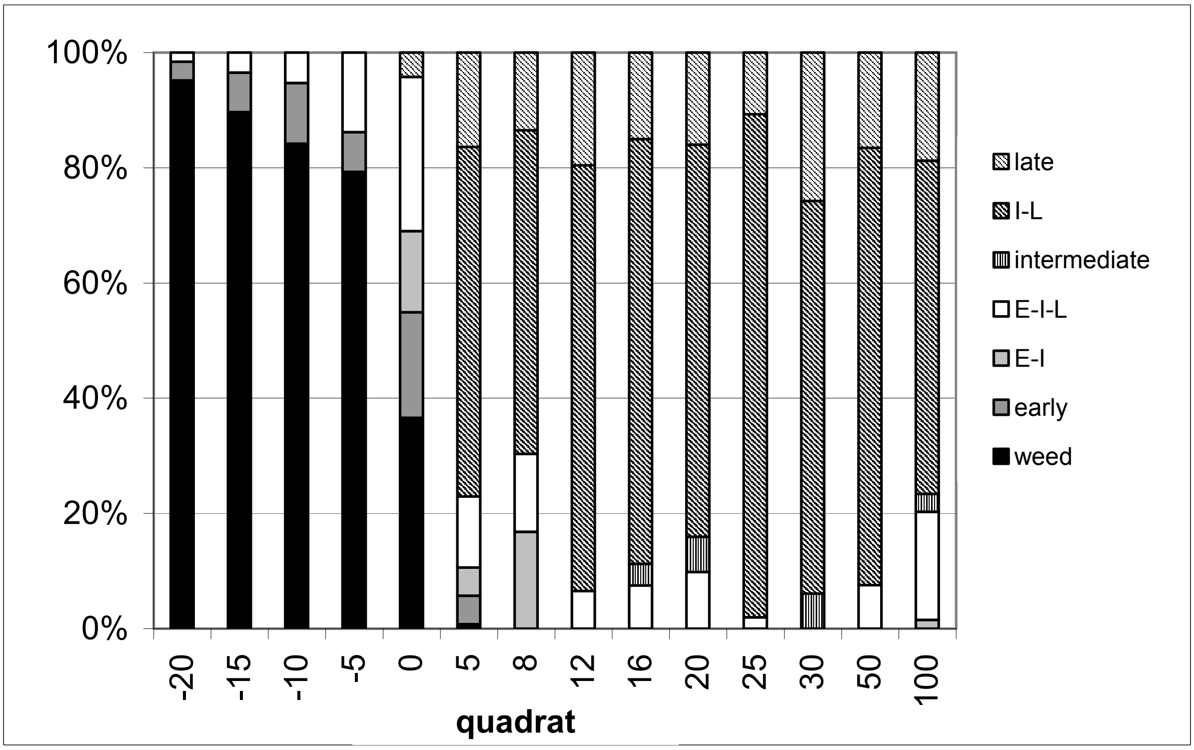


Figure 3.5: Abundance of species found in each successional stage expressed as a percentage of total abundance. Occurrence categories weighted as dominant 20, common 10, occasional 3, rare 1.

3.4.3 Classification and Ordination of Quadrats on Transects

Differences in floristic composition between quadrats on transects were demonstrated by examples of complementary two-dimensional ordination using non-metric multi-dimensional scaling and hierarchical agglomerative classification analysis for Control Site 1 in Figure 3.6 and 3.7 and Rehabilitation Site 2 in Figure 3.8 and 3.9. Results for Control Site 2 and Rehabilitation Site 1 are presented in Appendix 2.3. One metre quadrat data were not found to produce ecologically interpretable ordinations or classifications, probably due to the variability inherent in a quadrat of small size, and thus the five metre quadrat data are presented here.

Hierarchical cluster analyses and ordinations were in close agreement concerning groupings. Each demonstrated four groups of quadrats:

1) A group from the powerline clearing;
2) A group from the edge;
3) A group from the rainforest interior; and
4) One or two groups from the far interior.

Table 3.1: Composition of classification and ordination quadrat groups for the four transects.

	Quadrat Locations Included in Group			
Group	**Clearing**	**Edge**	**Interior**	**Far Interior**
Control 1	-15, -10, -5	0, 5, 8, 12	16, 20, 25, 30	50, 100
Control 2	-20, -15, -10, -5, 0	5, 8	12, 16, 20	50, 100; 25, 30
Rehabilitation 1	-20, -15, -10, -5, 0	5, 8, 12	16, 20, 25, 30	50, 100
Rehabilitation 2	-20, -15, -10, -5	0, 5, 8	12, 16, 20, 25, 30, 50	100

The composition of these groups was similar across the four transects but varied slightly between transects, particularly with respect to the edge and far interior groups (Table 3.1). At two of the sites (Control 1 and Rehabilitation 1), the edge group included the twelve metre quadrat. This suggests that edge changes in floristic composition extend to seven metres in distance from the edge, rather than the three metres found at the other two transects. A second group that may relate to less obvious edge effects in floristic composition include those of the near interior. Again the extent to which these possible edge effects penetrate varies. In one case the far interior group included only the one hundred metre quadrat, whereas in another, the far interior group included quadrats from twenty-five metres inwards.

Key to Figure 3.6 – Figure 3.10

- CON1 = control site 1; N5 = -5 metre quadrat; M0 = 0m quadrat; B – data from quadrats of 5m radius;
- REH2 = rehabilitation site 2; N20 = -20m quadrat; M12 = 12m quadrat; M5 = 5m quadrat i.e. edge.

Hierarchical Agglomerative Clustering, Ward's Method:
Rescaled Distance Cluster Combine

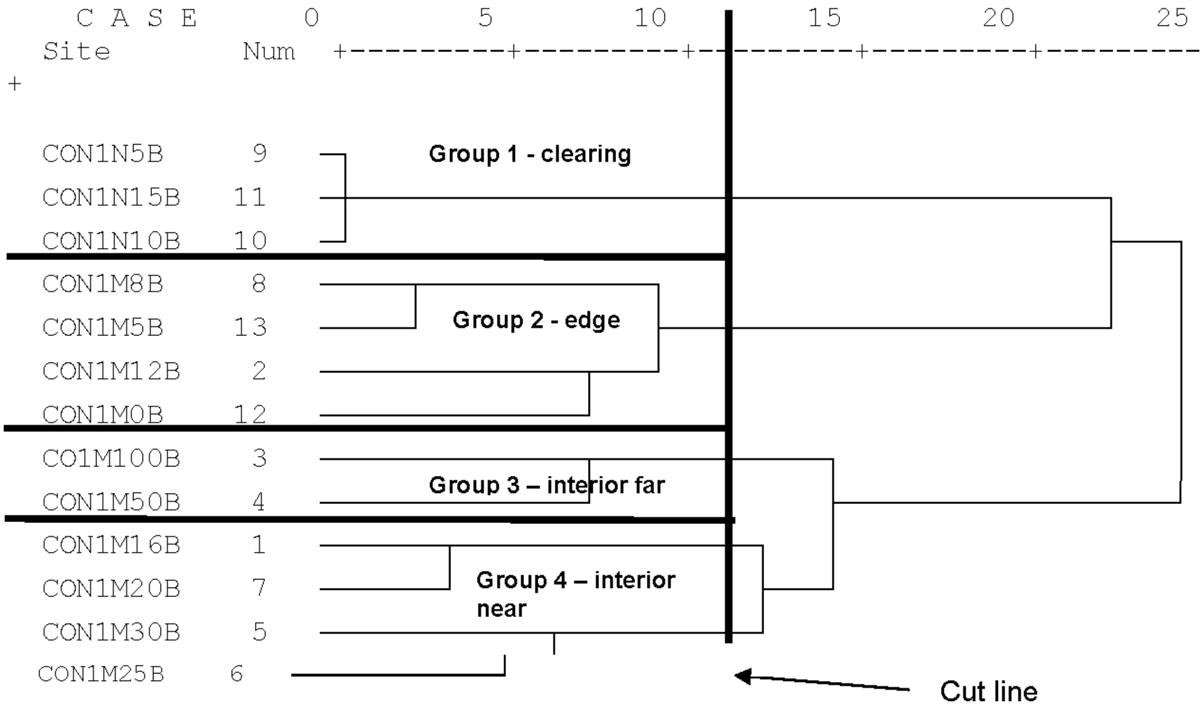


Figure 3.6: Classification of presence / absence data for quadrats from Control Site 1.

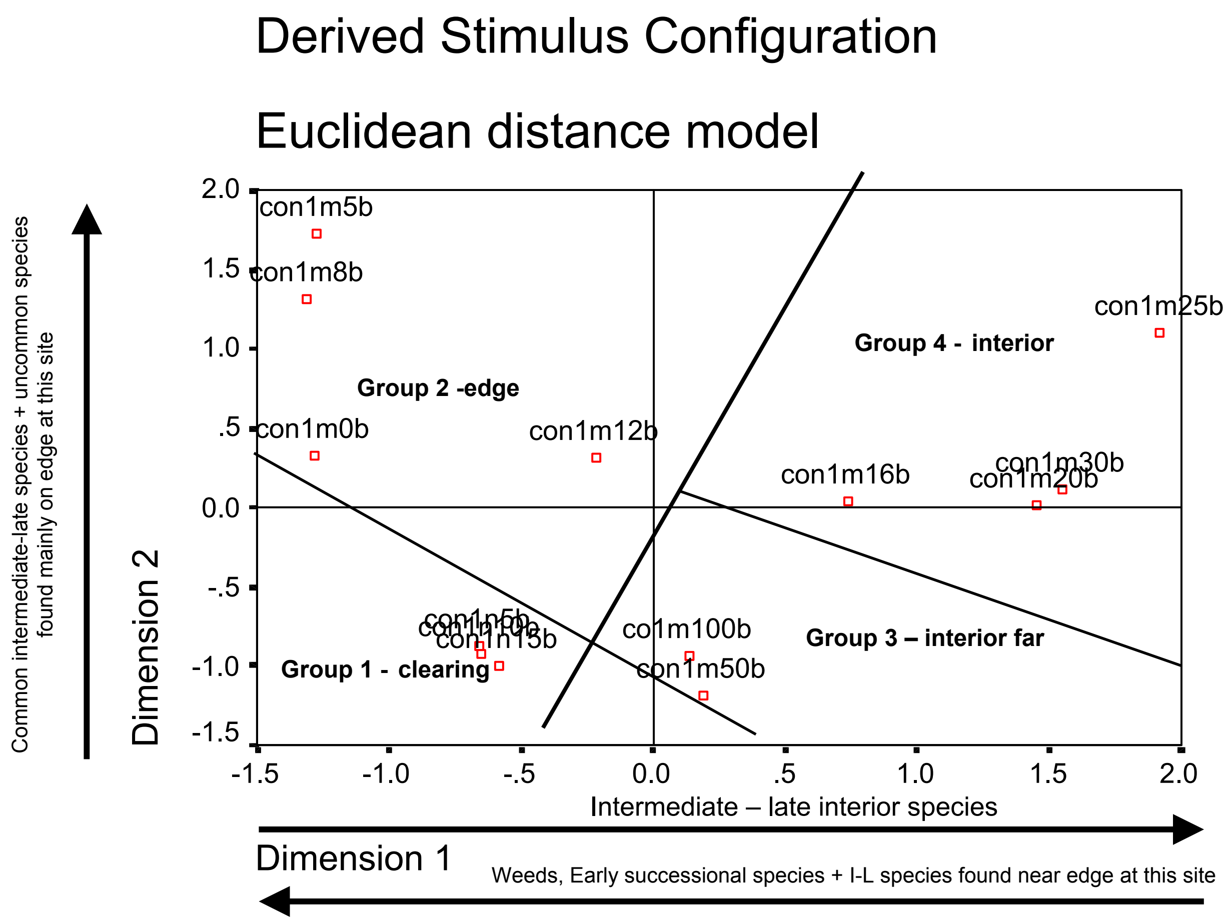


Figure 3.7: Non-metric multidimensional scaling of presence / absence data from Control Site 1.

Hierarchical Agglomerative Clustering, Ward's Method
Rescaled Distance Cluster Combine

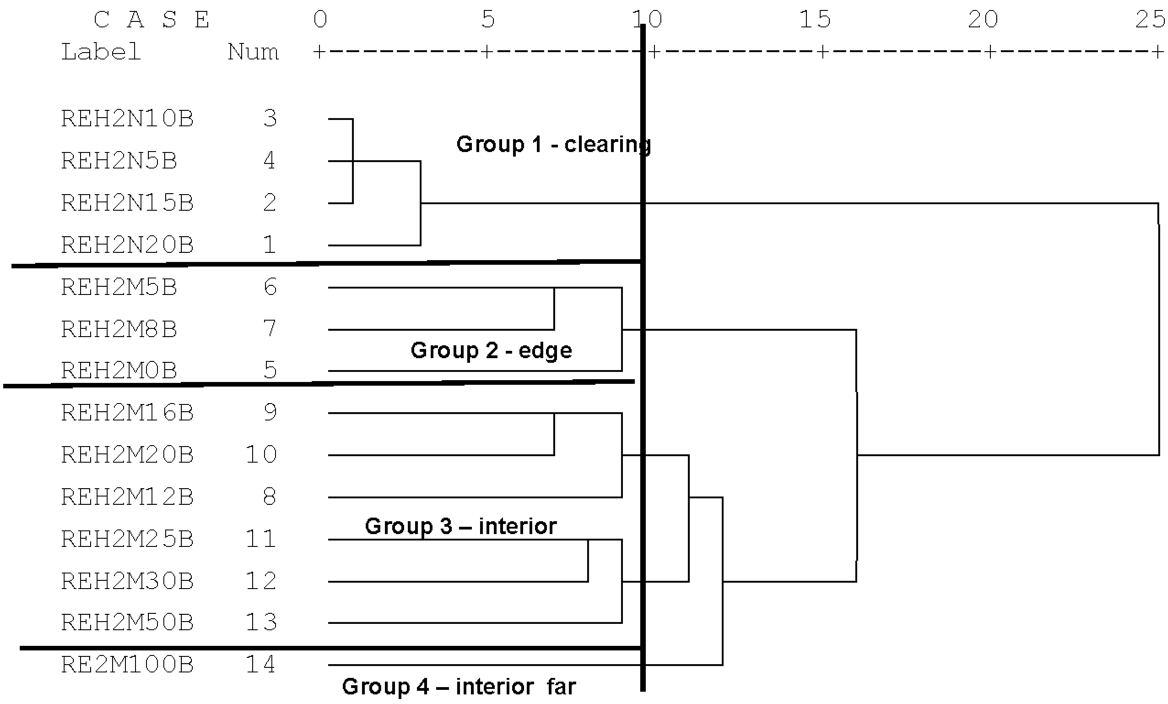


Figure 3.8: Classification of presence / absence data for quadrats from Rehabilitation Site 2.

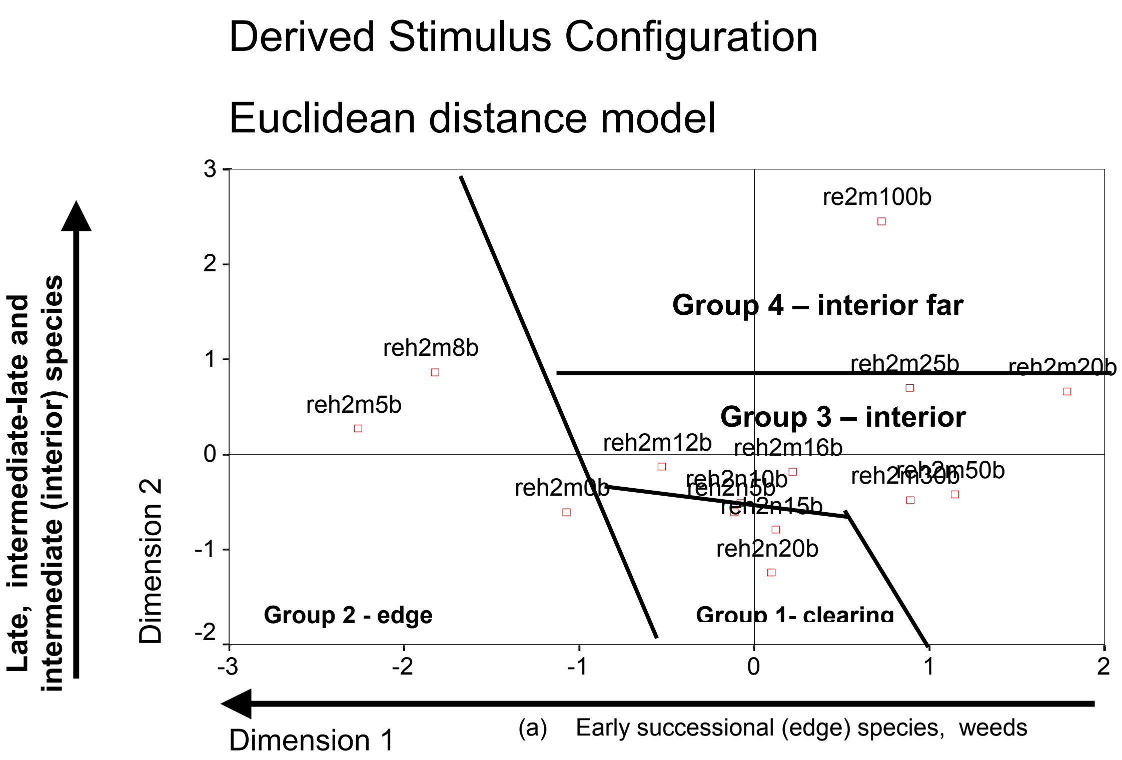


Figure 3.9: Non-metric multidimensional scaling of presence / absence data from Rehabilitation Site 2.

The age of this powerline corridor, constructed in the 1950's, suggests that edge effects from linear clearings may cause long-term changes in floristic composition. It appears that rainforest at the edge of the corridor has gradually expanded into the clearing over the past ten years in some places (personal observation), where such expansion was not completely prevented by shading or competition from weeds. Thus we would expect the current edge to demonstrate an altered floristic composition and to include many more early successional stage rainforest species, as these are the species likely to survive occasionally in competition with the dominant weeds. However, the floristic composition appears to be altered to greater distances when a quadrat of five metre radius at ninety-five metres into the forest is used as the point of comparison. At one site, this alteration in floristic composition appeared only to occur within twenty metres of the edge, whilst in others it may reach forty-five metres or more. However, collection of data from a greater number of transects will produce a much more reliable estimate of this distance.

When all five metre radius quadrats were classified using hierarchical agglomerative clustering, the obvious differences between quadrats within the clearing and those within the rainforest was demonstrated by the first major division of the dendrogram (shown by dashed line in Figure 3.10). Within the clearing, the two treatments (rehabilitation Group 2 and control Group 1, Figure 3.10) were separated on the basis of the presence of the three species of planted early successional tree species and the reduction in grassy weed species. Rainforest interior sites tended to cluster together on the basis of site, rather than on distance from edge. However the rehabilitation site edges were relatively similar (Groups 8 and 9), as were the control site far interior quadrats (Group 4) and rehabilitation site far interior quadrats (Group 7, Figure 3.10). Thus, inter-site variability in this diverse Complex Mesophyll Vine Forest at present partially obscures edge effects in floristic composition when examined on a larger scale, although edge and far interior quadrats do cluster together in some cases. Further sites will serve to clarify these less obvious divisions.

3.4.4 Soil Seed Bank

Little data was obtained from this section of the study, though species germinating in soil samples from the clearing appeared to be only weeds, mainly herbaceous weeds rather than grasses. Soil samples from the rainforest interior have a variety of species germinating, again many appear to be weeds together with some early successional species. Few weeds germinated beyond a distance of about twenty-five metres from the rainforest edge. However, the majority of rainforest species were difficult to identify and suffered damage in the greenhouse before the experiment was complete.

3.5 CONCLUSION

Weeds dominated the clearing at the sites where rehabilitation has not been undertaken. At the rehabilitation sites weeds were still common under the low canopy but the type of weed has changed to include more herbaceous species and fewer grass species. The abundance of weeds has also been dramatically reduced, particularly the grasses which dominate in the clearing elsewhere; they are only common or occasional under the rehabilitation canopy. Although the age of the rehabilitation plantings is still relatively young, rehabilitation is having a positive impact on the weeds of the clearing. Reduction in the abundance of fire-promoting grasses, such as Molasses grass and Guinea grass, must be considered as demonstrating early success of the rehabilitation plantings

Hierarchical Agglomerative Clustering, Ward's method:
Rescaled Distance Cluster Combine

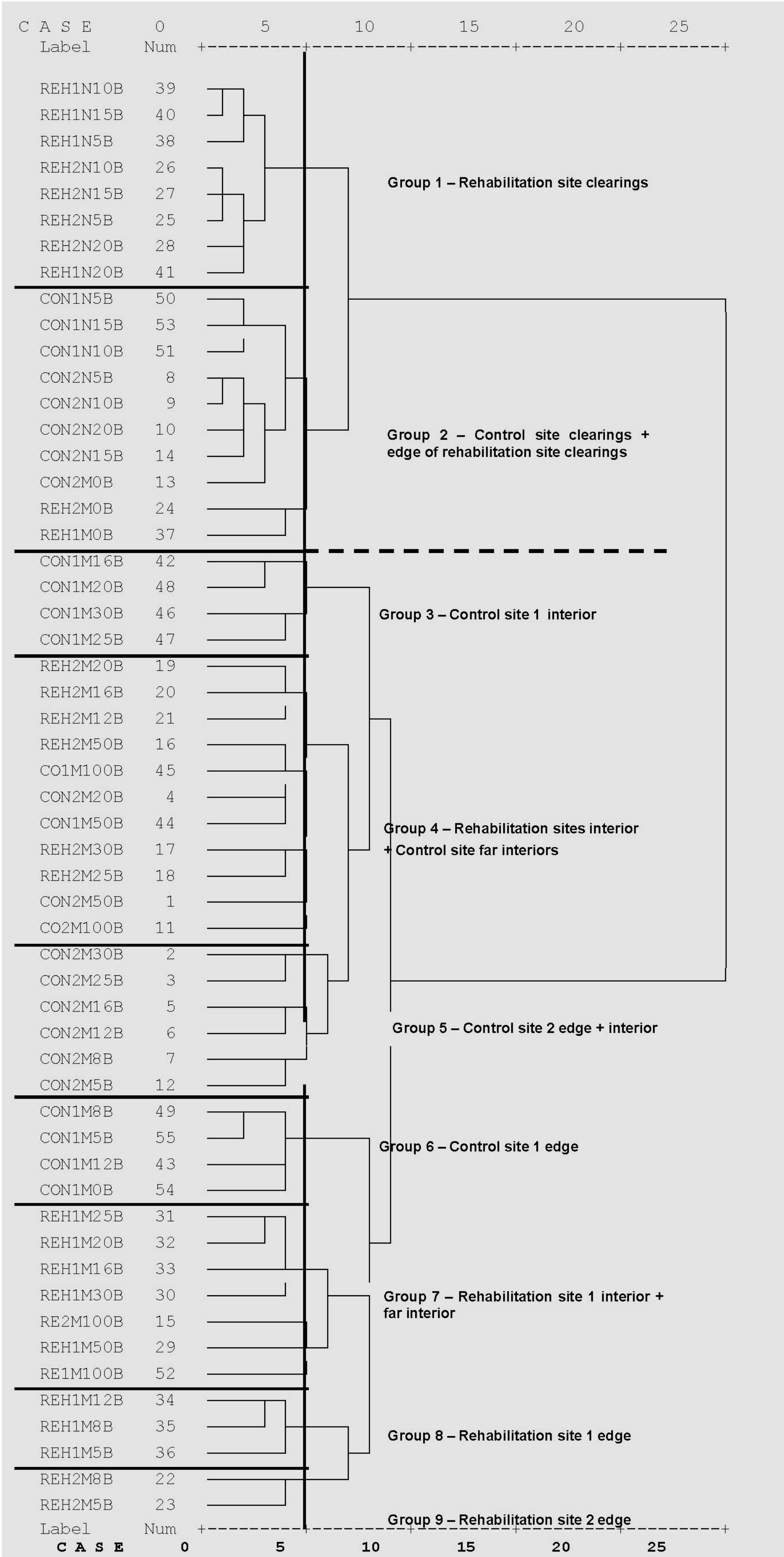


Figure 3.10: Classification of presence / absence data for quadrats from all four transects.

Edge effects in floristic composition have been demonstrated at the four sites along the Palmerston powerline corridor sampled to date. Floristics have been altered in favour of early successional (pioneer or edge) species in a band adjacent to the clearing that varies between three metres and seven metres in width. At the edge, the rainforest may be expanding into the clearing in some areas; however, a second group of floristic changes have been detected using classification and ordination techniques. These floristic alterations penetrate to distances varying between twenty and forty-five metres, demonstrating much longer-term and more insidious changes than those on the edge. These changes appear to show that the presence of a weedy linear clearing passing through rainforest can result in alterations to floristic composition adjacent to the edge for considerable distances. Such alteration in habitat may have flow-on effects for other floral and faunal species in terms of indirect biotic changes such as alterations in species interactions (pollination, predation, competition, herbivory, seed dispersal etc).

3.6 RECOMMENDATIONS

- Completion of the study to include several more transects with differing edge aspects on the control and rehabilitation sites at the Palmerston powerline clearing.
- Completion of the study to include a similar number of transects from the Palmerston highway near to the powerline clearing sites to provide a direct comparison.
- Completion of the study to include analysis of soil seed bank results..

3.7 MANAGEMENT IMPLICATIONS

- Success of the rehabilitation works has already started to manifest itself after only two and a half years in terms of reduction in fire-promoting grassy weeds.
- If the powerline is to remain *in situ* for several more years (rather than be removed as was mooted when these rehabilitation works were first undertaken), removal of trees should only be contemplated where their growth is a source of imminent danger to the powerline. Lopping should be considered as an alternative to removal as these rehabilitation plantings are already serving a useful ecological function.
- The dominance of weeds within the powerline clearing almost eliminates the possibility of native species recolonisation without assistance in terms of restoration works. Where fires have been less frequent over recent years, woody weeds including *Lantana camara* (lantana) and *Rubus alceifolius* (Giant bramble) are spreading across the clearing. These weeds can also prevent recolonisation by native species. Further restoration works within the powerline clearing are necessary if the recovery of native habitat is the goal.
- Edge effects that penetrate from the rainforest edge to distances of three to seven metres were expected in this study. However, the floristic alterations demonstrated to distances of between twenty to forty-five metres suggest a more insidious, long-term and widespread effect of wide linear clearings on floristic composition. Such changes could have a flow-on effect to other flora and fauna of the rainforest.
- The distance of these changes may mean that a larger area of the Wet Tropics World Heritage Area than was previously thought may be altered due to linear clearings through the rainforest. As this powerline clearing was created in the 1950s, reduction of these changes after removal of linear clearings may be a long-term process.

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APPENDIX 1.1

WEED SURVEYS ALONG THE CHALUMBIN-WOREE POWERLINE NETWORK

Key D = Dominant
C = Common
O = Ocassional
R = Rare
+ = Incidental occurrence nearby
* = Denotes a weed species

Site	**Tower 10091 Bridle Creek**				**Tower 10096 Bridle Creek**				**Tower 10094 Bridle Creek**			
	351336 E		**8121985 N**		**353531 E**		**8121669 N**					
	Abundance Rank				**Abundance Rank**				**Abundance Rank**			
Species	**0-5**	**5-10**	**10-20**	**20-30**	**0-5**	**5-10**	**10-20**	**20-30**	**0-5**	**5-10**	**10-20**	**20-30**
**Ageratum conyzoides*	C					C-D	C-D					
**Arundo donax*				+								
**Axonopus compressus*		C-D	C		C		C					
**Axonopus fissifolius*												
**Bidens pilosa*		O										
**Brachiaria decumbens*					D	C-D	D	D				D
**Centratherum punctatum* var. *punctatum*												
**Citrus limon*												
**Conyza leucantha*	C											
**Crotalaria goreensis*	O											
**Crotalaria lanceolata*					O							
**Cynodon dactylon*											R	
**Cyperus aromaticus*												
**Emilia sonchifolia*												
**Euphorbia hirta*			R									
**Hyptis capitata*					O							
**Hyptis suaveolens*		C										
**Indigofera suffruticosa*				O								R
**Lantana camara camara*	O	O		C		C	C-D	C	D	D	C	O
**Macroptilium atropurpureum*				O	C							O
**Melinis minutiflora*	C		D					C			C-D	D
**Melinis repens*				O						O		
**Mimosa pudica*		C	O		C					C		
**Mitracarpus hirtus*												
**Panicum maximum*								C				
**Paspalum conjugatum*												
**Paspalum paniculatum*	C	D	D					C				O
**Passiflora edulis*							R					

Site	Tower 10091 Bridle Creek				Tower 10096 Bridle Creek				Tower 10094 Bridle Creek			
	351336 E		8121985 N		353531 E		8121669 N					
	Abundance Rank				Abundance Rank				Abundance Rank			
Species	0-5	5-10	10-20	20-30	0-5	5-10	10-20	20-30	0-5	5-10	10-20	20-30
**Passiflora foetida*		O										
**Polygala paniculata*	C				O					C	O	
**Praxelis clematidea*			O	C								
**Richardia brasiliensis*			O								C	
**Rubus alceifolius*												
**Scoparia dulcis*			C		O							
**Sida rhombifolia*	C	O										
**Solanum americanum*					O							
**Solanum mauritianum*												
**Solanum torvum*												+
**Spermacoce latifolia*	O											
**Sporobolus jacquemontii*				O								O
**Sporobolus jacquemontii*					C					O		
**Stachytarpheta jamaicensis*	C-D	D	D	C-D	O	C-D	C	C			C	C-D
**Stylosanthes humilis*	C	C	O									R
**Tagetes minuta*												+
**Tristemma mauritianum*												
**Urena lobata*	O											
Abrophyllum ornans												
Acacia celsa				O	P	O		C				
Acacia polystachya	O		O	C								
Acacia simsii			O		C							C
Agathis robusta			P		P							
Aleurites rockinghamensis							R					
Alloteropsis semialata	C											
Alphitonia excelsa			R								R	
Alphitonia incana	O			O								
Alphitonia petriei			P		P	P	R					P
Alpinia arctiflora												
Alpinia caerulea								O	O			
Alstonia muelleriana		O					R	C				
Alyxia grandis					R	R	O					
Aphananthe philippinensis		O										
Archidendron ramiflora												+
Archirhodomyrtus beckleri												
Arytera pauciflora			P									
Atractocarpus fitzalani												P
Austrosteenisia stipularis												
Blechnum cartilagineum												
Blechnum orientale								+				

Site	**Tower 10091 Bridle Creek**				**Tower 10096 Bridle Creek**				**Tower 10094 Bridle Creek**			
	351336 E		**8121985 N**		**353531 E**		**8121669 N**					
	Abundance Rank				**Abundance Rank**				**Abundance Rank**			
Species	**0-5**	**5-10**	**10-20**	**20-30**	**0-5**	**5-10**	**10-20**	**20-30**	**0-5**	**5-10**	**10-20**	**20-30**
Breynia oblongifolia			O									
Breynia stipitata		R										
Buckinghamia celsissima		P			P			P				
Calamus australis								+	O			
Calamus caryotoides							R			R	O	
Calamus motii												
Caldcluvia australiensis												
Cardwellia sublimis												
Carex indica		O							O			
Carnarvonia araliifolia			R			R	P					
Carronia pedicellata						R						
Castanospermum australe												
Centella asiatica												
Christella dentata												
Chrysopogon aciculatus		O								O		
Cissus hypoglauca								R				
Cissus penninervis												
Claoxylon tenerifolium												
Cleistanthus semiopacus												P
Clerodendrum longiflorum var. *glabrum*								R				
Coveniella poecilophlebia									R			
Cupaniopsis foveolata										R		
Cyathea cooperi								R				
Cyathea rebeccae												
Cyperus polystachyos					O							
Cyperus sphacelatus					O		C					
Dalbergia densa												
Darlingia darlingiana												
Decaspermum humile						R						
Derris sp. Daintree		O										
Desmodium nemorosum												
Desmodium triflorum	O											
Dianella atraxis												
Dianella caerulea		C					R					
Dicranopteris linearis												
Digitaria parviflora					C							
Dioscorea transversa		R										
Drynaria rigidula						O						
Drypetes deplanchei		O		O								
Duboisia myoporoides	R											

Site	Tower 10091 Bridle Creek				Tower 10096 Bridle Creek				Tower 10094 Bridle Creek			
	351336 E		8121985 N		353531 E		8121669 N					
	Abundance Rank				Abundance Rank				Abundance Rank			
Species	0-5	5-10	10-20	20-30	0-5	5-10	10-20	20-30	0-5	5-10	10-20	20-30
Elaeocarpus bancroftii												
Elaeocarpus grahamii												
Elaeocarpus grandis			P		P							
Embelia australiana						O		R				
Entolasia stricta												
Eragrostris elongata					C							
Eriachne sp.				O								
Euroschinus falcata		O								O		
Eustrephus latifolius									O			
Ficus congesta					R			R				
Ficus opposita			O									
Ficus septica												
Fimbristylis dichotoma												
Flagellaria indica								+		C		
Flindersia bourjotiana					P				R			
Flindersia pimenteliana												
Flindersia schottiana	R											
Gahnia aspera				O		O		C				
Gahnia sieberiana												
Gardenia ovularis												
Geitonoplesium cynosum		O		O					O			
Glochidion harveyanum		O								R		
Glochidion hylandii						R						
Glochidion sumatranum			P			R						
Gmelina fasciculiflora							O					
Grevillea baileyana						R		R		R		P
Guioa acutifolia			P		P						O	
Guioa lasioneura												
Hedycarya loxocarya												
Hibbertia scandens							O	O				
Homalium circumpinnatum		O		O								
Hypericum gramineum					C							
Hypserpa decumbens												
Hypserpa laurina				R								+
Ichnocarpus frutescens	R			C					R	R		
Imperata cylindrica	C-D				O	C-D	O	C-D				+
Ischaemum australe												O
Jagera dasyantha												
Jagera pseudorhus		O		C			R					
Jasminum didymum	C	C		O					R	O		

Site	**Tower 10091 Bridle Creek**				**Tower 10096 Bridle Creek**				**Tower 10094 Bridle Creek**			
	351336 E		**8121985 N**		**353531 E**		**8121669 N**					
	Abundance Rank				**Abundance Rank**				**Abundance Rank**			
Species	**0-5**	**5-10**	**10-20**	**20-30**	**0-5**	**5-10**	**10-20**	**20-30**	**0-5**	**5-10**	**10-20**	**20-30**
Leucopogon spathaceus												+
Ligustrum australianum											O	
Lindsaea brachypoda												
Litsea fawcettiana				+								
Litsea leefeana												
Lophostemon confertus				O								
Lophostemon suaveolens				C								
Lycopodiella cernua												
Lygodium reticulatum												
Macaranga involucrata					P	O	C	R		O	R	
Macaranga tanarius					P	O						
Maclura cochincinensis											R	
Maesa dependens								+				
Mallotus mollissimus												
Mallotus paniculatus							O					
Mallotus philippensis		O									O	
Maytenus fasciculiflora			R									
Melastoma affine						C	C	C				
Melicope elleryana			P		P	P						
Melicope xanthoxyloides												
Micromelum minutum		O							R		C	
Mischocarpus pyriformis										R		
Neolitsea dealbata												
Neosepicaea jucunda												
Omalanthus novo-guineensis		O				O						
Pachygone ovata										R	R	
Palmeria scandens												
Pandanus monticola								+				
Parsonsia latifolia							R					
Paspalum scrobiculatum		O			C							
Passiflora sp. Kuranda												
Pavetta australiensis		O	O									
Piper novae-hollandiae												
Pittosporum venulosum				+						O	O	
Pittosporum wingii												
Placospermum coriaceum					P							
Polyalthia nitidissima				R					R			
Polyscias australiana								R				
Polyscias elegans			O								O	
Polyscias murrayi												

Site	Tower 10091 Bridle Creek				Tower 10096 Bridle Creek				Tower 10094 Bridle Creek			
	351336 E		8121985 N		353531 E		8121669 N					
	Abundance Rank				Abundance Rank				Abundance Rank			
Species	0-5	5-10	10-20	20-30	0-5	5-10	10-20	20-30	0-5	5-10	10-20	20-30
Pouteria chartacea						O						
Rapanea variabilis												P
Rhodomyrtus macrocarpa									R			
Ripogonum album					R		O			O		
Rubus moluccanus								O				
Rubus probus												
Salacia disepala							R					
Sarcopteryx martyana												
Sarcopteryx reticulata												
Scaevola enantophylla												
Schefflera actinophylla												
Scolopia braunii									R			
Sida cordifolia	C		C								C	
Smilax australis		C					R	R		O		
Stephania japonica						R			R			
Symplocos cochinchinensis								R				
Syzygium cormiflorum					P							
Syzygium papyraceum					P							
Syzygium tierneyanum							P					
Tabernaemontana pandacaqui												
Tarenna dallachiana	R											
Terminalia sericocarpa			P		P	O						
Tetracera daemeliana												
Tetracera nordtiana								+				
Themeda triandra	D	D	D	D								
Timonius timon						R						
Toona ciliata											R	
Tristaniopsis exiliflora			P									
Ventilago ecorollata				+			R					
Wikstroemia indica	O	O								O		
Xanthophyllum octandrum		O										
Xylopia maccreae											R	
Zanthoxylon ovalifolium									R	R		

APPENDIX 1.1 (CONT'D)

Site	Tower 10109, Copperlode				Tower 10108, Copperlode				Tower 10104, Shoteel Creek			
	Abundance Rank				Abundance Rank				Abundance Rank			
Species	0-5	5-10	10-20	20-30	0-5	5-10	10-20	20-30	0-5	5-10	10-20	20-30
Ageratum conyzoides	C		O						O			
Arundo donax												
Axonopus compressus			C									
Axonopus fissifolius									C		C	
Bidens pilosa												
Brachiaria decumbens												
Centratherum punctatum var. punctatum		C										
Citrus limon				R							C	
Conyza leucantha												
Crotalaria goreensis												
Crotalaria lanceolata												
Cynodon dactylon												
Cyperus aromaticus		C-D	C-D	C								O
Emilia sonchifolia												
Euphorbia hirta												
Hyptis capitata				R					C			
Hyptis suaveolens												
Indigofera suffruticosa												
Lantana camara camara	O											
Macroptilium atropurpureum											O	
Melinis minutiflora	C-D		O	C-D						C-D	C-D	C-D
Melinis repens												
Mimosa pudica	C	C	C	C						C		
Mitracarpus hirtus												
Panicum maximum									C	C		
Paspalum conjugatum									C			
Paspalum paniculatum	C	C	C-D	C					C-D	C	C-D	C
Passiflora edulis												
Passiflora foetida												
Polygala paniculata	C	C	C	C					C		O	
Praxelis clematidea									O		O	
Richardia brasiliensis												
Rubus alceifolius					R					C	C	c-d
Scoparia dulcis												
Sida rhombifolia									O	C		
Solanum americanum												
Solanum mauritianum												
Solanum torvum												

Site	Tower 10109, Copperlode				Tower 10108, Copperlode				Tower 10104, Shoteel Creek			
	Abundance Rank				Abundance Rank				Abundance Rank			
Species	0-5	5-10	10-20	20-30	0-5	5-10	10-20	20-30	0-5	5-10	10-20	20-30
**Spermacoce latifolia*												
**Sporobolus jacquemontii*		C							C-D		C	
**Sporobolus jacquemontii*												
**Stachytarpheta jamaicensis*	C	O	C	C					C-D	C-D	C-D	C-D
**Stylosanthes humilis*		C		C					C			
**Tagetes minuta*												
**Tristemma mauritianum*	C	C	C	C								
**Urena lobata*	C	C	C						O			
Abrophyllum ornans												
Acacia celsa	R			O	O					C	O	R
Acacia polystachya												
Acacia simsii		O		C						C		
Agathis robusta												
Aleurites rockinghamensis												
Alloteropsis semialata												
Alphitonia excelsa											R	
Alphitonia incana												
Alphitonia petriei	R		O	R						O	C	R
Alpinia arctiflora				O								
Alpinia caerulea												
Alstonia muelleriana	C	R		C	R					C		C
Alyxia grandis												
Aphananthe philippinensis												
Archidendron ramiflora												
Archirhodomyrtus beckleri			O									
Arytera pauciflora												
Atractocarpus fitzalani												
Austrosteenisia stipularis											O	
Blechnum cartilagineum			O							R		
Blechnum orientale										C		
Breynia oblongifolia												
Breynia stipitata	R											
Buckinghamia celsissima												
Calamus australis												C
Calamus caryotoides												
Calamus motii											C	
Caldcluvia australiensis	R		R	R								
Cardwellia sublimis												R
Carex indica												
Carnarvonia araliifolia				R								R
Carronia pedicellata												

Site	**Tower 10109, Copperlode**				**Tower 10108, Copperlode**				**Tower 10104, Shoteel Creek**			
	Abundance Rank				**Abundance Rank**				**Abundance Rank**			
Species	**0-5**	**5-10**	**10-20**	**20-30**	**0-5**	**5-10**	**10-20**	**20-30**	**0-5**	**5-10**	**10-20**	**20-30**
Castanospermum australe												
Centella asiatica		R										
Christella dentata												
Chrysopogon aciculatus				C							C	D
Cissus hypoglauca	R											
Cissus penninervis				R								
Claoxylon tenerifolium												
Cleistanthus semiopacus												
Clerodendrum longiflorum var. *glabrum*												
Coveniella poecilophlebia												
Cupaniopsis foveolata												
Cyathea cooperi		O								O	C	
Cyathea rebeccae	R		C								C	
Cyperus polystachyos												
Cyperus sphacelatus									C			
Dalbergia densa				C-D								
Darlingia darlingiana												
Decaspermum humile										O	R	
Derris sp. Daintree												
Desmodium nemorosum												
Desmodium triflorum		C							C			
Dianella atraxis										O		R
Dianella caerulea												
Dicranopteris linearis	C	C		C-D	D					C-D	C-D	C-D
Digitaria parviflora												
Dioscorea transversa												
Drynaria rigidula												
Drypetes deplanchei												
Duboisia myoporoides												
Elaeocarpus bancroftii	R											
Elaeocarpus grahamii				R								
Elaeocarpus grandis												
Embelia australiana												
Entolasia stricta												C-D
Eragrostris elongata										C		
Eriachne sp.												
Euroschinus falcata												
Eustrephus latifolius												
Ficus congesta												
Ficus opposita												
Ficus septica												

Site	Tower 10109, Copperlode				Tower 10108, Copperlode				Tower 10104, Shoteel Creek			
	Abundance Rank				Abundance Rank				Abundance Rank			
Species	0-5	5-10	10-20	20-30	0-5	5-10	10-20	20-30	0-5	5-10	10-20	20-30
Fimbristylis dichotoma		R		C								
Flagellaria indica	R		O							O	O	O
Flindersia bourjotiana										P		
Flindersia pimenteliana	R											
Flindersia schottiana												
Gahnia aspera												
Gahnia sieberiana	C		C-D	C-D	C				C	C	O	C-D
Gardenia ovularis				R							C-D	
Geitonoplesium cynosum												
Glochidion harveyanum												
Glochidion hylandii												
Glochidion sumatranum	O									R	O	
Gmelina fasciculiflora												
Grevillea baileyana					R					R	R	R
Guioa acutifolia												
Guioa lasioneura											O	
Hedycarya loxocarya				R						R		
Hibbertia scandens	C		O		R					O		
Homalium circumpinnatum												
Hypericum gramineum			C	O								
Hypserpa decumbens		O										
Hypserpa laurina			O							O		
Ichnocarpus frutescens	O											
Imperata cylindrica		C		C-D						C	C	
Ischaemum australe												
Jagera dasyantha										R		R
Jagera pseudorhus												
Jasminum didymum												
Leucopogon spathaceus												
Ligustrum australianum												
Lindsaea brachypoda			R									
Litsea fawcettiana												
Litsea leefeana			R									
Lophostemon confertus												
Lophostemon suaveolens												
Lycopodiella cernua	C	C	O	C-D	D				C-D	C-D		
Lygodium reticulatum	O	C	C	C-D					R	C		C
Macaranga involucrata												
Macaranga tanarius												
Maclura cochincinensis												
Maesa dependens		O		R								

Site	Tower 10109, Copperlode				Tower 10108, Copperlode				Tower 10104, Shoteel Creek			
	Abundance Rank				Abundance Rank				Abundance Rank			
Species	0-5	5-10	10-20	20-30	0-5	5-10	10-20	20-30	0-5	5-10	10-20	20-30
Mallotus mollissimus												
Mallotus paniculatus	R											R
Mallotus philippensis												
Maytenus fasciculiflora												
Melastoma affine										C	R	
Melicope elleryana												
Melicope xanthoxyloides		O										
Micromelum minutum												
Mischocarpus pyriformis												
Neolitsea dealbata	R											
Neosepicaea jucunda	R			C					R			
Omalanthus novo-guineensis										O		
Pachygone ovata												
Palmeria scandens					R							
Pandanus monticola												
Parsonsia latifolia	C	C	O	C	C				O		C	
Paspalum scrobiculatum	D	D	D	C								
Passiflora sp. Kuranda				R								
Pavetta australiensis												
Piper novae-hollandiae	R											
Pittosporum venulosum												
Pittosporum wingii												R
Placospermum coriaceum										R	R	R
Polyalthia nitidissima												
Polyscias australiana	O		C									O
Polyscias elegans											O	O
Polyscias murrayi												
Pouteria chartacea												
Rapanea variabilis												
Rhodomyrtus macrocarpa												
Ripogonum album									R			
Rubus moluccanus	C											O
Rubus probus				O							O	
Salacia disepala												
Sarcopteryx martyana				R								
Sarcopteryx reticulata												
Scaevola enantophylla	O	C										
Schefflera actinophylla										O	O	
Scolopia braunii												
Sida cordifolia												
Smilax australis											O	C

Site	Tower 10109, Copperlode				Tower 10108, Copperlode				Tower 10104, Shoteel Creek			
	Abundance Rank				Abundance Rank				Abundance Rank			
Species	0-5	5-10	10-20	20-30	0-5	5-10	10-20	20-30	0-5	5-10	10-20	20-30
Stephania japonica												
Symplocos cochinchinensis												
Syzygium cormiflorum										P		
Syzygium papyraceum												
Syzygium tierneyanum												
Tabernaemontana pandacaqui												R
Tarenna dallachiana	O											
Terminalia sericocarpa												
Tetracera daemeliana	O	C										
Tetracera nordtiana										O		
Themeda triandra												
Timonius timon												
Toona ciliata												
Tristaniopsis exiliflora												
Ventilago ecorollata												
Wikstroemia indica												
Xanthophyllum octandrum												
Xylopia maccreae												
Zanthoxylon ovalifolium												

APPENDIX 1.1 (CONT'D)

Site	Tower 10103, Shoteel Creek			
	Abundance Rank			
Species	0-5	5-10	10-20	20-30
**Ageratum conyzoides*	C-D	C-D	C-D	D
**Arundo donax*				
**Axonopus compressus*			O	
**Axonopus fissifolius*				
**Bidens pilosa*				
**Brachiaria decumbens*	D	D	D	D
**Centratherum punctatum* var. *punctatum*				
**Citrus limon*				
**Conyza leucantha*				
**Crotalaria goreensis*				
**Crotalaria lanceolata*				
**Cynodon dactylon*				
**Cyperus aromaticus*				
**Emilia sonchifolia*			R	
**Euphorbia hirta*				
**Hyptis capitata*		C-D		C
**Hyptis suaveolens*			C	
**Indigofera suffruticosa*				
**Lantana camara camara*		C		D
**Macroptilium atropurpureum*				
**Melinis minutiflora*			C-D	D
**Melinis repens*				
**Mimosa pudica*	C		C	
**Mitracarpus hirtus*			O	
**Panicum maximum*				
**Paspalum conjugatum*				
**Paspalum paniculatum*	C	C	C-D	D
**Passiflora edulis*				
**Passiflora foetida*				
**Polygala paniculata*		C		
**Praxelis clematidea*				
**Richardia brasiliensis*				
**Rubus alceifolius*		C		C
**Scoparia dulcis*	C	C	C	C
**Sida rhombifolia*	O			
**Solanum americanum*				
**Solanum mauritianum*		R	R	C
**Solanum torvum*				

Site	Tower 10103, Shoteel Creek			
	Abundance Rank			
Species	**0-5**	**5-10**	**10-20**	**20-30**
**Spermacoce latifolia*				
**Sporobolus jacquemontii*				
**Sporobolus jacquemontii*				
**Stachytarpheta jamaicensis*	C	C	C	C-D
**Stylosanthes humilis*				
**Tagetes minuta*				
**Tristemma mauritianum*				
**Urena lobata*		C	C	
Abrophyllum ornans				O
Acacia celsa		O	O	
Acacia polystachya				
Acacia simsii				
Agathis robusta				
Aleurites rockinghamensis				R
Alloteropsis semialata				
Alphitonia excelsa				
Alphitonia incana				
Alphitonia petriei	R		R	
Alpinia arctiflora				
Alpinia caerulea				O
Alstonia muelleriana				
Alyxia grandis				
Aphananthe philippinensis				
Archidendron ramiflora				
Archirhodomyrtus beckleri				
Arytera pauciflora				
Atractocarpus fitzalani				
Austrosteenisia stipularis				
Blechnum cartilagineum				
Blechnum orientale				
Breynia oblongifolia				
Breynia stipitata				
Buckinghamia celsissima				
Calamus australis				
Calamus caryotoides				
Calamus motii				
Caldcluvia australiensis				
Cardwellia sublimis				
Carex indica				
Carnarvonia araliifolia				
Carronia pedicellata				R

Site	Tower 10103, Shoteel Creek			
	Abundance Rank			
Species	**0-5**	**5-10**	**10-20**	**20-30**
Castanospermum australe			R	
Centella asiatica	C			
Christella dentata		R		
Chrysopogon aciculatus				
Cissus hypoglauca				
Cissus penninervis				
Claoxylon tenerifolium		R		
Cleistanthus semiopacus				
Clerodendrum longiflorum var. *glabrum*				
Coveniella poecilophlebia				
Cupaniopsis foveolata				
Cyathea cooperi				R
Cyathea rebeccae				
Cyperus polystachyos				
Cyperus sphacelatus				
Dalbergia densa				
Darlingia darlingiana			R	
Decaspermum humile				
Derris sp. Daintree				
Desmodium nemorosum				
Desmodium triflorum				
Dianella atraxis				
Dianella caerulea				
Dicranopteris linearis	O			
Digitaria parviflora				
Dioscorea transversa				
Drynaria rigidula				
Drypetes deplanchei				
Duboisia myoporoides				
Elaeocarpus bancroftii				
Elaeocarpus grahamii				
Elaeocarpus grandis	R		R	R
Embelia australiana				
Entolasia stricta				
Eragrostris elongata	C			
Eriachne sp.				
Euroschinus falcata				
Eustrephus latifolius				
Ficus congesta	R		O	
Ficus opposita				
Ficus septica		R		O

Site	Tower 10103, Shoteel Creek			
	Abundance Rank			
Species	**0-5**	**5-10**	**10-20**	**20-30**
Fimbristylis dichotoma				
Flagellaria indica		R		
Flindersia bourjotiana				
Flindersia pimenteliana				
Flindersia schottiana				
Gahnia aspera				
Gahnia sieberiana				
Gardenia ovularis				
Geitonoplesium cynosum				
Glochidion harveyanum		O		R
Glochidion hylandii				
Glochidion sumatranum			O	O
Gmelina fasciculiflora				
Grevillea baileyana				
Guioa acutifolia				
Guioa lasioneura		R	R	
Hedycarya loxocarya				
Hibbertia scandens			O	
Homalium circumpinnatum				
Hypericum gramineum				
Hypserpa decumbens				
Hypserpa laurina				
Ichnocarpus frutescens				
Imperata cylindrica				
Ischaemum australe				
Jagera dasyantha				
Jagera pseudorhus				
Jasminum didymum				
Leucopogon spathaceus				
Ligustrum australianum				
Lindsaea brachypoda				
Litsea fawcettiana			R	
Litsea leefeana				
Lophostemon confertus				
Lophostemon suaveolens				
Lycopodiella cernua				
Lygodium reticulatum				
Macaranga involucrata		O		
Macaranga tanarius				
Maclura cochinchinensis				
Maesa dependens				
Mallotus mollissimus	R			

Site	Tower 10103, Shoteel Creek			
	Abundance Rank			
Species	**0-5**	**5-10**	**10-20**	**20-30**
Mallotus paniculatus		R	O	
Mallotus philippensis				
Maytenus fasciculiflora				
Melastoma affine				
Melicope elleryana				
Melicope xanthoxyloides				
Micromelum minutum				
Mischocarpus pyriformis				
Neolitsea dealbata	R			
Neosepicaea jucunda				
Omalanthus novo-guineensis		C	C	O
Pachygone ovata				
Palmeria scandens				
Pandanus monticola				
Parsonsia latifolia				
Paspalum scrobiculatum	C-D			
Passiflora sp. Kuranda				R
Pavetta australiensis				
Piper novae-hollandiae				
Pittosporum venulosum				
Pittosporum wingii				
Placospermum coriaceum				
Polyalthia nitidissima				
Polyscias australiana	R		O	
Polyscias elegans		R	R	R
Polyscias murrayi				
Pouteria chartacea				
Rapanea variabilis				
Rhodomyrtus macrocarpa				
Ripogonum album				
Rubus moluccanus		O		D
Rubus probus				
Salacia disepala				
Sarcopteryx martyana				
Sarcopteryx reticulata		R	R	
Scaevola enantophylla				
Schefflera actinophylla				
Scolopia braunii				
Sida cordifolia				
Smilax australis	O	O		
Stephania japonica				

Site	Tower 10103, Shoteel Creek			
	Abundance Rank			
Species	**0-5**	**5-10**	**10-20**	**20-30**
Symplocos ochinchinensis	R			
Syzygium cormiflorum				
Syzygium papyraceum				
Syzygium tierneyanum				
Tabernaemontana pandacaqui				
Tarenna dallachiana				
Terminalia sericocarpa				
Tetracera daemeliana				
Tetracera nordtiana			O	
Themeda triandra				
Timonius timon				
Toona ciliata				
Tristaniopsis exiliflora				
Ventilago ecorollata				
Wikstroemia indica				
Xanthophyllum octandrum				
Xylopia maccreae				
Zanthoxylon ovalifolium				

APPENDIX 1.2

WEEDS SURVEYS ALONG THE PALMERSTON ROAD AND POWERLINE NETWORK

Key D = Dominant
C = Common
O = Ocassional
R = Rare
+ = Incidental occurrence nearby
* = Denotes a weed species

Site	Powerline Cross1, K-tree				Powerline, K-Tree, Fossick				K-tree, Jordan Creek Turnoff			
	368996 E		8052377 N		366786 E		8051177 N		366322E		8050542 N	
	Abundance Rank				Abundance Rank				Abundance Rank			
Species	0-5	5-10	10-20	20-30	0-5	5-10	10-20	20-30	0-5	5-10	10-20	20-30
*Ageratum conyzoides		O	O					+		C-D	C-D	C
*Arundina bambusaefolia												
*Axonopus compressus												
*Axonopus fissifolius												
*Bidens pilosa												
*Brachiaria decumbens	D	O						R		O		O
*Brachiaria mutica												
*Calyptocarpus vialis								+				
*Centrosema pubescens												
*Conyza leucantha				+								
*Crassocephalum crepidioides				+				+		O	O	
*Crotalaria lanceolata					O	O	O	O				
*Crotalaria pallida				+								
*Cyperus aromaticus												O
*Desmodium intortum												
*Desmodium uncinatum				+				R			O	O
*Dicrocephala integrifolia												
*Echinochloa colona												
*Eleusine indica											R	
*Emilia sonchifolia				+				+				
*Erechtites valerianifolia										O		O
*Hyptis capitata									O			+
*Ipomoea indica												
*Lantana camara camara				C								
*Macroptilium atropurpureum												
*Melinis minutiflora		D	D					R				
*Mimosa pudica				+							O	
*Mitracarpus hirtus								+		C		

Site	Powerline Cross1, K-tree				Powerline, K-Tree, Fossick				K-tree, Jordan Creek Turnoff			
	368996 E		8052377 N		366786 E		8051177 N		366322E		8050542 N	
	Abundance Rank				Abundance Rank				Abundance Rank			
Species	**0-5**	**5-10**	**10-20**	**20-30**	**0-5**	**5-10**	**10-20**	**20-30**	**0-5**	**5-10**	**10-20**	**20-30**
**Oxalis corniculata*												
**Panicum maximum*	O	C-D	C		D	D	D	D	D	C-D	C-D	O
**Paspalum conjugatum*												
**Paspalum paniculatum*												
**Passiflora edulis*												
**Phyllanthus amarus*												
**Polygala paniculata*		O	O		O	O	O	O		C		
**Richardia brasiliensis*												
**Rubus alceifolius*				C					D		C	
**Scoparia dulcis*												
**Setaria sphacelata*												
**Sida rhombifolia*									O			R
**Sigesbeckia orientalis*												
**Solanum americanum*												
**Solanum mauritianum*												
**Solanum torvum*												
**Spermacoce latifolia*				+						C		
**Sporobolus jacquemontii*											R	
**Stylosanthes humilis*												
**Synedrella nodiflora*												
**Triumfetta rhomboidea*												
**Urena lobata*												
Acronychia acidula								+				
Adiantum hispidulum												
Aglaia meridionalis												
Alocasia brisbanensis												
Alphitonia petriei				+		R						
Alpinia arctiflora												
Alpinia caerulea												
Argyrodendron peralatum												
Austrosteenisia blackii												
Austrosteenisia stipularis												
Bacopa monnieri												
Blechnum orientale				C								
Bowenia spectabilis			R									
Breynia stipitata			R	O								
Caesalpinia traceyi												
Calamus australis												
Calamus motii												
Cardwellia sublimis												

Site	Powerline Cross1, K-tree				Powerline, K-Tree, Fossick				K-tree, Jordan Creek Turnoff			
	368996 E		8052377 N		366786 E		8051177 N		366322E		8050542 N	
	Abundance Rank				Abundance Rank				Abundance Rank			
Species	**0-5**	**5-10**	**10-20**	**20-30**	**0-5**	**5-10**	**10-20**	**20-30**	**0-5**	**5-10**	**10-20**	**20-30**
Carnarvonia araliifolia												
Centella asiatica								+		C	C-D	C
Christella dentata									R		O	C
Cissus vinosa												
Cryptocarya murrayi												
Cryptocarya oblata												
Cupaniopsis flagelliformis												
Cyathea cooperi								+				O
Cyperus difformis												
Cyperus pilosus												
Cyperus polystachyos										O		
Cyperus sp.												
Cyperus sphacelatus												
Cyrtococcum oxyphyllum												+
Dendrocnide photinophylla												
Desmodium triflorum												
Dicranopteris linearis												
Dienia montana												
Drymaria cordata												
Eclipta prostrata												
Elaeocarpus grandis										R		
Eragrostris unioloides											R	
Faradaya splendida												
Ficus congesta												
Ficus copiosa												
Ficus hispida												
Ficus septica												
Fimbristylis dichotoma												
Flagellaria indica												
Flindersia bourjotiana				R								
Flindersia brayleyana								+				
Freycinetia scandens												R
Gahnia sieberiana												
Geissois biagiana											R	R
Glochidion hylandii												
Hypericum gramineum												
Imperata cylindrica		R	C									
Ludwigia octovalvis											O	R
Lycopodiella cernua										C	C	C
Mallotus paniculatus												

Site	Powerline Cross1, K-tree				Powerline, K-Tree, Fossick				K-tree, Jordan Creek Turnoff			
	368996 E		8052377 N		366786 E		8051177 N		366322E		8050542 N	
	Abundance Rank				Abundance Rank				Abundance Rank			
Species	0-5	5-10	10-20	20-30	0-5	5-10	10-20	20-30	0-5	5-10	10-20	20-30
Melastoma affine												
Melicope elleryana				O								
Microlepia speluncae												
Mucuna gigantea												
Neolitsea dealbata												
Nephrolepis cordifolia												
Omalanthus novo-guineensis				O				+	O	R	D	
Oplismenus compositus												
Oplismenus hirtellus												
Otanthera bracteata										C-D	C-D	D
Palmeria scandens												R
Paspalum scrobiculatum												
Piper caninum												
Pollia macrophylla												
Polyscias elegans								+				
Polyscias murrayi								+				
Pteridium esculentum												
Pteris tripartita												
Pullea stutzeri												
Rhodomyrtus pervagata												
Ripogonum album												
Rubus moluccanus												
Rubus probus				O					O		O	
Scaevola enantophylla												
Solanum dallachii												
Spermacoce latifolia				+				+				
Stephania japonica												
Tetrastigma nitens												
Tetrasynandra laxiflora												
Toechima erythrocarpum												
Vernonia cinerea										O		
Xanthophyllum octandrum				R								
Zehneria cunninghamii												

APPENDIX 1.2 (CONT'D)

Site	**K-tree, Log-Dump Creek**				**Maple Creek, Downey Ck**				**Maple Creek, Creek1 Clearing**			
	365573E		**8048631 N**		**364601 E**		**8046372 N**		**361893 E**		**8043777 N**	
	Abundance Rank				**Abundance Rank**				**Abundance Rank**			
Species	**0-5**	**5-10**	**10-20**	**20-30**	**0-5**	**5-10**	**10-20**	**20-30**	**0-5**	**5-10**	**10-20**	**20-30**
**Ageratum conyzoides*	D	C-D	C	C	C-D			+	C			
**Arundina bambusaefolia*												
**Axonopus compressus*												
**Axonopus fissifolius*												
**Bidens pilosa*								+				
**Brachiaria decumbens*		O	O		D	D	D	D				
**Brachiaria mutica*												
**Calyptocarpus vialis*	O											
**Centrosema pubescens*												
**Conyza leucantha*												
**Crassocephalum crepidioides*	O		O		C							
**Crotalaria lanceolata*					C	O		+				
**Crotalaria pallida*		R										
**Cyperus aromaticus*												
**Desmodium intortum*												
**Desmodium uncinatum*												
**Dicrocephala integrifolia*												
**Echinochloa colona*												
**Eleusine indica*												
**Emilia sonchifolia*	C		C						R			
**Erechtites valerianifolia*			R									
**Hyptis capitata*												
**Ipomoea indica*												
**Lantana camara camara*								D				
**Macroptilium atropurpureum*								+				
**Melinis minutiflora*		O	O					C	C			
**Mimosa pudica*												
**Mitracarpus hirtus*	O		O		C			+				
**Oxalis corniculata*												
**Panicum maximum*	D	D	D	D		D	D	D	D	D	D	D
**Paspalum conjugatum*												
**Paspalum paniculatum*												
**Passiflora edulis*												
**Phyllanthus amarus*	C											
**Polygala paniculata*	C		C		C-D				C			
**Richardia brasiliensis*												
**Rubus alceifolius*			C-D	O								

Site	K-tree, Log-Dump Creek				Maple Creek, Downey Ck				Maple Creek, Creek1 Clearing			
	365573E		8048631 N		364601 E		8046372 N		361893 E		8043777 N	
	Abundance Rank				Abundance Rank				Abundance Rank			
Species	**0-5**	**5-10**	**10-20**	**20-30**	**0-5**	**5-10**	**10-20**	**20-30**	**0-5**	**5-10**	**10-20**	**20-30**
**Scoparia dulcis*												
**Setaria sphacelata*												
**Sida rhombifolia*												
**Sigesbeckia orientalis*												
**Solanum americanum*												
**Solanum mauritianum*								+				
**Solanum torvum*								+				
**Spermacoce latifolia*												
**Sporobolus jacquemontii*												
**Stylosanthes humilis*												
**Synedrella nodiflora*								+				
**Triumfetta rhomboidea*												
**Urena lobata*												
Acronychia acidula												
Adiantum hispidulum												
Aglaia meridionalis												
Alocasia brisbanensis												
Alphitonia petriei												
Alpinia arctiflora												
Alpinia caerulea												
Argyrodendron peralatum												
Austrosteenisia blackii												
Austrosteenisia stipularis												
Bacopa monnieri												
Blechnum orientale												
Bowenia spectabilis												
Breynia stipitata												
Caesalpinia traceyi												
Calamus australis												
Calamus motii												
Cardwellia sublimis		R						+				
Carnarvonia araliifolia												
Centella asiatica	C-D	C-D	C		C							
Christella dentata												
Cissus vinosa												
Cryptocarya murrayi												
Cryptocarya oblata												
Cupaniopsis flagelliformis												
Cyathea cooperi	R											
Cyperus difformis												

Site	K-tree, Log-Dump Creek				Maple Creek, Downey Ck				Maple Creek, Creek1 Clearing			
	365573E		8048631 N		364601 E		8046372 N		361893 E		8043777 N	
	Abundance Rank				Abundance Rank				Abundance Rank			
Species	**0-5**	**5-10**	**10-20**	**20-30**	**0-5**	**5-10**	**10-20**	**20-30**	**0-5**	**5-10**	**10-20**	**20-30**
Cyperus pilosus												
Cyperus polystachyos												
Cyperus sp.												
Cyperus sphacelatus												
Cyrtococcum oxyphyllum												
Dendrocnide photinophylla												
Desmodium triflorum												
Dicranopteris linearis		O	C	O								
Dienia montana		R										
Drymaria cordata												
Eclipta prostrata		O							O			
Elaeocarpus grandis												
Eragrostris unioloides												
Faradaya splendida												
Ficus congesta										R		
Ficus copiosa												
Ficus hispida												
Ficus septica												
Fimbristylis dichotoma												
Flagellaria indica												
Flindersia bourjotiana												
Flindersia brayleyana												
Freycinetia scandens												
Gahnia sieberiana												
Geissois biagiana												
Glochidion hylandii									R			
Hypericum gramineum												
Imperata cylindrica												
Ludwigia octovalvis												
Lycopodiella cernua	C	C-D	C-D	O								
Mallotus paniculatus												
Melastoma affine												
Melicope elleryana												
Microlepia speluncae												
Mucuna gigantea									R			
Neolitsea dealbata												
Nephrolepis cordifolia												
Omalanthus novo-guineensis												
Oplismenus compositus												

Site	K-tree, Log-Dump Creek				Maple Creek, Downey Ck				Maple Creek, Creek1 Clearing			
	365573E		8048631 N		364601 E		8046372 N		361893 E		8043777 N	
	Abundance Rank				Abundance Rank				Abundance Rank			
Species	0-5	5-10	10-20	20-30	0-5	5-10	10-20	20-30	0-5	5-10	10-20	20-30
Oplismenus hirtellus												
Otanthera bracteata	R	O	O									
Palmeria scandens												
Paspalum scrobiculatum												
Piper caninum												
Pollia macrophylla												
Polyscias elegans												
Polyscias murrayi												
Pteridium esculentum												
Pteris tripartita												
Pullea stutzeri												
Rhodomyrtus pervagata												
Ripogonum album												
Rubus moluccanus												
Rubus probus												
Scaevola enantophylla												
Solanum dallachii												
Spermacoce latifolia					C-D							
Stephania japonica												
Tetrastigma nitens												
Tetrasynandra laxiflora												
Toechima erythrocarpum												
Vernonia cinerea												
Xanthophyllum octandrum												
Zehneria cunninghamii												

APPENDIX 1.2 (CONT'D)

Site	Maple Creek, Major Rd Exit				Charappa Forestry Camp				Sutties Gap, Powerline			
	361607E		8041945 N		359066E		8042549 N		357957 E		8044652N	
	Abundance Rank				Abundance Rank				Abundance Rank			
Species	0-5	5-10	10-20	20-30	0-5	5-10	10-20	20-30	0-5	5-10	10-20	20-30
Ageratum conyzoides					C	C	C	C				O
Arundina bambusaefolia								+				
Axonopus compressus												
Axonopus fissifolius		O			R							
Bidens pilosa												
Brachiaria decumbens	C	D	D	D	D	D	D	D	D	C-D	D	D
Brachiaria mutica										O		
Calyptocarpus vialis												
Centrosema pubescens						R						
Conyza leucantha												
Crassocephalum crepidioides							C	O				
Crotalaria lanceolata					C	O	R	O				
Crotalaria pallida												
Cyperus aromaticus					C	O		C	C			
Desmodium intortum												
Desmodium uncinatum						R						
Dicrocephala integrifolia												
Echinochloa colona												
Eleusine indica												
Emilia sonchifolia					R				R			
Erechtites valerianifolia												
Hyptis capitata												
Ipomoea indica												
Lantana camara camara								+				O
Macroptilium atropurpureum						C						
Melinis minutiflora	C										D	C-D
Mimosa pudica									C-D	C	C	C
Mitracarpus hirtus												
Oxalis corniculata							O					
Panicum maximum				D	R	C	D	D	C-D	D	D	D
Paspalum conjugatum												
Paspalum paniculatum												
Passiflora edulis												
Phyllanthus amarus												
Polygala paniculata	C				C	R	C	O	C	C	C	C
Richardia brasiliensis					R							
Rubus alceifolius												

Site	Maple Creek, Major Rd Exit				Charappa Forestry Camp				Sutties Gap, Powerline			
	361607E		8041945 N		359066E		8042549 N		357957 E		8044652N	
	Abundance Rank				Abundance Rank				Abundance Rank			
Species	**0-5**	**5-10**	**10-20**	**20-30**	**0-5**	**5-10**	**10-20**	**20-30**	**0-5**	**5-10**	**10-20**	**20-30**
**Scoparia dulcis*												
**Setaria sphacelata*					R				R		R	
**Sida rhombifolia*												
**Sigesbeckia orientalis*												
**Solanum americanum*												
**Solanum mauritianum*									R			
**Solanum torvum*												
**Spermacoce latifolia*												
**Sporobolus jacquemontii*					R				R			O
**Stylosanthes humilis*									R	C-D		
**Synedrella nodiflora*												
**Triumfetta rhomboidea*												
**Urena lobata*										R		
Acronychia acidula												
Adiantum hispidulum												
Aglaia meridionalis												
Alocasia brisbanensis												
Alphitonia petriei		R										
Alpinia arctiflora												
Alpinia caerulea												
Argyrodendron peralatum												
Austrosteenisia blackii											R	
Austrosteenisia stipularis												
Bacopa monnieri												
Blechnum orientale	R											O
Bowenia spectabilis												
Breynia stipitata												
Caesalpinia traceyi												
Calamus australis												
Calamus motii												
Cardwellia sublimis												
Carnarvonia araliifolia												R
Centella asiatica					C		R					
Christella dentata												
Cissus vinosa												
Cryptocarya murrayi												
Cryptocarya oblata												
Cupaniopsis flagelliformis												
Cyathea cooperi									O			
Cyperus difformis										R		

Site	Maple Creek, Major Rd Exit				Charappa Forestry Camp				Sutties Gap, Powerline			
	361607E		8041945 N		359066E		8042549 N		357957 E		8044652N	
	Abundance Rank				Abundance Rank				Abundance Rank			
Species	0-5	5-10	10-20	20-30	0-5	5-10	10-20	20-30	0-5	5-10	10-20	20-30
Cyperus pilosus									R			
Cyperus polystachyos	O									O		R
Cyperus sp.												
Cyperus sphacelatus												
Cyrtococcum oxyphyllum												
Dendrocnide photinophylla												
Desmodium triflorum					R		R					
Dicranopteris linearis	D	C-D										C-D
Dienia montana												
Drymaria cordata												
Eclipta prostrata												
Elaeocarpus grandis												
Eragrostris unioloides												
Faradaya splendida												
Ficus congesta												
Ficus copiosa									R			
Ficus hispida												
Ficus septica												
Fimbristylis dichotoma					R				D	C	C-D	C-D
Flagellaria indica												
Flindersia bourjotiana												
Flindersia brayleyana												
Freycinetia scandens												
Gahnia sieberiana												O
Geissois biagiana	R											R
Glochidion hylandii												R
Hypericum gramineum												
Imperata cylindrica			O					O	C			C
Ludwigia octovalvis												
Lycopodiella cernua	C		C						C			C
Mallotus paniculatus												
Melastoma affine									R			
Melicope elleryana												
Microlepia speluncae												
Mucuna gigantea												
Neolitsea dealbata												
Nephrolepis cordifolia												
Omalanthus novo-guineensis												
Oplismenus compositus												

Site	Maple Creek, Major Rd Exit				Charappa Forestry Camp				Sutties Gap, Powerline			
	361607E		8041945 N		359066E		8042549 N		357957 E		8044652N	
	Abundance Rank				Abundance Rank				Abundance Rank			
Species	0-5	5-10	10-20	20-30	0-5	5-10	10-20	20-30	0-5	5-10	10-20	20-30
Oplismenus hirtellus												
Otanthera bracteata												
Palmeria scandens												
Paspalum scrobiculatum												
Piper caninum												
Pollia macrophylla												
Polyscias elegans												
Polyscias murrayi												
Pteridium esculentum												
Pteris tripartita												
Pullea stutzeri												O
Rhodomyrtus pervagata												
Ripogonum album												
Rubus moluccanus												
Rubus probus												
Scaevola enantophylla												
Solanum dallachii												
Spermacoce latifolia												
Stephania japonica												
Tetrastigma nitens												
Tetrasynandra laxiflora												
Toechima erythrocarpum												
Vernonia cinerea												
Xanthophyllum octandrum												
Zehneria cunninghamii												

APPENDIX 1.2 (CONT'D)

Site	Maalan Verge, 1st trap				Maalan Verge				Maalan, Log Dump			
					361757 E		8053271 N		361044 E		8053141 N	
	Abundance Rank				Abundance Rank				Abundance Rank			
Species	0-5	5-10	10-20	20-30	0-5	5-10	10-20	20-30	0-5	5-10	10-20	20-30
*Ageratum conyzoides	C	C	O	C-D	C-D	C-D	C-D	C-D	C-D	C-D	C	C
*Arundina bambusaefolia												
*Axonopus compressus		R										
*Axonopus fissifolius			R		R							
*Bidens pilosa												
*Brachiaria decumbens					O							
*Brachiaria mutica												
*Calyptocarpus vialis	R											
*Centrosema pubescens												
*Conyza leucantha												
*Crassocephalum crepidioides			R		C	C	C	C				
*Crotalaria lanceolata												
*Crotalaria pallida												
*Cyperus aromaticus			O									
*Desmodium intortum												
*Desmodium uncinatum												
*Dicrocephala integrifolia	O			O								
*Echinochloa colona			R									
*Eleusine indica	R				R							
*Emilia sonchifolia			R		O		O		C			
*Erechtites valerianifolia			O	O				O				
*Hyptis capitata												
*Ipomoea indica												
*Lantana camara camara							C-D			C	C-D	
*Macroptilium atropurpureum												
*Melinis minutiflora												
*Mimosa pudica												
*Mitracarpus hirtus	C-D	O	O	C	D	C-D	C			C-D		
*Oxalis corniculata							C	C				
*Panicum maximum	R	O	O	O	C	C	C	C	O	D	D	D
*Paspalum conjugatum	R											
*Paspalum paniculatum			R									
*Passiflora edulis			R									
*Phyllanthus amarus	O		R	C	O		O			C-D		
*Polygala paniculata	C	C			C	C	C	C	C			
*Richardia brasiliensis												
*Rubus alceifolius								O	O		O	

Site	Maalan Verge, 1st trap				Maalan Verge				Maalan, Log Dump			
					361757 E		8053271 N		361044 E		8053141 N	
	Abundance Rank				Abundance Rank				Abundance Rank			
Species	**0-5**	**5-10**	**10-20**	**20-30**	**0-5**	**5-10**	**10-20**	**20-30**	**0-5**	**5-10**	**10-20**	**20-30**
**Scoparia dulcis*		R										
**Setaria sphacelata*												
**Sida rhombifolia*	O		R	O								
**Sigesbeckia orientalis*	C	O	O	O								
**Solanum americanum*					R							
**Solanum mauritianum*												
**Solanum torvum*												
**Spermacoce latifolia*												
**Sporobolus jacquemontii*												
**Stylosanthes humilis*												
**Synedrella nodiflora*			O					O				
**Triumfetta rhomboidea*												
**Urena lobata*												
Acronychia acidula												
Adiantum hispidulum	O											
Aglaia meridionalis												
Alocasia brisbanensis				R				R				
Alphitonia petriei											O	
Alpinia arctiflora	R		O	R								
Alpinia caerulea												
Argyrodendron peralatum												
Austrosteenisia blackii												
Austrosteenisia stipularis			R									
Bacopa monnieri												
Blechnum orientale												
Bowenia spectabilis	R		R									
Breynia stipitata												
Caesalpinia traceyi								R				
Calamus australis												
Calamus motii		O	O									
Cardwellia sublimis												
Carnarvonia araliifolia												
Centella asiatica	C-D			C			C	C	C			
Christella dentata	C			O	O		O	O				
Cissus vinosa	O											
Cryptocarya murrayi	O											
Cryptocarya oblata				R								
Cupaniopsis flagelliformis	R											
Cyathea cooperi								R				
Cyperus difformis												

Site	Maalan Verge, 1st trap				Maalan Verge				Maalan, Log Dump			
					361757 E		8053271 N		361044 E		8053141 N	
	Abundance Rank				Abundance Rank				Abundance Rank			
Species	**0-5**	**5-10**	**10-20**	**20-30**	**0-5**	**5-10**	**10-20**	**20-30**	**0-5**	**5-10**	**10-20**	**20-30**
Cyperus pilosus												
Cyperus polystachyos												
Cyperus sp.												
Cyperus sphacelatus												
Cyrtococcum oxyphyllum												
Dendrocnide photinophylla												
Desmodium triflorum												
Dicranopteris linearis												
Dienia montana												
Drymaria cordata	C-D		C-D									
Eclipta prostrata					O		O	O				
Elaeocarpus grandis												
Eragrostris unioloides												
Faradaya splendida												
Ficus congesta												
Ficus copiosa												
Ficus hispida												
Ficus septica												
Fimbristylis dichotoma												
Flagellaria indica			R									
Flindersia bourjotiana												
Flindersia brayleyana												
Freycinetia scandens												
Gahnia sieberiana												
Geissois biagiana												
Glochidion hylandii												
Hypericum gramineum												
Imperata cylindrica												
Ludwigia octovalvis												
Lycopodiella cernua												
Mallotus paniculatus												
Melastoma affine												
Melicope elleryana												
Microlepia speluncae				R								
Mucuna gigantea												
Neolitsea dealbata				R								
Nephrolepis cordifolia												
Omalanthus novo-guineensis		R				R	O	O				
Oplismenus compositus	C	C-D	C-D									
Oplismenus hirtellus		C-D										

Site	Maalan Verge, 1st trap				Maalan Verge				Maalan, Log Dump			
					361757 E		8053271 N		361044 E		8053141 N	
	Abundance Rank				Abundance Rank				Abundance Rank			
Species	0-5	5-10	10-20	20-30	0-5	5-10	10-20	20-30	0-5	5-10	10-20	20-30
Otanthera bracteata												
Palmeria scandens												
Paspalum scrobiculatum	O			O								
Piper caninum			R	O								
Pollia macrophylla	C-D	C-D	C-D	C								
Polyscias elegans			R									
Polyscias murrayi												
Pteridium esculentum												
Pteris tripartita												
Pullea stutzeri												
Rhodomyrtus pervagata												
Ripogonum album	O		O									
Rubus moluccanus								C				
Rubus probus												
Scaevola enantophylla												
Solanum dallachii			R									
Spermacoce latifolia												
Stephania japonica		R	O	O								
Tetrastigma nitens												
Tetrasynandra laxiflora	O		O									
Toechima erythrocarpum			R									
Vernonia cinerea												
Xanthophyllum octandrum												
Zehneria cunninghamii		R										

APPENDIX 1.2 (CONT'D)

Site	Maalan, Powerline1				Maalan, Powerline 2 KI55				Maalan, :Powerline 3			
	360875 E		8052605 N		360042 E		8050941 N		359598 E		8050319 N	
	Abundance Rank				Abundance Rank				Abundance Rank			
Species	0-5	5-10	10-20	20-30	0-5	5-10	10-20	20-30	0-5	5-10	10-20	20-30
Ageratum conyzoides	O	O			O		C	C	C	C	C	
Arundina bambusaefolia												
Axonopus compressus												
Axonopus fissifolius												
Bidens pilosa	+											
Brachiaria decumbens	C-D								C			
Brachiaria mutica												
Calyptocarpus vialis												
Centrosema pubescens												
Conyza leucantha							O			C		
Crassocephalum crepidioides	R								+			
Crotalaria lanceolata												
Crotalaria pallida	+											
Cyperus aromaticus												
Desmodium intortum												
Desmodium uncinatum												
Dicrocephala integrifolia												
Echinochloa colona												
Eleusine indica												
Emilia sonchifolia	O											
Erechtites valerianifolia												
Hyptis capitata												
Ipomoea indica												
Lantana camara camara	D	D	D	D			O				D	D
Macroptilium atropurpureum												
Melinis minutiflora			O	C-D	C	O	D	D				
Mimosa pudica												
Mitracarpus hirtus	O											
Oxalis corniculata												
Panicum maximum	D	C-D	D	C-D	D	D	D	D	D	D	D	D
Paspalum conjugatum												
Paspalum paniculatum												
Passiflora edulis												
Phyllanthus amarus	O											

Site	Maalan, Powerline1				Maalan, Powerline 2 KI55				Maalan, :Powerline 3			
	360875 E		8052605 N		360042 E		8050941 N		359598 E		8050319 N	
	Abundance Rank				Abundance Rank				Abundance Rank			
Species	0-5	5-10	10-20	20-30	0-5	5-10	10-20	20-30	0-5	5-10	10-20	20-30
**Polygala paniculata*	O				C	O	O	C	C	C	C	
**Richardia brasiliensis*												
**Rubus alceifolius*		C	C	C				C				
**Scoparia dulcis*												
**Setaria sphacelata*												
**Sida rhombifolia*												
**Sigesbeckia orientalis*												
**Solanum americanum*												
**Solanum mauritianum*		R		R								
**Solanum torvum*												
**Spermacoce latifolia*												
**Sporobolus jacquemontii*												
**Stylosanthes humilis*												
**Synedrella nodiflora*												
**Triumfetta rhomboidea*												
**Urena lobata*					R							
Acronychia acidula												
Adiantum hispidulum												
Aglaia meridionalis												
Alocasia brisbanensis												
Alphitonia petriei				+								
Alpinia arctiflora												
Alpinia caerulea												
Argyrodendron peralatum												
Austrosteenisia blackii												
Austrosteenisia stipularis												
Bacopa monnieri												
Blechnum orientale						O	O					
Bowenia spectabilis				O	O		O	O			R	
Breynia stipitata												
Caesalpinia traceyi												
Calamus australis												
Calamus motii												
Cardwellia sublimis				+								
Carnarvonia araliifolia												
Centella asiatica												
Christella dentata												
Cissus vinosa												

Site	Maalan, Powerline1				Maalan, Powerline 2 KI55				Maalan, :Powerline 3			
	360875 E		8052605 N		360042 E		8050941 N		359598 E		8050319 N	
	Abundance Rank				Abundance Rank				Abundance Rank			
Species	0-5	5-10	10-20	20-30	0-5	5-10	10-20	20-30	0-5	5-10	10-20	20-30
Cryptocarya murrayi												
Cryptocarya oblata												
Cupaniopsis flagelliformis												
Cyathea cooperi						R	R					
Cyperus difformis												
Cyperus pilosus												
Cyperus polystachyos												
Cyperus sp.												
Cyperus sphacelatus												
Cyrtococcum oxyphyllum												
Dendrocnide photinophylla												
Desmodium triflorum										O	O	
Dicranopteris linearis												
Dienia montana												
Drymaria cordata												
Eclipta prostrata												
Elaeocarpus grandis												
Eragrostris unioloides												
Faradaya splendida												
Ficus congesta												
Ficus copiosa												
Ficus hispida												
Ficus septica												
Fimbristylis dichotoma												
Flagellaria indica												
Flindersia bourjotiana												
Flindersia brayleyana												
Freycinetia scandens												
Gahnia sieberiana												
Geissois biagiana												
Glochidion hylandii												
Hypericum gramineum												
Imperata cylindrica								O				
Ludwigia octovalvis												
Lycopodiella cernua												
Mallotus paniculatus				+								
Melastoma affine												
Melicope elleryana												

Site	Maalan, Powerline1				Maalan, Powerline 2 KI55				Maalan, :Powerline 3			
	360875 E		8052605 N		360042 E		8050941 N		359598 E		8050319 N	
	Abundance Rank				Abundance Rank				Abundance Rank			
Species	**0-5**	**5-10**	**10-20**	**20-30**	**0-5**	**5-10**	**10-20**	**20-30**	**0-5**	**5-10**	**10-20**	**20-30**
Microlepia speluncae												
Mucuna gigantea												
Neolitsea dealbata												
Nephrolepis cordifolia												
Omalanthus novo-guineensis												
Oplismenus compositus												
Oplismenus hirtellus												
Otanthera bracteata												
Palmeria scandens												
Paspalum scrobiculatum												
Piper caninum												
Pollia macrophylla												
Polyscias elegans												
Polyscias murrayi												
Pteridium esculentum					C	C	C	C				
Pteris tripartita												
Pullea stutzeri												
Rhodomyrtus pervagata												
Ripogonum album												
Rubus moluccanus			O	O								
Rubus probus	+					O	C					
Scaevola enantophylla							O					
Solanum dallachii												
Spermacoce latifolia	+								+			
Stephania japonica												
Tetrastigma nitens								R				
Tetrasynandra laxiflora												
Toechima erythrocarpum												
Vernonia cinerea												
Xanthophyllum octandrum												
Zehneria cunninghamii												

APPENDIX 1.2 (CONT'D)

Site	Maalan, Wide Verge Site1				Maalan, Quarry			
	357393E		8053072 N					
	Abundance Rank				Abundance Rank			
Species	**0-5**	**5-10**	**10-20**	**20-30**	**0-5**	**5-10**	**10-20**	**20-30**
**Ageratum conyzoides*	D	D	D	D	C	C	C	C
**Arundina bambusaefolia*								
**Axonopus compressus*								
**Axonopus fissifolius*								
**Bidens pilosa*								
**Brachiaria decumbens*	C		O	O	C-D	C-D		
**Brachiaria mutica*								
**Calyptocarpus vialis*	O	C						
**Centrosema pubescens*								
**Conyza leucantha*					C			
**Crassocephalum crepidioides*	D		D	D	C	C		
**Crotalaria lanceolata*								
**Crotalaria pallida*					O			
**Cyperus aromaticus*					O			
**Desmodium intortum*								
**Desmodium uncinatum*								
**Dicrocephala integrifolia*								
**Echinochloa colona*								
**Eleusine indica*	O	O	O					
**Emilia sonchifolia*								
**Erechtites valerianifolia*								
**Hyptis capitata*								
**Ipomoea indica*					O	O		
**Lantana camara camara*	D	D	D	D	O	O		D
**Macroptilium atropurpureum*								
**Melinis minutiflora*					D	D		
**Mimosa pudica*					O			
**Mitracarpus hirtus*								
**Oxalis corniculata*	O	O	O		O			
**Panicum maximum*	C	C	C	C			O	
**Paspalum conjugatum*								
**Paspalum paniculatum*								
**Passiflora edulis*								
**Phyllanthus amarus*	C				O			
**Polygala paniculata*	C	C	C	D	C			
**Richardia brasiliensis*								
**Rubus alceifolius*								

Site	Maalan, Wide Verge Site1				Maalan, Quarry			
	357393E		8053072 N					
	Abundance Rank				Abundance Rank			
Species	**0-5**	**5-10**	**10-20**	**20-30**	**0-5**	**5-10**	**10-20**	**20-30**
**Scoparia dulcis*								
**Setaria sphacelata*								
**Sida rhombifolia*			O					
**Sigesbeckia orientalis*				+	O			
**Solanum americanum*	O		O	O	O			
**Solanum mauritianum*								
**Solanum torvum*								
**Spermacoce latifolia*								
**Sporobolus jacquemontii*				R				
**Stylosanthes humilis*					O	O		
**Synedrella nodiflora*								
**Triumfetta rhomboidea*					R			
**Urena lobata*								
Acronychia acidula								
Adiantum hispidulum								
Aglaia meridionalis	R							
Alocasia brisbanensis					O			
Alphitonia petriei								
Alpinia arctiflora								
Alpinia caerulea					O			
Argyrodendron peralatum	O							
Austrosteenisia blackii								
Austrosteenisia stipularis								
Bacopa monnieri					O			
Blechnum orientale						O		O
Bowenia spectabilis								
Breynia stipitata								
Caesalpinia traceyi								
Calamus australis								
Calamus motii								
Cardwellia sublimis							O	O
Carnarvonia araliifolia								
Centella asiatica	C	C	C		C			
Christella dentata								
Cissus vinosa								
Cryptocarya murrayi	C							
Cryptocarya oblata								
Cupaniopsis flagelliformis								
Cyathea cooperi					O	O	O	C
Cyperus difformis								
Cyperus pilosus								

Site	**Maalan, Wide Verge Site1**				**Maalan, Quarry**			
	357393E		**8053072 N**					
	Abundance Rank				**Abundance Rank**			
Species	**0-5**	**5-10**	**10-20**	**20-30**	**0-5**	**5-10**	**10-20**	**20-30**
Cyperus polystachyos		O				C		
Cyperus sp.	R							
Cyperus sphacelatus	O							
Cyrtococcum oxyphyllum								
Dendrocnide photinophylla						O		
Desmodium triflorum								
Dicranopteris linearis							D	
Dienia montana								
Drymaria cordata								
Eclipta prostrata								
Elaeocarpus grandis								
Eragrostris unioloides	O							
Faradaya splendida		R						
Ficus congesta								O
Ficus copiosa								
Ficus hispida					O			
Ficus septica		R						
Fimbristylis dichotoma								
Flagellaria indica				O				
Flindersia bourjotiana								
Flindersia brayleyana								
Freycinetia scandens								
Gahnia sieberiana								
Geissois biagiana							O	
Glochidion hylandii								
Hypericum gramineum					O			
Imperata cylindrica						O		
Ludwigia octovalvis								
Lycopodiella cernua					C			C
Mallotus paniculatus								
Melastoma affine								
Melicope elleryana								
Microlepia speluncae								
Mucuna gigantea								
Neolitsea dealbata	O							
Nephrolepis cordifolia			O		O			
Omalanthus novo-guineensis					R			O
Oplismenus compositus								
Oplismenus hirtellus								
Otanthera bracteata								

Site	Maalan, Wide Verge Site1				Maalan, Quarry			
	357393E		8053072 N					
	Abundance Rank				Abundance Rank			
Species	**0-5**	**5-10**	**10-20**	**20-30**	**0-5**	**5-10**	**10-20**	**20-30**
Palmeria scandens								
Paspalum scrobiculatum								
Piper caninum								
Pollia macrophylla								
Polyscias elegans								
Polyscias murrayi								
Pteridium esculentum								
Pteris tripartita								
Pullea stutzeri								
Rhodomyrtus pervagata							O	
Ripogonum album								
Rubus moluccanus		O			O		O	
Rubus probus	C				O			
Scaevola enantophylla								
Solanum dallachii								
Spermacoce latifolia								
Stephania japonica								
Tetrastigma nitens								
Tetrasynandra laxiflora	R							
Toechima erythrocarpum								
Vernonia cinerea								
Xanthophyllum octandrum								
Zehneria cunninghamii								

APPENDIX 1.3

PALMERSTON POWERLINE CLEARING AERIAL VIDEO ANALYSIS OF ECOLOGICAL CONDITION

SPAN	E	N	VEGETATION BETWEEN TOWERS	COMMENTS
58-59	372483	8052073	Banana farm, Palmerston highway, grass to tower, Brachiaria on track, molasses and Guinea patchwork, lantana and Rubus on edge	Crosses highway, slightly north of west, track enters near tower 59
59-60	372201	8052098	Lantana across clearing except track, small areas of Guinea and molasses grass, revegetation site - more molasses grass, Guinea grass to tower, Brachiaria in centre, Molasses under tower	Track to south to creek for farmer, Palmerston connectivity revegetation site 1 in centre
60-61	371571	8052152	Grades from Guinea grass into lantana on south side near tower, lantana across clearing to gully, except track with Guinea grass and Brachiaria, mainly low shrubs in gully, lantana across rest, few larger areas of molasses grass and Guinea to tower	Grass transect 1 at tower 60, powerline clearing track washout
61-62	371297	8052177	Molasses grass under tower, *Omalanthus* revegetation plot with large molasses grass area opposite, *Brachiaria* on track itself, large areas of molasses on slope where revegetation plot 2 went in, Guinea grass up to tower, lantana on edge	*Omalanthus* plot, thesis trapping site, grass/weed transects 2, track from highway enters from north, revegetation site 2 on slope
62-63	370796	8052223	Molasses grass under tower and to north of tower, Guinea grass to South, lantana and Rubus on edge, lantana in both gullies, especially to south in second gully, Molasses to south to third (major) gully, regrowth rainforest and tree ferns in gully, molasses, Guinea and Lantan / Rubus on edge at revegetation site 3, lantana in fouth gully, Guinea grass to gully and up hill to tower, some *Brachiaria* on track	Grass/weed transects at tower 62, revegetation site 3 past third gully, grass/weed transects at tower 63
63-64	370419	8052256	Guinea grass to south of tower, Molasses to north, *Brachiaria* on track, large gully runs parallel to clearing with regrowth and lantana on cliffs, molasses / Guinea patchwork, *Brachiaria* on track, regrowth connection second gully, lantana across in one area	
64-65	370133	8052281	*Brachiaria* under tower, large areas of molasses and Guinea grass patchwork, lantana on edges, regrowth in gully almost forms connection,	
65-66	369804	8052310	*Brachiaria* under tower, smaller areas of molasses, mainly Guinea grass, regrowth in creekline about halfway across clearing in one area and almost complete connection in another, tree ferns obvious, lantana areas to south, molasses to north, Guinea elsewhere	Creekline parallel to north edge of clearing for substantial distance

SPAN	E	N	VEGETATION BETWEEN TOWERS	COMMENTS
65-66	369804	8052310	*Brachiaria* under tower, smaller areas of molasses, mainly Guinea grass, regrowth in creekline about halfway across clearing in one area and almost complete connection in another, tree ferns obvious, lantana areas to south, molasses to north, Guinea elsewhere	Creekline parallel to north edge of clearing for substantial distance
66-67	369336	8052352	Large areas of molasses to south, fringed by lantana and rubus, creek still to north with low regrowth, crosses clearing twice with very low quality regrowth connections, lantana completely across in one area, mainly molasses and Guinea to tower	
67-68	369057	8052378	Large molasses grass swathes, fringed by lantana, low quality regrowth gully two-thirds across, molasses grass up slope, large area of *Brachiaria*, molasses to tower	Thesis grass site 2 at *Brachiaria/*molasses swathe, tower is K-tree powerline weed survey site 1
68-69	368820	8052279	Grass swathes, mostly Guinea with large areas of molasses, *Brachiaria* on track, narrow lantana edges	Crosses K-Tree track, powerline turns to west-south-west at tower 68
69-70	368568	8052393	Large grass swathes, mainly Guinea with area of molasses to south of tower 70	Continues over K-Tree track
70-71	368192	8051932	Large area of grass on hill, mostly Guinea with some smaller molasses areas, deep forested gully - forest connection for long distance, molasses and Guinea grass on slope to tower	Crossing Weekenah Creek
71-72	367471	8051533	Molasses grass under tower, Guinea on hill crest, deep gully with forest, grass swathes on next crest - mainly Guinea but some molasses, long regrowth gully area - fairly disturbed, second crest with molasses and Guinea grass swathes, third regrowth gully to grass swathes on crest with tower, some *Brachiaria,* molasses, Guinea	
72-73	366852	8051206	Molasses under tower, large swathes of Guinea grass to small gully with lantana and few regrowth shrubs, lantana swathes to south of track, Guinea to north, grades into Guinea swathes to tower interspersed with few small molasses areas	Crosses K-Tree track close to tower 72
73-74	366635	8051093	Guinea grass swathe, small patch of molasses close to tower 73, *Brachiaria* on track	K-tree track curves around clearing edge, Goolagan Creek fossicking field turnoff –weed survey site 2
74-75	366206	8051182	Guinea grass under tower and to top of gully, good regrowth connection across gully, Guinea grass up slope with scattered regrowth saplings and tree ferns, to tower	Regrowth gully is thesis trapping site 3,powerline turns to west-north-west at tower 74
75-76	365839	8051292	Guinea grass at tower, gully with lantana on slope completely across clearing, base of gully has reasonable regrowth connection, Guinea grass and molasses on slope to tower	

SPAN	E	N	VEGETATION BETWEEN TOWERS	COMMENTS
76-77	365334	8054137	Grass under tower and on crest, long forested gully - good connection, lantana swathe on slope, *Brachiaria* on track	
77-78	365082	8051510	Lantana almost completely across, except five to ten metre wide strip around track with mainly Guinea grass, some molasses patches	
78-79	364262	8051753	Molasses grass under and near tower, lantana and Rubus on edges, deep gully with long stretch of regrowth, particularly Acacias, molasses grass to tower	Gully is thesis trapping site 4, but much more regrowth than ten years ago
79-80	363759	8051898	Gully continues to south of clearing, Guinea grass banks to north with lantana to edge, deep forested gully, lantana and Guinea grass on slope to tower	Crosses Jordan Goldfields track
80-81	363223	8052052	Guinea grass grades to lantana on slope, deep forested gully, lantana and Guinea grass on slope and under tower	
81-82	362764	8052183	Guinea grass swathe at tower grades to lantana and regrowth gully, swathe of lantana up slope from gully, then Guinea grass swathe with lantana on edges and occasional molasses grass patches	
82-83	362493	8052263	Wide Guinea grass swathe with molasses grass patches, larger areas of molasses closer to tower	Jordan Goldfields track obvious
83-84	362163	8052358	Molasses / signal grass under tower, Guinea and molasses grass patchwork swathe, lantana on edge mostly but lantana connection in one place, swathes of molasses and Guinea grass along track, molasses swathe edged with lantana, lantana edges wider near tower 84	
84-85	361944	8052420	Molasses / signal grass under tower, Guinea grass along track, lantana almost completely across clearing, mostly molasses swathe but some Guinea grass, patches of signal grass, molasses and Guinea grass swathe to tower	
85-86	361541	8052537	Molasses / signal grass under tower, Guinea grass swathe on hill, deep forested gully for majority of span	Tributary of Kaaru Creek
86-87	361299	8052606	Molasses and Guinea grass patchwork swathe, lantana on edge and in gully running parallel to powerline, molasses grass to tower	
87-88	361068	8052347	Molasses grass under tower, molasses and Guinea grass patchwork swathe, lantana on both slopes into narrow regrowth gully connection, molasses and Guinea grass to tower with lantana along rainforest edge	Powerline turns toward southwest and Maalan track
88-89	360889	8052102	Approx. ten metre wide lantana edge of Guinea and molasses grass and approx. twenty metre wide swathe, lantana stretches completely across clearing, grades into Guinea grass at crest	Encounters Maalan track at crest; first Maalan track powerline clearing weed site

SPAN	E	N	VEGETATION BETWEEN TOWERS	COMMENTS
89-90	360520	8051595	Guinea grass swathe with some large patches of molasses grass, lantana along rainforest edge, regrowth gully, narrow well-forested gully section in centre of span, molasses and Guinea grass patchwork swathe	
90-91	360281	8051271	Molasses grass under tower, molasses and Guinea grass patchwork swathe, lantana edges, probably similar to tower but difficult to interpret because of high plane level and shadow over section	second crossing of Maalan track
91-92	360062	8050970	Similar to previous span, again difficult to interpret due to shadow and plane height, may be more lantana than previous span, Guinea and molasses grass to tower	third crossing of Maalan track; second Maalan track powerline clearing site
92-93	359784	8050591	Guinea and molasses grass patchwork swathe from tower running parallel to Maalan track, lantana-edge gully with some regrowth, then creek with low forest, then good forest or regrowth connection, regrowth grading up from gully to lantana to grass under tower	Maalan track runs parallel to line for reasonable distance
93-94	359613	8050358	Guinea grass swathe with molasses grass areas, lantana and Guinea grass mixture to Guinea grass swathe at tower 94	
94-95	359390	8050052	Guinea grass swathe grades to wide lantana edge with tree ferns and Guinea grass in clearing centre, grades to deep gully - in shadow but appears to forested or regrowth, lantana swathe up slope from gully, Guinea and molasses grass under tower 95	Maalan track crosses
95-96	359318	8049804	Guinea grass with wide lantana edges, lantana swathe across small gully, Guinea grass swathe with large molasses patches, molasses swathe to tower 96	Line veers to south
96-97	359269	8049571	Molasses swathe, deep forested gully, lantana-edged molasses swathe to tower 97	Tributary of garee creek
97-98	359186	8049174	Molasses under tower, wide Guinea grass swathe grades to swathe edged with lantana, molasses grass swathe, deep lantana and tree-fern edged forested gully, molasses swathe to tower 98	Karang Creek
98-99	359131	8048913	Molasses and Guinea grass swathe at tower, deep forested gully, lantana swathe grades into Guinea grass and then molasses grass swathe with some wide lantana edges	Tributary of Karang Creek
99-100	359050	8048529	Signal grass under tower, molasses swathe on hill crest, lantana swathe, gully in shadow possibly lantana, Guinea grass on crest, deep forested gully edged with lantana and Guinea grass, narrow molasses swathe, Guinea and molasses patchwork swathe to tower 100	

SPAN	E	N	VEGETATION BETWEEN TOWERS	COMMENTS
100-101	358866	8047656	Shadow and flight height restrict interpretation. Possibly short grass at tower, long forested gully, lantana swathe, guinea grass swathe, molasses swathe to tower	Maalan tracks turns away from powerline clearing
101-102	358805	8047370	Shadow and flight height restrict interpretation Probably molasses grass at tower, lantana-edged gully with regrowth, some guinea and molasses grass on crest, slimilar lantana gully with some regrowth or forested gully, guinea / lantana mixture to signal/guinea grass swathe on crest at tower 102	Tributary of south johnstone
102-103	358760	8047148	Grassy swathe of signal/Guinea grass grading to Guinea and molasses grass patchwork. Guinea grass swathe to tower 103	
103-104	358658	8046676	Guinea grass swathes grades into lantana/regrowth mixture, narrow regrowth forested gully, molasses grass swathe with wide lantana edges, Guinea grass swathe edged with lantana at tower	
104-105	358491	8045884	Regrowth gully half way across clearing, molasses grass on eastern side, grassy swathe on crest, lantana-regrowth swathe, deep forested gully connection, grass (probably Guinea) on river bank, Guinea grass swathe, molasses swathe edged with Guinea grass and some lantana, wide lantana edges with molasses grass grades into lantana and regrowth connection across clearing, molasses grass under tower	South Johnstone River crossing
105-106	358424	8045613	Molasses grass swathe, edged with lantana, regrowth or forested gully (interpretation difficult due to shadow), good forested connection, lantana edge of gully with creepers and tree ferns, Guinea grass swathe, track cutting near tower	West Palmerston track
106-107	358326	8045378	Good forested connection. Clearing or bare earth around tower 107. Guinea grass on crest	Powerline turns to southwest
107-108	358041	8044889	Another long forested connection, mixed Guinea grass swathe with regrowth connections, second forested gully	Suttie's Gap road follows clearing toward next tower
108-109	357783	8044427	Molasses / Guinea grass mixture, deep gully almost completely across clearing but track breaks connection, molasses / Guinea grass on eastern side, deep forested gully to west, signal grass next to track, molasses / Guinea grass patchwork to tower	Cross Suttie's Gap road, H road follows down centre, Suttie's Gap powerline crossing weed site
109-110	357664	8043777	Grassy swathe at crest, deep forested gully, track fringed with Guinea and molasses grass, landslip or track cutting, second forested gully, Guinea grass swathe to tower	H road crosses twice

SPAN	E	N	VEGETATION BETWEEN TOWERS	COMMENTS
110-111	357603	8043394	Guinea grass under tower, area of bare earth / track, long deep forested gully, Guinea grass swathe to tower 111 with lantana edges, but difficult to interpret because of shadows	H road crosses twice
111-112	357580	8043252	Signal grass under tower, Guinea grass / lantana swathe but difficult to interpret because of shadow	H road follows
112-113	357557	8043100	Similar – Guinea / lantana mixture - interpretation difficult	Road obvious
113-114	357405	8042957	Molasses / Guinea grass swathe, narrow forested gully, molasses swathe with Guinea patches to tower 114	Powerline veers west
114-115	357177	8042797	Molasses grass swathe, deep forested gully, molasses / Guinea grass swathe to tower 115	
115-116	356824	8042549	Molasses / Guinea grass in small clearing around and under tower, long deep forested gully, lantana-fringed, molasses and Guinea grass to tower	
116-117	356501	8042304	Similar, larger grassy swathe to tower 117, lantana and regrowth along clearing edge - tree ferns, molasses grass near track and road cutting	H-road obvious
117-118	356219	8042016	Molasses / Guinea grass in clearing around tower, low forest and regrowth, forested gully, lantana and regrowth to tower, small grassy clearing near tower	Powerline veers slightly to south east
118-119	355297	8041674	Shadows - very difficult to interpret. Clearing may be regrowth or forest trimmed low, possibly forested gully then long regrowth or lantana swathe	
119-120	355922	8041171	Difficult to interpret because plane veers and misses most of span. Possibly deep forested gully, tower clearing small with molasses / Guinea grass, possibly vine towers on canopy near tower, regrowth / lantana / bramble swathe	Powerline veers east
120-121	356092	8040260	Long forested connection, similar to 119-120, small tower 121 footprint with molasses grass	
121-122	356210	8039836	Powerline swings above canopy, shorter section, tower clearing larger, regrowth on slope, tree ferns etc, regrowth close to tower 122	
122-123	356347	8039346	Powerline swings above canopy, concrete tower pad with small area of Guinea grass around pad	
123-124	356491	8038838	Similar, clearing to tower larger area with Guinea grass	
124-125	356435	8038452	Difficult to interpret because mainly obscured on video. Similar, grass, regrowth or lantana in clearing.	Powerline veers south

SPAN	E	N	VEGETATION BETWEEN TOWERS	COMMENTS
125-126	356112	80.3249	Again difficult to interpret - plane flying very high. Vegetation appears lower, possibly regrowth.	
126-127	355804	8038068	Similar problem with interpretation. Vegetation appears lower, possibly regrowth, Guinea grass swathe in places, forested gully, molasses and Guinea grass under tower	Powerline access track obvious
127-128	355358	8037802	Guinea and molasses grass on slope down from tower crest, deep forested gully, very small clearing with regrowth for tower 128	
128-129	354634	8037357	Large clearing around river bank, Guinea / signal grass on island in river, mainly grassy weeds on bank, otherwise mainly forested connection, grassy swathe to tower 129 with Guinea and molasses	Crosses Tully River
129-130	354402	8037216	Complete grassy swathe with Guinea and molasses grass, lantana on edges and steep cliffs	
130-131	353905	8036914	Grassy swathe under tower and to cliff edge, river banks less disturbed, deep forested gully rainforest connection, small clearing with Guinea and molasses at tower 131	Crosses Tully River. Access track obvious
131-132	353202	8036832	Difficult to interpret because of plane height. River bank and road disturbance, swathe clearing with regrowth in small gully, lantana and Guinea grass, possibly small forested gully, Guinea grass under tower 132	Following Tully Gorge
132-133	352902	8036806	Similar - regrowth and clearing, occasional deeper gully with better regrowth, large swathes of molasses and Guinea grass to tower 133	
133-134	352558	8036774	Swathe of Guinea and molasses grass continues, lantana and Rubus on edges, forested remnant closer to river with reasonable riparian strip following gully through clearings further up hill away from powerline, Guinea grass under tower 134	
134-135	352248	8036743	Guinea and molasses grass swathe continues, road cuttings with molasses grass, other powerlines and clearings adjacent	Runs parallel to Tully Gorge Road
135-136	351922	8036576	Mostly obscured due to plane turning, partial grassy swathe, some regrowth, possibly reasonable gully forest or regrowth connection	Powerline clearing veers south west
136-137	351788	8036496	Very difficult to interpret because plane high while turning and searching. Possibly regrowth with some grass, tower also obscured.	
137-138	351603	8036295	Too difficult to interpret. Tower 137 close to road. Possibly mainly regrowth or lantana with some grassy areas. Tower 138 may be on bare Earth or landslip area on hillside.	

SPAN	E	N	VEGETATION BETWEEN TOWERS	COMMENTS
138-139	351390	8036005	Again difficult to interpret - plane flying high. May be forested or regrowth with some grassy swathe leading to tower 139, grass mainly around track, regrowth and lantana adjacent to edge	Track obvious
139-140	351232	8035795	Difficult to interpret. Clearing with Guinea grass, track and regrowth, molasses grass under tower 140	
140-141	350919	8035383	Various clearings adjacent to road, car park, river bank vegetation less disturbed, molasses and Guinea grass adjacent to road and tower 141	Crosses Tully Gorge Road
141-142	350814	8035259	Difficult to interpret. River bank vegetation relatively undisturbed, grass under tower 142	Crosses Tully Gorge Road again
142-143	350477	8035163	Difficult to interpret. River bank vegetation relatively undisturbed, some Guinea and molasses grass on river edge near tower 143	Crosses Tully Gorge Road again
143-144	350073	8035163	Crosses river, difficult to interpret. Possibly swathe of regrowth and some forest, low but doesn't appear to form connection	Crosses Tully River
144-145	349728	8035156	Difficult to interpret - plane high, turning and shadows over clearing. Appears to be regrowth with Guinea grass patches, possibly molasses, probably lantana edges, possibly some forest	
145-146	349449	8035160	Still difficult to interpret. Similar regrowth, Guinea and molasses grass	
146-KPS	349308	8035092	Crosses river to Kareeya power station. Grass clearings up ridges of gorge from power station, possibly fire scars. Cleared swathe (over regrowth) for cable car.	Kareeya power station. Some powerlines come down gorge to power station from Koombooloomba. Cable car to access Koombooloomba from Kareeya

APPENDIX 1.4

CHALUMBIN-WOREE POWERLINE CLEARING AERIAL VIDEO ANALYSIS OF ECOLOGICAL CONDITION

Span	E	N	Vegetation Between Towers	Comments
10085-10086	349722	8122843	Cleared, some grader grass adjacent to tower and track, mangos. Bridle Creek has reasonable riparian connection but some bare Earth. Bridle Creek follows edge of clearing to tower 10086, probably some grass alongside riparian strip. Forest adjacent appears to be eucalypts	Powerline turns to south-east at tower 10085 (349413E, 8122978N). Crosses Bridle Creek Road and Bridle Creek
10086-10087	350090	8122695	Cleared swathe, probably grass e.g. *Themeda* or *imperata*, plane very high so hard to interpret, bridle creek riparian strip runs parallel to clearing on north side, beyond that is mainly eucalypts and acacia forest, clearing crosses bridle creek, grass to tower 10087	Bridle creek track obvious
10087-10088	350376	8122579	Cleared, some *Themeda*, rainforest or wet sclerophyll adjacent to clearing, grass on edge of track, probably Lantana in gully to south of track, probably scattered regrowth shrubs, more lantana to tower 10088	Track passes through tower 10087, track obvious
10088-10089	350752	8122428	Similar but probably more Lantana on southern side of track, grass in centre of clearing and partly regrowth on northern side, gully connection probably rainforest before tower 10089	Track passes through tower 10088
10089-10090	351032	8122315	Good forested connection almost complete distance between towers, cleared grassy area under tower 10090	
10090-10091	351393	8122172	Forest or more probably regrowth, clearing under towers not large, regrowth in second gully, some *Themeda* on intermediate crest, regrowth to north of track and taller regrowth to south of track	Track obvious
10091-10092	351700	8122111	Near tower grassy cleared area with herbaceous weeds, good forested connection to tower 10092	Road veers away past tower, powerline veers slightly to east, first weed site occurs from tower 10091 to east
10092-10093	352114	8122058	Grass under tower, excellent forested connection, Acacia canopies obvious, clearing only under tower 10093,	Track crosses clearing
10093-10094	352619	8121986	Appears to be regrowth either side of track, probably grass (molasses?). On edges of track and crests above cuttings, lantana in gully beside track	Track obvious, second weed site
10094-10095	353313	8121886	Grass under and around towers, probably *Brachiaria* or Guinea grass, long forested gully	Track veers to south

Span	E	N	Vegetation Between Towers	Comments
10095-10096	353612	8121845	Acacia regrowth in gully forms connection across clearing, large grassy areas - probably *Brachiaria, Melinis* and Guinea further up hill, regrowth to south side of track, grassy swathe to towerx	Track obvious, third weed site
10096-10097	354038	8121786	Grassy, weedy swathe, some Acacia regrowth on edges, followed by canopy connectivity over track with Acacias, then good forested gully, grassy and weedy area to tower 10097	Track obvious
10097-10098	354412	8121956	Clearing under tower, good forested connection	Powerline veers to north east, tributary of Clohessy river
10098-10099	354779	8122154	Clearing only under tower, good forested connection	Clohessy River
10099-10100	355189	8122369	Clearing around towers only - grass *Brachiaria or Melinis*, Acacia regrowth further down slopes, Acacia regrowth canopies then good forested connection	Tributary of Clohessy River
10100-10101	355380	8122470	Small clearing around tower, regrowth and grassy swathe to tower 10101 - close to top of range, scattered Acacias but mainly weeds, possibly Lantana and *Brachiaria*	
10101-10102	355709	8122638	Acacia regrowth canopies. Grassy swathe around towers. Good forested connection to tower 10102	
10102-10103	356426	8122574	Plane flying very high - difficult to interpret. Possibly forested conneciton then regrowth swathes then lantana then grass to tower 10103. Weeds along track - possibly lantana and bramble	Powerline veers to east. Shoteel Creek Road rejoins powerline. Weed site number 4
10103-10104	356887	8122518	Short clearing to east of tower. Long forested connection, followed by grassy / weedy / shrubby swathe to tower 10104.	Road crosses below tower 10104. Weed site number 5. Highest point
10104-10105	357429	8122453	Acacia regrowth canopies near tower, clearing under. Long forested connection. *Brachiara* close to tower, possibly lantana also.	Track runs under tower 10105.
10105-10106	358012	8122383	*Brachiaria* around tower clearing. Regrowth and lantana swathe, then forested connection, then regrowth and lantana to tower 10106	Track veers to south then recrosses clearing
10106-10107	358864	8122281	Grass under tower, regrowth / lantana to track crossing. Long forested connection over deep gully, grass clearing above dam wall, possibly molasses grass, water at base of dam, clearing to tower 10107	Headwaters of Freshwater Creek. Crosses dam overflow area of water.
10107-10108	359308	8122245	Clearing next to kiosk, large clearing including tracks and roads, regrowth especially Acacia along road, short area of grassy swathe, clearing probably *Dicranopteris* or lantana	Powerline veers slightly north. Follows Copperlode Road. Tracks and roads near Copperlode Dam kiosk. Weed site number 6.

Span	E	N	Vegetation Between Towers	Comments
10108-10109	359535	8122208	Regrowth, probably some Acacia between towers, low regrowth / *Dicranopteris* / lantana near and under towers, also some bare Earth.	Copperlode road follows clearing. Powerline veers slightly south. Crosses road again.
10109-10110	360129	8122325	Weedy crest near tower then deep forested gully, regrowth to 10110.	Powerline turns north. Tributary of Freshwater Ck. Weed site number 7.
10110-10111	360462	8122405	Small clearing around tower, probably grass. Forested gully, crest then smaller gully, then lantana and grass to tower 10111	Smaller tributary of Freshwater Creek. Copperlode Road runs next to tower 10111.
10111-10112	360994	8122506	Larger clearing under and near tower, Crest slope possibly molasses grass with regrowth on edges, Some lantana or bramble also. Probably *Dicranopteris* and *Lycopodiella* on road bank, probably *Gahnia* or shrubs. Deep, forested gully. Grass on road verge mowed, embankment probably bramble. Grass to tower 10112	Access track to tower 10111 obvious. Road turns north. Road crosses clearing. Copperlode Road veers back and runs along clearing.
10112-10113	361242	8122585	Small tower clearing. Low regrowth to tower 10113.	Powerline veers slightly north.
10113-10114	361474	8122647	Small clearing with bare Earth for tower 10113. Grass in clearing then lower regrowth - possibly lantana and bramble or *Dicranopteris,* then grass to tower	Powerline veers back slightly to south. Road crosses. Obvious access track for tower 10114
10114-10115	362172	8122915	Bare earth under tower 10114. Regrowth on slope near tower then long span across deep, forested gully. Tower 10115 sited further up hill from small tower and only footprint cleared, smaller tower next to road has clearing with grass and lantana	Powerline veers north. Tributary of Freshwater Creek. Road crosses.
10115-10116	362545	8123082	Road embankment with woody weeds – lantana / bramble and/or *Dicranopteris* etc. Forested or regrowth in gully. Swathe with molasses, probably *Paspalum,* maybe *Dicranopteris* to tower 10116	Road runs parallel. New line higher up slope, small towers follow road. Road with mowed verges turns north
10116-10117	362859	8123231	Tower clearing with molasses grass, possibly blue snakeweed and *Paspalum.* Regrowth then grassy swathe with regrowth edges. Road verges may be bramble or *Dicranopteris,* long swathe to tower probably grass, possibly *Dicranopteris*	Road crosses. Road crosses a second time and turns north. Tower on escarpment edge.
10117-10118	363637	8123343	Difficult to interpret, plane very high. Big forested gully. Hillslopes have grass patches (fire scars) etc	Powerline turns south-east to follow escarpment. Tower 10118 above highest clearing for water tank behind Woree.
10118-10119	360493	8123163	Canopy with Acacias, line swings above to tower 10119	Powerline turns south.
10119-10120	364544	8122937	Tower on eucalypt-dominated ridge, rainforest gully to next ridge	Tower above highest home sites on hillslope

Span	E	N	Vegetation Between Towers	Comments
10120-10121	364898	8123047	Tower on grassy ridge - fire scar. Probably molasses grass.	Powerline turns east down to White Rock. Substation next to Forest Gardens.

APPENDIX 2.1

PALMERSTON TOTAL SPECIES LIST

Key

Habit

H = Herb	G = Grass	GT = Gap Tree	F = Fern
S = Shrub	U = Understory	V = Vine	HE = Hemiepiphyte
C = Canopy Tree	E = Epiphyte		

Successional Stage

W = Weed	E = Early	I = Intermediate	L = Late

SCIENTIFIC NAME	FAMILY	COMMON NAME	NCA STATUS	SUCCESSIONAL STAGE	HABIT
**Ageratum conyzoides*	Asteraceae	blue top		W	H
**Axonopus fissifolius*	Poaceae	narrow leaf carpet grass		W	G
**Brachiaria decumbens*	Poaceae	signal grass		W	G
**Crassocephalum crepidiodes*	Asteraceae	thickhead		W	H
**Crotalaria pallida*	Fabaceae	rattlepod		W	H
**Erechtites valerianifolia*	Asteraceae	Brazilian fireweed		W	H
**Lantana camara*	Verbenaceae	lantana		W	S
**Melinus minutiflora*	Poaceae	molasses grass		W	G
**Panicum maximum*	Poaceae	Guinea grass		W	G
**Passiflora subpeltata*	Passifloraceae	passionfruit		W	V
**Rubus alceifolius*	Rosaceae	giant bramble		W	S
**Sida rhombifolia*	Malvaceae	arrowleaf sida		W	H
**Solanum mauritianum*	Solanaceae	wild tobacco		W	S
**Solanum torvum*	Solanaceae	devil's fig		W	S
**Stylosanthes humilis*	Fabaceae	townsville lucerne		W	H
**Triumfetta rhomboidea*	Tiliaceae	Chinese burr		W	H
Acacia celsa	Mimosaceae	brown salwood		**E**	C
Acacia mangium	Mimosaceae	brown salwood		E	GT
Acmena divaricata	Myrtaceae	cassowary satinash	R	*L*	C
Acmena graveolens	Myrtaceae	cassowary satinash		*L*	C
Acronychia vestita	Rutaceae	white aspen		*I*	C
Aglaia tomentosa	Meliaceae	rusty aglaia		*I-L*	U
Alangium villosum	Alangiaceae	canary muskheart		**I-L**	C
Aleurites rockinghamensis	Euphorbiaceae	candlenut		**E**	C
Alocasia brisbanensis	Araceae	cunjevoi		**E-I-L**	H
Alphitonia petriei	Rhamnaceae	pink ash/ sarsaparilla		**E**	GT
Alpinia arctiflora	Zingiberaceae	snow ginger		*E*	H
Alpinia modesta	Zingiberaceae	narrow-leaf ginger		**I-L**	H
Alstonia muelleriana	Apocynaceae	hard milkwood		**E**	C

SCIENTIFIC NAME	FAMILY	COMMON NAME	NCA STATUS	SUCCESSIONAL STAGE	HABIT
Antidesma erostre	Euphorbiaceae	wild currant		*I-L*	U
Antirrhea tenuiflora	Rubiaceae	crimson berry		*I*	U
Apodytes brachystylis	Icacinaceae	buff alder		*I-L*	U
Archidendron whitei	Mimosaceae		R	*I*	U
Ardisia pachyrrachis	Myrsinaceae	mountain ardisia		I	U
Argyrodendron peralatum	Sterculiaceae	red tulip oak		**L**	C
Argyrodendron trifoliolatum	Sterculiaceae	brown tulip oak		*L*	C
Arthropteris palisotii	Nephrolepidaceae			*I-L*	HE
Arytera pauciflora	Sapindaceae	pink tamarind		**I-L**	U
Asplenium australasicum	Aspleniaceae		C	**E-I-L**	E
Asplenium laserpitiifolium	Aspleniaceae	Johnstone R maidenhair	C	*E-I-L*	E
Atractocarpus hirtus	Rubiaceae	hairy gardenia		*I-L*	U
Atractocarpus merikin	Rubiaceae	mountain gardenia		*I-L*	U
Austrobaileya scandens	Austrobaileyaceae			*I-L*	V
Austromyrtus dallachiana	Myrtaceae	lignum		*L*	U
Austrosteenisia stipularis	Fabaceae	northern blood vine		*E-I-L*	V
Backhousia bancroftii	Myrtaceae	Johnstone R hardwood		*I-L*	C
Beilschmiedia bancroftii	Lauraceae	yellow walnut		*L*	C
Beilschmiedia tooram	Lauraceae	coach walnut		*L*	C
Blechnum cartilagineum	Blechnaceae		C	*E-I-L*	F
Bowenia spectabilis	Zamiaceae	zamia fern		*I*	H
Breynia stipitata	Euphorbiaceae	coffee bush		**E**	S
Brombya platynema	Rutaceae	brombya		*I-L*	U
Calamus australis	Arecaceae	hairy Mary		**I-L**	V
Calamus caryotoides	Arecaceae	fishtail lawyer cane		*I-L*	V
Calamus motii	Arecaceae	lawyer cane		*I-L*	V
Callicarpa longifolia	Verbenaceae	chukin		*I-L*	U
Cardiopteris moluccana	Cardiopteridaceae			*I-L*	V
Cardwellia sublimis	Proteaceae	northern silky/bull oak		**E-I-L**	C
Carnarvonia araliifolia	Proteaceae	Caledonian oak		*I-L*	C
Carronia pedicellata	Menispermaceae		E	*I-L*	V
Carronia protensa	Menispermaceae			**I-L**	V
Castanospermum australe	Fabaceae	black bean		**I-L**	C
Castanospora alphandii	Sapindaceae	brown tamarind		**I-L**	C
Chionanthus ramiflora	Oleaceae	northern olive		*E-I*	C
Cissus vinosa	Vitaceae			*E-I*	V
Citronella smythii	Icacinaceae	silky beech		*I-L*	C
Colysis ampla	Polypodiaceae			*I-L*	HE
Connarus conchocarpus	Connaraceae	shell vine		*I-L*	V
Cordyline cannifolia	Agavaceae	palm lily		**E-I-L**	H
Corymborkis veratrifolia	Orchidaceae			*E-I-L*	H

SCIENTIFIC NAME	FAMILY	COMMON NAME	NCA STATUS	SUCCESSIONAL STAGE	HABIT
Corynocarpus cribbianus	Corynocarpaceae	cribwood		*I-L*	C
Cryptocarya angulata	Lauraceae	ivory laurel		*I-L*	C
Cryptocarya grandis	Lauraceae	cinnamon laurel		**I-L**	C
Cryptocarya mackinnoniana	Lauraceae	rusty laurel		**I-L**	C
Cryptocarya murrayi	Lauraceae	Murray's laurel		**I-L**	C
Cryptocarya pleurosperma	Lauraceae	poison laurel	R	*I-L*	C
Cupaniopsis flagelliformis	Sapindaceae	brown tuckeroo		*I*	U
Daphnandra repandula	Monimiaceae	sassafras		*I-L*	C
Darlingia darlingiana	Proteaceae	brown silky oak		**E-I**	C
Davidsonia pruriens	Davidsoniaceae	Davidson's plum		*I*	C
Delarbrea michieana	Araliaceae	blue nun		*I-L*	C
Desmos goezeanus	Annonaceae			**L**	V
Dichapetalum papuanum	Dichapetelaceae			*I-L*	S
Diospyros sp. Millaa Millaa	Ebenaceae	ebony		*L*	U
Diplazium dilatatum	Athyriaceae			**I-L**	F
Diploglottis smithii	Sapindaceae	Smith's tamarind		*I*	C
Doryphora aromatica	Monimiaceae	sassafras		*I-L*	C
Drynaria rigidula	Polypodiaceae			**E-I-L**	E
Dysoxylum klanderi	Meliaceae	buff mahogany		*I*	U
Dysoxylum muelleri	Meliaceae			**E-I**	C
Dysoxylum oppositifolium	Meliaceae	pink mahogany		*I*	C
Dysoxylum papuanum	Meliaceae	spice mahogany		*I*	C
Dysoxylum parasiticum	Meliaceae	yellow mahogany		*I*	C
Elaeagnus triflora	Elaeagnaceae	Millaa Millaa vine		**E-I**	V
Elaeocarpus grandis	Elaeocarpaceae	silver quandong		*E-I*	C
Embelia australiana	Myrsinaceae			**I-L**	V
Endiandra compressa	Lauraceae	Queensland greenheart		*I-L*	U
Endiandra globosa	Lauraceae	ball fruited walnut	R	*I-L*	C
Endiandra insignis	Lauraceae	hairy walnut		*I-L*	C
Endiandra leptodendron	Lauraceae			*I-L*	U
Endiandra monothyra	Lauraceae	rose walnut		*I-L*	C
Endiandra sankeyana	Lauraceae	Sankey's walnut		*I-L*	C
Epipremnum pinnatum	Araceae	native monstera		*E-I-L*	HE
Erycibe coccinea	Convolvulaceae			**I-L**	V
Erythroxylum ecarinatum	Erythroxylaceae	brown plum		*I-L*	C
Eupomatia sp. Noah Head	Eupomatiaceae			*I*	U
Ficus pleurocarpa	Moracaeae	figwood		*I-L*	C
Flagellaria indica	Flagellariaceae	supplejack		**E-I**	V
Flindersia acuminata	Rutaceae	silver silkwood		*I*	C
Flindersia bourjotiana	Rutaceae	silver ash		*I*	C
Franciscodendron laurifolium	Sterculiaceae	tulip kurrajong		*L*	C

SCIENTIFIC NAME	FAMILY	COMMON NAME	NCA STATUS	SUCCESSIONAL STAGE	HABIT
Freycinetia excelsa	Pandanaceae	climbing pandan		*I-L*	HE
Galbulimima baccata	Himantandraceae	pigeonberry ash		*L*	C
Gillbeea adenopetala	Cunoniaceae	pink alder		*I-L*	C
Glochidion harveyanum	Euphorbiaceae	buttonwood		**E**	GT
Gmelina fasciculiflora	Verbenaceae	white beech		**I-L**	C
Guioa lasioneura	Sapindaceae	silky tamarind		**E-I**	U
Haplostichanthus sp. Johnstone R.	Annonaceae			*I-L*	U
Haplostichanthus sp. Topaz	Annonaceae			*I-L*	U
Helicia nortoniana	Proteaceae	Norton's silky oak		**I-L**	U
Hoya pottsii	Asclepiadaceae	Nicholson's wax vine		*I-L*	V
Hypserpa decumbens	Menispermaceae			*E-I*	V
Hypserpa laurina	Menispermaceae			*E-I*	V
Hypserpa smilacifolia	Menispermaceae			*E-I*	V
Ichnocarpus frutescens	Apocynaceae			**E-I-L**	V
Ixora baileyana	Rubiaceae	Bailey's ixora	R	*L*	U
Lasianthus strigosus	Rubiaceae	blue rubi		*L*	U
Lepiderema sericolignis	Sapindaceae	silkwood		**I-L**	U
Linospadix micrcocarya	Arecaceae	walking stick palm		*I-L*	H
Linospadix minor	Arecaceae	walking stick palm		*I-L*	H
Litsea leefeana	Lauraceae	bollywood		*E*-***I-L***	C
Mackinlaya confusa	Araliaceae			*E-I*	U
Maclura cochinchinensis	Moracaeae	Cockspur thorn		**E**	V
Mallotus paniculatus	Euphorbiaceae	turn in the wind		*E-I*	C
Medicosma fareana	Rutaceae	white aspen		*I-L*	U
Melicope vitiflora	Rutaceae	northern evodia		*E-I*	GT
Melicope xanthoxyloides	Rutaceae	yellow evodia		*E-I*	U
Melodinus australis	Apocynaceae	bellbird vine		*I*	V
Melodinus bacellianus	Apocynaceae	murpe	R	*I*	V
Melodorum uhrii	Annonaceae			*I*	V
Mischocarpus stipitatus	Sapindaceae	purple aril mischocarp		*I*	U
Morinda umbellata	Rubiaceae			*I*	V
Myristica globosa	Myristicaceae	nutmeg		**I-L**	U
Neolitsea dealbata	Lauraceae	white bollywood		*E-I*	GT
Niemeyera prunifera	Sapotaceae	plum boxwood		*I-L*	U
Oberonia titania	Orchidaceae			*L*	E
Omalanthus novo-guineensis	Euphorbiaceae	bleeding heart		**E**	GT
Ophioglossum pendulum	Ophioglossaceae	ribbon fern		*L*	E
Opistheolepis heterophylla	Proteaceae	blush silky oak		*L*	C
Oplismenus hirtellus	Poaceae			**E-I**	G
Pandanus monticola	Pandanaceae	screw palm		*L*	U
Pandorea pandorana	Bignoniaceae	wonga vine		**E-I-L**	V

SCIENTIFIC NAME	FAMILY	COMMON NAME	NCA STATUS	SUCCESSIONAL STAGE	HABIT
Pararistolochia australopithecurus	Aristolochiaceae			*I*	V
Pilidiostigma tropicum	Myrtaceae	apricot myrtle		**I-L**	U
Piper caninum	Piperaceae			*E-I*	V
Piper novaehollandiae	Piperaceae	giant pepper vine		*E-I*	V
Pitaviaster haplophyllus	Rutaceae	yellow aspen		*I*	U
Pittosporum rubiginosum	Pittosporaceae	hairy red pittosporum		*I*	U
Pleuranthodium racemigerum	Zingiberaceae			*I-L*	U
Podocarpus dispermus	Podocarpaceae	broadleaf brown pine		*L*	U
Polyalthia michaelii	Annonaceae	canary beech	R	*I-L*	U
Polyosma hirsuta	Grossulariaceae	hairy polyosma		*I-L*	U
Polyscias australiana	Araliaceae	ivory boxwood		*E*	U
Polyscias elegans	Araliaceae	celery wood		*E*	C
Polyscias mollis	Araliaceae	grab me please		*E*	U
Pothos longipes	Araceae	candle vine		*E-I-L*	HE
Prunus turneriana	Rosaceae	almondbark		*E*	C
Pseuderanthemum variabile	Acanthaceae			**E-I-L**	H
Pseuduvaria villosa	Annonaceae		R	*L*	U
Psychotria sp. Utchee Creek	Rubiaceae	big leaf psychotria		*L*	U
Pyrrosia longifolia	Polypodiaceae			*I-L*	HE
Randia tuberculosa	Rubiaceae			*I*	U
Rhaphidophora australasica	Araceae			*L*	HE
Rhodamnia sessiliflora	Myrtaceae	iron malleewood		**E-I**	U
Rhodomyrtus macrocarpa	Myrtaceae	finger cherry		*I*	U
Ripogonum album	Smilacaceae			*I*	V
Rockinghamia angustifolia	Euphorbiaceae	kamala		*I*	U
Rourea brachyandra	Connaraceae		R	*I-L*	V
Rubus probus	Rosaceae	wild raspberry		**E**	H
Sageretia hamosa	Rhamnaceae			*I-L*	V
Salacia disepala	Celastraceae			*I-L*	V
Sarcopteryx martyana	Sapindaceae	scrub tamarind		**E-I**	U
Schefflera actinophylla	Araliaceae	umbrella tree		*E-I*	E
Schefflera elliptica	Araliaceae			*I*	V
Selaginella longipinna	Selaginellaceae			*L*	F
Siphonodon membranaceus	Celastraceae	ivorywood		*I-L*	C
Sloanea macbrydei	Eleaocarpaceae	grey carabeen		**L**	C
Smilax calophylla	Smilacaceae			*I*	V
Solanum viridifolium	Solanaceae	nightshade		*E*	S
Symplocos cochinchinensis var. *pilosiuscula*	Symplocaceae	white hazlewood		**E-I**	GT
Symplocos paucistaminea	Symplocaceae			*I-L*	U

SCIENTIFIC NAME	FAMILY	COMMON NAME	NCA STATUS	SUCCESSIONAL STAGE	HABIT
Synima cordierorum	Sapindaceae	synima		*I-L*	U
Syzygium alliiligneum	Myrtaceae	onionwood		*L*	C
Syzygium cormiflorum	Myrtaceae	bumpy satinash		**L**	C
Syzygium gustavioides	Myrtaceae	grey satinash		*L*	C
Tabernaemontana pandacqui	Apocynaceae	banana bush		*I*	U
Tetracera nordtiana var. *nordtiana*	Dilleniaceae	small-leaved fire vine		**E-I**	V
Tetrasynandra laxiflora	Monimiaceae	tetra beech		**I-L**	U
Toechima erythrocarpum	Sapindaceae	pink tamarind		**I-L**	U
Ventilago ecorollata	Rhamnaceae			*E-I*	U
Viticipremna queenslandica	Verbenaceae	vitex		*I-L*	U
Wilkiea angustifolia	Monimiaceae			*L*	U
Wrightia laevis ssp *millgar*	Apocynaceae	millgar		*I-L*	C
Xanthophyllum octandrum	Xanthophyllaceae	yellow boxwood		**I-L**	C

APPENDIX 2.2

SPECIES, STRATA OCCURRING AND DOMINANCE CATEGORY AT EACH TRANSECT

CONTROL SITE 1. NON-HIGHWAY SIDE TRANSECTS

17°36.872S 145°46.936E
14/06/02

Key:

	To one metre from Stake	To five metres from Stake
dominant	D	d
common	C	c
occasional	O	o
rare	R	r
introduced species	*	*

Site	-15 Metres						-10 Metres					
CONTROL TRANSECT 1N	Abundance Rank						Abundance Rank					
Species	Canopy	Sub-canopy	Under-storey	Ground-cover	Vine	Epipyte	Canopy	Sub-canopy	Under-storey	Ground-Cover	Vine	Epiphyte
Ageratum conyzoides				C						C		
Lantana camara										C		
Melinus minutiflora				D						D		
Panicum maximum									C			
Solanum mauritianum									O			
Ageratum conyzoides				c						c		
Lantana camara										c		
Melinus minutiflora				d						d		
Panicum maximum				c					c			
Solanum mauritianum			o						o			
Acacia celsa									r			
Acacia mangium				r								
Alphitonia petriei				r								
Cardwellia sublimis									r			
Castanospermum australe									r			
Omalanthus novo-guineensis			r						o			

Site	-5 Metres						0 Metres					
CONTROL TRANSECT 1N	Abundance Rank						Abundance Rank					
Species	Canopy	Sub-canopy	Under-storey	Ground-cover	Vine	Epipyte	Canopy	Sub-canopy	Under-storey	Ground-Cover	Vine	Epiphyte
Ageratum conyzoides				C								
Lantana camara				C						C		
Melinus minutiflora				D						D		
Ageratum conyzoides				c						c		
Lantana camara				c						c		
Melinus minutiflora				d						d		
Acacia mangium				r								
Aleurites rockinghamensis				r								
Castanospermum australe				r								

Site	5 Metres						8 Metres					
CONTROL TRANSECT 1N	Abundance Rank						Abundance Rank					
Species	Canopy	Sub-canopy	Under-storey	Ground-cover	Vine	Epipyte	Canopy	Sub-canopy	Under-storey	Ground-Cover	Vine	Epiphyte
Axonopus fissifolius				O								
Lantana camara			O	O								
Aglaia tomentosa				O								
Alangium villosum									O			
Argyrodendron peralatum			C									
Brombya platynema								O				
Calamus motii				O	O							
Cryptocarya murrayi				O					R			
Darlingia darlingiana		C						O	O			
Diploglottis smithii	D											
Epipremnum pinnatum						O						
Flindersia bourjotiana			C									
Litsea leefeana			O									
Niemeyera prunifera										O		
Pandorea pandorana					O							
Pilidiostigma tropicum			C							O		
Piper caninum				R	R							
Polyscias australiana			R									
Rourea brachyandra					R							
Sarcopteryx martyana			C									
Sloanea macbrydei							R					
Synima cordierorum				O								
Tetrasynandra laxiflora			C						R			
Passiflora subpeltata					o							
Alangium villosum									o			

Site	5 Metres						8 Metres					
CONTROL TRANSECT 1N	Abundance Rank						Abundance Rank					
Species	Canopy	Sub-canopy	Under-storey	Ground-cover	Vine	Epipyte	Canopy	Sub-canopy	Under-storey	Ground-Cover	Vine	Epiphyte
Alstonia muelleriana	r											
Archidendron whitei			o									
Asplenium australasicum						o						o
Asplenium laserpitiifolium						o						o
Austrosteenisia stipularis			o		o				o		o	
Bowenia spectabilis				o						o		
Brombya platynema		o						o				
Callicarpa longifolia			o									
Carronia protensa					c						c	
Castanospermum australe				o								
Corynocarpus cribbianus		c						c				
Darlingia darlingiana								o	o			
Diploglottis smithii	c						c					
Drynaria rigidula						o						
Embelia australiana				o								
Endiandra compressa		o						o				
Flindersia bourjotiana		o						o				
Litsea leefeana	c						c					
Melicope xanthoxyloides	o											
Melodinus australis					c						c	
Myristica globosa	o	o	o	o			o	o	o	o		
Neolitsea dealbata		o						o				
Niemeyera prunifera										o		
Ophioglossum pendulum						o					o	
Ripogonum album					o						o	
Sloanea macbrydei	r						r					
Synima cordierorum		o						o				

Site	12 Metres						16 Metres					
CONTROL TRANSECT 1N	Abundance Rank						Abundance Rank					
Species	Canopy	Sub-canopy	Under-storey	Ground-cover	Vine	Epipyte	Canopy	Sub-canopy	Under-storey	Ground-Cover	Vine	Epiphyte
Arthropteris palisotii												R
Arytera pauciflora								R				
Castanospermum australe				R								
Endiandra globosa										R		
Haplostichanthus sp. Topaz								R				
Melodinus australis				R	R							
Ripogonum album				R	R							
Alangium villosum			o									
Argyrodendron peralatum	o		o				r					
Arthropteris palisotii												r
Arytera pauciflora								r				
Asplenium australasicum						o						
Atractocarpus merikin									r			
Austromyrtus dallachiana								o				
Austrosteenisia stipularis											r	
Bowenia spectabilis				o						r		
Brombya platynema		o						o				
Carronia protensa				o	o							
Castanospermum australe				r								
Cryptocarya mackinnoniana									o			
Cryptocarya murrayi			r									
Cupaniopsis flagelliformis										o		
Darlingia darlingiana		o	o							r		
Diploglottis smithii		o	o									
Endiandra globosa				r						r		
Endiandra leptodendron								o				
Flindersia acuminata								c				
Flindersia bourjotiana	r		r									
Haplostichanthus sp. Topaz								r				
Ixora baileyana										c		
Litsea leefeana	o						o		o			
Melodinus australis					o					o	o	
Myristica globosa	o	o	o	o			o			o		
Niemeyera prunifera				o						o		
Pilidiostigma tropicum				o								
Pothos longipes												o
Ripogonum album					o						o	
Sloanea mcbrydei							r					
Symplocos cochinchinensis									o			
Tetrasynandra laxiflora									r			
Toechima erythrocarpum								o				

Site	20 Metres						25 Metres					
CONTROL TRANSECT 1N	**Abundance Rank**						**Abundance Rank**					
Species	**Canopy**	**Sub-canopy**	**Under-storey**	**Ground-cover**	**Vine**	**Epipyte**	**Canopy**	**Sub-canopy**	**Under-storey**	**Ground-Cover**	**Vine**	**Epiphyte**
Atractocarpus merikin			R									
Austrosteenisia stipularis					R							
Bowenia spectabilis				R								
Brombya platynema									O	O		
Calamus australis											C	
Cissus vinosa											O	
Cryptocarya murrayi							D					
Darlingia darlingiana				R								
Dichapetalum papuanum										O		
Drynaria rigidula												O
Endiandra globosa									O			
Flindersia acuminata							D					
Litsea leefeana			R									
Melodinus australis				R								
Myristica globosa				O								
Niemeyera prunifera				R								
Pothos longipes						R						
Pyrrosia longifolia												O
Rhaphidophora australasica												O
Salacia disepala											O	
Aglaia tomentosa									o			
Argyrodendron peralatum							d	o				
Atractocarpus merikin									o			
Austromyrtus dallachiana		o										
Brombya platynema		o						c				
Calamus australis											c	
Carronia pedicellata											o	
Corynocarpus cribbianus									o			
Cryptocarya mackinnoniana			o									
Cupaniopsis flagelliformis				o								
Diospyros sp. Millaa Millaa									r			
Doryphora aromatica									o			
Endiandra globosa								o				
Endiandra leptodendron		o										
Flindersia acuminata		d										
Ixora baileyana				c								
Melodinus australis					o						o	
Mischocarpus stipitatus		o		c					o			
Myristica globosa	o								o			
Neolitsea dealbata									o			
Pittosporum rubiginosum									r			
Psychotria sp. Utchee Ck									o			
Ripogonum album					o							
Symplocos cochinchinensis			o						o			
Synima cordierorum								o				

Site	20 Metres						25 Metres					
CONTROL TRANSECT 1N	Abundance Rank						Abundance Rank					
Species	Canopy	Sub-canopy	Under-storey	Ground-cover	Vine	Epipyte	Canopy	Sub-canopy	Under-storey	Ground-Cover	Vine	Epiphyte
Syzygium alliiligneum								o				
Tetrasynandra laxiflora									o			
Toechima erythrocarpum		o										

Site	30 Metres						50 Metres					
CONTROL TRANSECT 1N	Abundance Rank						Abundance Rank					
Species	Canopy	Sub-canopy	Under-storey	Ground-cover	Vine	Epipyte	Canopy	Sub-canopy	Under-storey	Ground-Cover	Vine	Epiphyte
Argyrodendron peralatum				O								
Arthropteris palisotii												O
Atractocarpus merikin									O			
Austrosteenisia stipularis					O							
Bowenia spectabilis				O						O		
Brombya platynema		R										
Calamus caryotoides				R								
Carronia pedicellata											O	
Carronia protensa											O	
Cissus vinosa					O							
Colysis ampla				R								
Dichapetalum papuanum				R								
Diospyros sp. Millaa Millaa									O			
Endiandra globosa				O								
Endiandra insignis			O									
Erythroxylum ecarinatum				R								
Haplostichanthus sp. Johnstone R.			O									
Haplostichanthus sp. Topaz			O									
Ixora baileyana										O		
Lepiderema sericolignis				O								
Myristica globosa			O									
Niemeyera prunifera			O	O					O			
Podocarpus dispermus			R									
Pseuderanthemum variabile				R								
Synima cordierorum									O			
Acronychia vestita							o					
Argyrodendron peralatum	c	o										
Arytera pauciflora		r										
Asplenium australasicum												c
Austromyrtus dallachiana		o						o				
Brombya platynema		o										
Calamus australis											c	

Site	**30 Metres**						**50 Metres**					
CONTROL TRANSECT 1N	**Abundance Rank**						**Abundance Rank**					
Species	**Canopy**	**Sub-canopy**	**Under-storey**	**Ground-cover**	**Vine**	**Epipyte**	**Canopy**	**Sub-canopy**	**Under-storey**	**Ground-Cover**	**Vine**	**Epiphyte**
Calamus caryotoides											c	
Citronella smythii								c				
Colysis ampla			o									
Cryptocarya murrayi	o							o				
Dysoxylum muelleri							o					
Flindersia bourjotiana	o											
Haplostichanthus sp. Johnstone R.		o										
Mackinlaya confusa									o			
Mischocarpus stipitatus									o			
Neolitsea dealbata		o										
Niemeyera prunifera								o				
Pothos longipes						c						c
Randia tuberculosa									o			
Rhodomyrtus macrocarpa		o										
Syzygium cormiflorum							o					
Tetrasynandra laxiflora		o										
Toechima erythrocarpum								o				

Site	100 Metres					
CONTROL TRANSECT 1N	Abundance Rank					
Species	Canopy	Sub-canopy	Under-storey	Ground-cover	Vine	Epipyte
Aglaia tomentosa			O			
Blechnum cartilagineum						O
Brombya platynema	D	D	C			
Carronia pedicellata					O	
Diospyros sp. Millaa Millaa			C			
Ixora baileyana				O		
Niemeyera prunifera			O			
Pothos longipes						O
Aglaia tomentosa		o	o			
Atractocarpus hirtus			o			
Austrosteenisia stipularis					d	
Beilschmiedia tooram		o				
Bowenia spectabilis				o		
Blechnum cartilagineum						o
Brombya platynema	d	d	c			
Carronia pedicellata					o	
Castanospermum australe	c					
Diospyros sp. Millaa Millaa			c			
Doryphora aromatica	d	d				
Flindersia bourjotiana	c					
Haplostichanthus sp. Topaz			o			
Ixora baileyana				o		
Niemeyera prunifera			o			
Pothos longipes						o
Pseuduvaria villosa			o			
Toechima erythrocarpum			o			
Viticipremna queenslandica			o			
Wilkiea angustifolia			o			

CONTROL SITE 2. NON-HIGHWAY SIDE TRANSECTS

17°36.895S 145°47.127E
20/06/02

Key:

	To one metre from Stake	To five metres from Stake
dominant	D	d
common	C	c
occasional	O	o
rare	R	r
introduced species	*	*

Site	-20 Metres						-15 Metres					
CONTROL SITE 2	Abundance Rank						Abundance Rank					
Species	Canopy	Sub-canopy	Under-storey	Ground-cover	Vine	Epipyte	Canopy	Sub-canopy	Under-storey	Ground-Cover	Vine	Epiphyte
**Ageratum conyzoides*										O		
**Lantana camara*										R		
**Melinus minutiflora*										C		
**Panicum maximum*			D						D			
**Stylosanthes humilis*										O		
Cissus vinosa											R	
**Ageratum conyzoides*				o						o		
**Lantana camara*			r						c			
**Melinus minutiflora*			c							c-d		
**Panicum maximum*			d						d			
**Rubus alceifolius*			o						c			
**Solanum mauritianum*							r					
**Stylosanthes humilis*			o							o		
Rubus probus										r		

Site	-10 Metres						-5 Metres					
CONTROL SITE 2	Abundance Rank						Abundance Rank					
Species	Canopy	Sub-canopy	Under-storey	Ground-cover	Vine	Epipyte	Canopy	Sub-canopy	Under-storey	Ground-Cover	Vine	Epiphyte
**Lantana camara*			C	C					D	C		
**Melinus minutiflora*			C-D	O						C		
**Rubus alceifolius*			C	C					C	C		
**Ageratum conyzoides*				c						c		
**Lantana camara*			c-d						c-d			
**Melinus minutiflora*				c-d						c-d		
**Panicum maximum*			c-d						c			
**Rubus alceifolius*			c						c			
**Stylosanthes humilis*				c						c		
Bowenia spectabilis				r						r		
Cissus vinosa					r							

Site	0 Metres						5 Metres					
CONTROL SITE 2	Abundance Rank						Abundance Rank					
Species	Canopy	Sub-canopy	Under-storey	Ground-cover	Vine	Epipyte	Canopy	Sub-canopy	Under-storey	Ground-Cover	Vine	Epiphyte
**Lantana camara*			D	D								
**Melinus minutiflora*				C								
**Rubus alceifolius*			C	C					D	D		
**Stylosanthes humilis*				C								
Helicia nortoniana										O		
Oplismenus hirtellus										C		
Piper novae-hollandiae											O	
Tetrasynandra laxiflora										O		
**Ageratum conyzoides*				c								
**Lantana camara*			d	d					c			
**Melinus minutiflora*				c						o		
**Rubus alceifolius*			c	c					d	d		
**Stylosanthes humilis*				c						o		
Alocasia brisbanensis										r		
Cissus vinosa					o							
Diploglottis smithii										o		
Flindersia acuminata							o			o		
Ichnocarpus frutescens					o							
Omalanthus novo-guineensis				r								
Oplismenus hirtellus										c		
Piper novae-hollandiae											o	
Pitaviaster haplophyllus								o				
Toechima erythrocarpum								o				

Site	8 Metres						12 Metres					
CONTROL SITE 2	Abundance Rank						Abundance Rank					
Species	Canopy	Sub-canopy	Under-storey	Ground-cover	Vine	Epipyte	Canopy	Sub-canopy	Under-storey	Ground-Cover	Vine	Epiphyte
**Rubus alceifolius*			O	O								
Argyrodendron trifoliolatum										O		R
Asplenium australasicum							O					O
Carronia pedicellata								O	O	O	O	
Cordyline cannifolia										O		
Flindersia acuminata	O			O								
Gmelina fasciculiflora									O			
Litsea leefeana				R								
Medicosma fareana										O		
Myristica globosa								O	O			O
Neolitsea dealbata				O								
Niemeyera prunifera				C						O		
Pitaviaster haplophyllus			O	O								
Raphidophora australasica							O		O			O
Rockinghamia angustifolia			O	O						O		
Sageretia hamosa					O							
Smilax calophylla									O		O	
Tetrasynandra laxiflora				C					C			
Toechima erythrocarpum		O						O		O		
Aglaia tomentosa								o				
Argyrodendron peralatum							o	o	o			
Argyrodendron trifoliolatum									o			
Atractocarpus hirtus									o			
Beilschmiedia bancroftii		o										
Beilschmiedia tooram			o					o	o	c		
Bowenia spectabilis										o		
Carronia pedicellata		o	o		o							
Cordyline cannifolia				o								
Desmos goezeanus			o		o							
Diospyros sp. Millaa Millaa				r					o			
Diploglottis smithii	o											
Doryphora aromatica									o			
Elaeagnus triflora		c	c		c							
Endiandra sankeyana		c										
Flagellaria indica			o		o							
Haplostichanthus sp. Topaz									o			
Helicia nortoniana		o										
Ixora baileyana										c		
Linospadix microcarya										o		
Litsea leefeana				o			o		o			
Medicosma fareana			o									
Melicope xanthoxyloides								o				
Neolitsea dealbata									c			
Niemeyera prunifera			c	c								
Oplismenus hirtellus										o		

Site	8 Metres						12 Metres					
CONTROL SITE 2	Abundance Rank						Abundance Rank					
Species	Canopy	Sub-canopy	Under-storey	Ground-cover	Vine	Epipyte	Canopy	Sub-canopy	Under-storey	Ground-Cover	Vine	Epiphyte
Pitaviaster haplophyllus		o							o	d		
Pothos longipes			o			o						
Psychotria sp. Utchee Ck									r			
Rockinghamia angustifolia			o									
Siphonodon membranaceum			o									
Smilax calophylla			c		c							
Synima cordierorum			o						o			
Tetracera nordtiana							o	o	o		o	
Tetrasynandra laxiflora	o								c			

Site	16 Metres						20 Metres					
CONTROL SITE 2	Abundance Rank						Abundance Rank					
Species	Canopy	Sub-canopy	Under-storey	Ground-cover	Vine	Epipyte	Canopy	Sub-canopy	Under-storey	Ground-Cover	Vine	Epiphyte
Aglaia tomentosa										C		
Argyrodendron peralatum										O		
Bowenia spectabilis				O								
Calamus australis				O	O							
Carronia pedicellata				C	C					O	O	
Diospyros sp. Millaa Millaa				O								
Gmelina fasciculiflora				O								
Helicia nortoniana				O								
Melodinus australis				O	O							
Mischocarpus stipitatus										D		
Pothos longipes									O			O
Randia tuberculosa				O								
Ripogonum album										C	C	
Smilax calophylla				O	O							
Toechima erythrocarpum				O								
Xanthophyllum octandrum									O			
Aglaia tomentosa				c					o			
Apodytes brachystylis								o				
Argyrodendron peralatum	o			c				o				
Asplenium australasicum						o						
Atractocarpus merikin									r			
Austromyrthus dallachiana									r			
Beilschmiedia tooram	o											
Bowenia spectabilis				c								
Brombya platynema			o					o	c			
Calamus australis		c	c		c					c	c	

Site	**16 Metres**						**20 Metres**					
CONTROL SITE 2	**Abundance Rank**						**Abundance Rank**					
Species	**Canopy**	**Sub-canopy**	**Under-storey**	**Ground-cover**	**Vine**	**Epipyte**	**Canopy**	**Sub-canopy**	**Under-storey**	**Ground-Cover**	**Vine**	**Epiphyte**
Carronia pedicellata										c	c	
Castanospermum australe								o				
Citronella smythii								o				
Corynocarpus cribbianus									o			
Elaeocarpus grandis								o	o	o		
Endiandra monothyra			o									
Flagellaria indica			o		o							
Flindersia bourjotiana									o			
Guioa lasioneura			o									
Haplostichanthus sp. Topaz									o			
Ixora baileyana				c						c		
Myristica globosa				o					o			
Neolitsea dealbata		o										
Niemeyera prunifera				c				o				
Pararistolochia australopithecurus			c		c							
Pitaviaster haplophyllus		o	o									
Polyalthia michaelii			o									
Polyscias elegans	o											
Pothos longipes		o	o			o						
Psychotria sp. Utchee Ck				o								
Rockinghamia angustifolia			o					o	o			
Synima cordierorum							o		o			
Tetracera nordtiana	o	o	o		o							
Tetrasynandra laxiflora			o						o			
Toechima erythrocarpum								o				
Xanthophyllum octandrum									o			

Site	25 Metres						30 Metres					
CONTROL SITE 2	Abundance Rank						Abundance Rank					
Species	Canopy	Sub-canopy	Under-storey	Ground-cover	Vine	Epipyte	Canopy	Sub-canopy	Under-storey	Ground-Cover	Vine	Epiphyte
Aglaia tomentosa									O			
Calamus australis										O	O	
Cissus vinosa											O	
Colysis ampla												O
Doryphora aromatica							O					
Endiandra sankeyana										O		
Freycinetia excelsa								C	C		C	
Haplostichanthus sp. Johnstone R										O		
Hoya pottsii											R	
Medicosma fareana			O									
Melodorum uhrii										O	O	
Mischocarpus stipitatus				D						C		
Prunus turneriana										O		
Raphidophora australasica							O	O	O			O
Selaginella longipinna										D		
Tetracera nordtiana								O	O		O	
Acmena divaricata			o									
Aglaia tomentosa		c						o				
Argyrodendron peralatum									o			
Atractocarpus hirtus									o			
Atractocarpus merikin									o			
Austromyrtus dallachiana								o	o			
Beilschmiedia bancroftii							o		c			
Beilschmiedia tooram			o						o	o		
Bowenia spectabilis										o		
Calamus australis			c	c	c			c	c	c	c	
Cryptocarya pleurosperma									o			
Dysoxylum oppositifolium										r		
Elaeocarpus grandis		o										
Erycibe coccinea								r	r		r	
Freycinetia excelsa				o	o							
Gillbeea adenopetala									o			
Haplostichanthus sp Topaz									o			
Hypserpa laurina								o	o		o	
Linospadix microcarya										c		
Medicosma fareana									o			
Melodinus bacellianus			o		o							
Mischocarpus stipitatus								o		d		
Myristica globosa		c							o			
Niemeyera prunifera			o	o				o	o			
Opistheolepis heterophylla									r	r		
Pitaviaster haplophyllus									o			
Polyscias elegans		o										
Pothos longipes			o			o						

Site	25 Metres						30 Metres					
CONTROL SITE 2	Abundance Rank						Abundance Rank					
Species	Canopy	Sub-canopy	Under-storey	Ground-cover	Vine	Epipyte	Canopy	Sub-canopy	Under-storey	Ground-Cover	Vine	Epiphyte
Prunus turneriana										o		
Raphidophora australasica		c	c			c						
Rockinghamia angustifolia		c						o				
Rourea brachyandra									r		r	
Selaginella longipinna				c-d						d		
Smilax calophylla									o	o	o	
Symplocos cochinchinensis		o										
Symplocos paucistaminea									o			
Synima cordierorum	o	c							o			
Xanthophyllum octandrum			c									

Site	50 Metres						100 Metres					
CONTROL SITE 2	Abundance Rank						Abundance Rank					
Species	Canopy	Sub-canopy	Under-storey	Ground-cover	Vine	Epipyte	Canopy	Sub-canopy	Under-storey	Ground-Cover	Vine	Epiphyte
Alpinia modesta										D		
Argyrodendron peralatum				R								
Arthropteris palisotii			O			O						
Beilschmiedia bancroftii								O				
Bowenia spectabilis										O		
Calamus caryotoides									O		O	
Cardiopteris moluccana												O
Carronia pedicellata										O	O	
Carronia protensa				O	O							
Cryptocarya murrayi				C					O			
Desmos goezeana									O		O	
Diospyros sp. Millaa Millaa				R								
Diploglottis smithii										D		
Endiandra monothyra										O		
Flagellaria indica				R	R							
Guioa lasioneura			O									
Ixora baileyana										O		
Niemeyera prunifera			O									
Pothos longipes			O			O						
Pseuduvaria villosa				R								
Selaginella longipinna				C								
Smilax calophylla										O	O	
Tetrasynandra laxiflora				O								
Toechima erythrocarpum										O		
Acmena graveolens			o									
Aglaia tomentosa			o						c			

Site	50 Metres						100 Metres					
CONTROL SITE 2	Abundance Rank						Abundance Rank					
Species	**Canopy**	**Sub-canopy**	**Under-storey**	**Ground-cover**	**Vine**	**Epipyte**	**Canopy**	**Sub-canopy**	**Under-storey**	**Ground-Cover**	**Vine**	**Epiphyte**
Alangium villosum								o				
Alpinia modesta				c						c		
Apodytes brachystylis				o								
Argyrodendron peralatum				c								
Asplenium australasicum												c
Atractocarpus hirtus									o			
Austrosteenisia stipularis							o	o	o		o	
Beilschmiedia bancroftii			o						o			
Beilschmiedia tooram		o							o			
Bowenia spectabilis				o								
Breynia stipitata			o									
Brombya platynema			c									
Calamus australis								c	c		c-d	
Calamus caryotoides									c		c-d	
Cardiopteris moluccana								o	o			o
Castanospermum australe	o	o										
Corymborkis veratrifolia				c								
Cryptocarya angulata				o								
Cryptocarya mackinnoniana										o		
Daphnandra repandula			o						o	o		
Dichapetalum papuanum			o		o							
Diospyros sp. Millaa Millaa			o									
Diploglottis smithii							o					
Doryphora aromatica									o			
Drynaria rigidula												c
Endiandra globosa									o			
Endiandra insignis							o					
Endiandra monothyra							o		c			
Epipremnum pinnatum								o	o			o
Flagellaria indica								c	c		c	
Gillbeea adenopetala	o											
Haplostichanthus sp. Johnstone R									o			
Haplostichanthus sp. Topaz			c									
Ixora baileyana				c								
Neolitsea dealbata				o								
Niemeyera prunifera		o	o									
Opistheolepis heterophylla		o										
Pitaviaster haplophyllus		o	o									
Pittosporum rubiginosum									r			
Polyosma hirsuta			o									
Pothos longipes		c	c			c		c	c			c-d
Prunus turneriana			o									
Psychotria sp. Utchee Ck			o									
Raphidophora australasica		c	c			c		c	c			c-d

Site	50 Metres						100 Metres					
CONTROL SITE 2	Abundance Rank						Abundance Rank					
Species	Canopy	Sub-canopy	Under-storey	Ground-cover	Vine	Epipyte	Canopy	Sub-canopy	Under-storey	Ground-Cover	Vine	Epiphyte
Rockinghamia angustifolia							o					
Selaginella longipinna				c-d						d		
Symplocos cochinchinensis			o									
Toechima erythrocarpum		c	c					o				
Xanthophyllum octandrum			o									

REHABILITATION SITE 1. NON-HIGHWAY SIDE TRANSECTS

17°36.945S 145°47.748E
20/6/02

Key:

	To one metre from Stake	To five metres from Stake
dominant	D	d
common	C	c
occasional	O	o
rare	R	r
introduced species	*	*

Site	-20 Metres						-15 Metres					
REHABILITATION SITE 1	Abundance Rank						Abundance Rank					
Species	Canopy	Sub-canopy	Understorey	Ground cover	Vine	Epiphyte	Canopy	Sub-canopy	Understorey	Ground-cover	Vine	Epiphyte
Ageratum conyzoides				C					C			
Crassocephalum crepidiodes				R								
Panicum maximum				O					D			
Ageratum conyzoides				c					c			
Brachiaria decumbens				c								
Crassocephalum crepidiodes				o					o			
Crotalaria pallida				o								
Melinus minutiflora				c					o			
Panicum maximum				c					c			
Acacia celsa	o						o					
Alphitonia petriei	o						o					
Elaeocarpus grandis	o						o					

Site	-10 Metres						-5 Metres					
REHABILITATION SITE 1	Abundance Rank						Abundance Rank					
Species	Canopy	Sub-canopy	Understorey	Ground cover	Vine	Epiphyte	Canopy	Sub-canopy	Understorey	Ground-cover	Vine	Epiphyte
**Ageratum conyzoides*				C-D						C		
**Crassocephalum crepidiodes*				O						O		
**Panicum maximum*				O						O		
Alphitonia petriei							O					
**Ageratum conyzoides*				c-d						c		
**Crassocephalum crepidiodes*				o						o		
**Panicum maximum*				c-d						c		
Acacia celsa	o						o					
Alphitonia petriei	o						o					
Elaeocarpus grandis	o						o					
Mallotus paniculatus			r									

Site	0 Metres						5 Metres (Edge)					
REHABILITATION SITE 1	Abundance rank						Abundance rank					
Species	Canopy	Sub-canopy	Understorey	Groundcover	Vine	Epiphyte	Canopy	Sub-canopy	Understorey	Ground-cover	Vine	Epiphyte
**Ageratum conyzoides*				D								
**Lantana camara*				D								
Bowenia spectabilis										O		
Cissus vinosa					O						O	
Diploglottis smithii									O	C		
Endiandra globosa										C		
Flagellaria indica											O	
Litsea leefeana										O		
Neolitsea dealbata										C		
Solanum viridifolium				O								
Tabernaemontana pandacqui				O								
Testrasynandra laxiflora										O		
Xanthophyllum octandrum									O	O		
**Ageratum conyzoides*				d				o	o	c		

Site	0 Metres						5 Metres (Edge)					
REHABILITATION SITE 1	**Abundance rank**						**Abundance rank**					
Species	**Canopy**	**Sub-canopy**	**Understorey**	**Groundcover**	**Vine**	**Epiphyte**	**Canopy**	**Sub-canopy**	**Understorey**	**Ground-cover**	**Vine**	**Epiphyte**
**Crassocephalum crepidiodes*				o								
**Lantana camara*			d	d						c		
**Panicum maximum*				o								
**Rubus alceifolius*			o	o								
Acacia celsa	o											
Alocasia brisbanensis				r								
Alphitonia petriei	o											
Alpinia modesta										c		
Argyrodendron peralatum				o								
Bowenia spectabilis										c		
Cardwellia sublimis				o			o					
Cissus vinosa											o	
Elaeocarpus grandis	o											
Embelia australiana											o	
Guoia lasioneura									o			
Hypserpa smilacifolia											o	
Ichnocarpus frutescens					o							
Rhodamnia sessiliflora								o				
Ripogonum album											o	
Rubus probus				o								
Synima cordierorum				o								
Toechima erythrocarpum									o			

Site	8 Metres						12 Metres					
REHABILITATION SITE 1	Abundance Rank						Abundance Rank					
Species	Canopy	Sub-canopy	Understorey	Ground-cover	Vine	Epiphyte	Canopy	Sub-canopy	Understorey	Ground-cover	Vine	Epiphyte
Alpinia modesta										O		
Argyrodendron peralatum										O		
Arthropteris palisotii						O						
Cardwellia sublimis				C								
Carnarvonia araliifolia				O								
Carronia protensa				C	C					C	C	
Castanospermum australe			O									
Citronella smythii								O				
Dichapetalum papuanum				O								
Diploglottis smithii				C					O			
Endiandra globosa										O		
Ixora baileyana										C		
Litsea leefeana	O											
Medicosma fareana			O									
Mischocarpus stipitatus			O									
Myristica globosa				C								
Neolitsea dealbata				O								
Polyscias elegans								O				
Rhodamnia sessiliflora				O								
Synima cordierorum	O											
Tetrasynandra laxiflora				C								
Toechima erythrocarpum				O								
Ventilago ecorollata											O	
Alpinia modesta				c						c		
Arthropteris palisotii			o			o						
Arytera pauciflora			o									
Beilschmiedia tooram			c									
Bowenia spectabilis				c						o		
Cardwellia sublimis			c									
Castanospermum australe									o			
Cryptocarya mackinnoniana			o									
Darlingia darlingiana								o				
Diploglottis smithii	c								c			
Endiandra monothyra		o										

Site	8 Metres						12 Metres					
REHABILITATION SITE 1	Abundance Rank						Abundance Rank					
Species	Canopy	Sub-canopy	Understorey	Ground-cover	Vine	Epiphyte	Canopy	Sub-canopy	Understorey	Ground-cover	Vine	Epiphyte
Flindersia acuminata									o			
Helicia nortoniana									o			
Ixora baileyana										c		
Litsea leefeana			o									
Melicope vitiflora									o			
Myristica globosa								o				
Pittosporum rubiginosum									r			
Polyscias elegans							o					
Polyscias mollis							o					
Smilax calophylla					o							
Synima cordierorum									c			
Xanthophyllum octandrum			o									

Site	16 Metres						20 Metres					
REHABILITATION SITE 1	Abundance Rank						Abundance Rank					
Species	Canopy	Sub-canopy	Understorey	Ground-cover	Vine	Epiphyte	Canopy	Sub-canopy	Understorey	Ground-cover	Vine	Epiphyte
Alpinia modesta				O								
Asplenium australasicum												C
Bowenia spectabilis										O		
Carronia pedicellata				C	C							
Carronia protensa										O	O	
Castanospermum australe										O		
Cryptocarya mackinnoniana				O						O		
Darlingia darlingiana								O				
Diospyros sp. Millaa Millaa										O		
Diploglottis smithii			O	O								
Epipremnum pinnatum								C	C			C
Helicia nortoniana										O		
Melodinus australis										O	O	
Myristica globosa			O							O		
Piper novae-hollandiae										O	O	

Site	**16 Metres**						**20 Metres**					
REHABILITATION SITE 1	**Abundance Rank**						**Abundance Rank**					
Species	**Canopy**	**Sub-canopy**	**Understorey**	**Ground-cover**	**Vine**	**Epiphyte**	**Canopy**	**Sub-canopy**	**Understorey**	**Ground-cover**	**Vine**	**Epiphyte**
Synima cordierorum			C	C						O		
Wilkiea angustifolia				O								
Xanthophyllum octandrum								O				
Aglaia tomentosa		o	o						c			
Argyrodendron peralatum	o						o					
Bowenia spectabilis				c								
Brombya platynema		o						o				
Calamus australis		c	c	o	c			c-d	c-d	c	c-d	
Calamus caryotoides			o	o	o							
Castanospermum australe									c	c		
Cryptocarya mackinnoniana							o					
Darlingia darlingiana							o					
Dysoxylum oppositifolium			o									
Galbulimima baccata							o					
Myristica globosa							o	c	c			
Pandanus monticola			o	o								
Polyalthia michaelii	o	o										
Polyscias australiana			o									
Pothos longipes								c	c			c
Rhodomyrtus macrocarpa								c				
Synima cordierorum									c	c		
Toechima erythrocarpum	o		o									
Wrightia laevis	o						o					

Site	25 Metres						30 Metres					
REHABILITATION SITE 1	Abundance Rank						Abundance Rank					
Species	Canopy	Sub-canopy	Understorey	Ground-cover	Vine	Epiphyte	Canopy	Sub-canopy	Understorey	Ground-cover	Vine	Epiphyte
Aglaia tomentosa				C								
Antidesma erostre				R								
Argyrodendron peralatum				C								
Bowenia spectabilis										C		
Calamus australis										O		
Carronia pedicellata				C						O		
Castanospermum australe			O									
Cryptocarya mackinnoniana				O								
Cryptocarya pleurosperma										O		
Diospyros sp. Millaa Millaa										O		
Dysoxylum parasiticum										O		
Helicia nortoniana				O								
Ixora baileyana										C		
Myristica globosa			O							O		
Neolitsea dealbata				O								
Pandanus monticola				C								
Rourea brachyandra					R							
Synima cordierorum										C		
Aglaia tomentosa			c						c			
Alangium villosum									o			
Apodytes brachystylis									o			
Argyrodendron peralatum							o	c	o			
Asplenium australasicum		o				o						
Austromyrtus dallachiana									o			
Beilschmiedia tooram										c		
Bowenia spectabilis										c		
Brombya platynema		o						c	c			
Calamus australis		c	c		c			c	c	c	c	
Calamus caryotoides										o	o	
Castanospermum australe							o					
Darlingia darlingiana	o											
Delarbrea michieana			o						o			
Desmos goezeana										c	c	

Site	25 Metres						30 Metres					
REHABILITATION SITE 1	**Abundance Rank**						**Abundance Rank**					
Species	**Canopy**	**Sub-canopy**	**Understorey**	**Ground-cover**	**Vine**	**Epiphyte**	**Canopy**	**Sub-canopy**	**Understorey**	**Ground-cover**	**Vine**	**Epiphyte**
Diospyros sp. Millaa Millaa										o		
Epipremnum pinnatum		o	o			o						
Ficus pleurocarpa							o					
Haplostichanthus sp. Topaz								o				
Ixora baileyana										d		
Linospadix microcarya										c		
Melodinus australis											o	
Neolitsea dealbata										o		
Pandanus monticola				c								
Pilidiostigma tropicum		o										
Pseuduvaria villosa			o									
Synima cordierorum									c			
Toechima erythrocarpum							o	o				
Xanthophyllum octandrum			c						o			

Site	50 Metres						100 Metres					
REHABILITATION SITE 1	Abundance Rrank						Abundance Rank					
Species	Can-opy	Subcanopy	Understorey	Ground-cover	Vine	Epiphyte	Canopy	Sub-canopy	Understorey	Ground-cover	Vine	Epiphyte
Acmena divaricata				O								
Acronychia vestita				O								
Aglaia tomentosa									C	C		
Alpinia arctiflora				O								
Alpinia modesta				C						O		
Argyrodendron peralatum				C					C	C		
Atractocarpus merikin										O		
Austromyrtus dallachiana										O		
Bowenia spectabilis				O								
Calamus australis			O	O	O							
Carronia protensa											O	
Castanospermum australe									O			
Cryptocarya mackinnoniana								O				
Cryptocarya murrayi										O		
Cryptocarya pleurosperma										C		
Desmos goezeanus										O	O	
Diploglottis smithii			O	C								
Helicia nortoniana				O					O	O		
Mischocarpus stipitatus				C					O	O		
Piper novae-hollandiae										O	O	
Pothos longipes								O	O			O
Rhodomyrtus macrocarpa									R			
Rourea brachyandra				R	R					C	C	
Synima cordierorum									C	O		
Syzygium alliiligneum									O			
Tetrasynandra laxiflora				C								
Toechima erythrocarpum				O								
Acmena graveolens	o							o				
Acronychia vestita		o										
Aglaia tomentosa									c			
Alpinia modesta				c-d						c		
Apodytes brachystylis		o										
Ardisia pachyrrachis									o			

Site	50 Metres						100 Metres					
REHABILITATION SITE 1	Abundance Rrank						Abundance Rank					
Species	Can-opy	Subcanopy	Understorey	Ground-cover	Vine	Epiphyte	Canopy	Sub-canopy	Understorey	Ground-cover	Vine	Epiphyte
Argyrodendron peralatum							c					
Arthropteris palisotii									c			c
Asplenium australasicum		c				c		c	c			c
Austromyrtus dallachiana			o					o	o			
Austrosteenisia stipularis							o	o	o		o	
Backhousia bancroftii			o									
Beilschmiedia bancroftii									o			
Beilschmiedia tooram		o								c		
Blechnum cartilagineum										c		
Bowenia spectabilis				c						c		
Breynia stipitata										c		
Brombya platynema		o	o					c	c			
Calamus australis		o	o	c	c			c	c	c	c	
Calamus caryotoides				o								
Carronia pedicellata		o	o		o			o	o		o	
Castanospermum australe			o				o					
Connarus conchocarpus								o	o		o	
Cryptocarya grandis									o			
Cryptocarya mackinnoniana	o						o	o				
Daphnandra repandula			o									
Darlingia darlingiana									o	o		
Davidsonia pruriens								o	o			
Desmos goezeanus										c	o	
Diospyros sp. Millaa Millaa										c		
Diploglottis smithii										c		
Dysoxylum klanderi			o									
Endiandra compressa									o			
Endiandra globosa				c			o					
Epipremnum pinnatum		c	c			c		c	c			c
Erythroxylum ecarinatum										c		
Flindersia acuminata									o			

Site	50 Metres						100 Metres					
REHABILITATION SITE 1	**Abundance Rrank**						**Abundance Rank**					
Species	**Can-opy**	**Subcanopy**	**Understorey**	**Ground-cover**	**Vine**	**Epiphyte**	**Canopy**	**Sub-canopy**	**Understorey**	**Ground-cover**	**Vine**	**Epiphyte**
Flindersia bourjotiana							o					
Franciscodendron laurifolium									o			
Haplostichanthus sp. Topaz									o	c		
Ixora baileyana										c		
Litsea leefeana				c								
Maclura cochinchinensis								o	o		o	
Medicosma fareana		o							c			
Melodinus australis								o	o		o	
Mischocarpus stipitatus								o	o			
Myristica globosa		c	c							o		
Neolitsea dealbata			c									
Pilidiostigma tropicum									o			
Polyscias elegans	o											
Pothos longipes								c	c			c
Raphidophora australasica								c	c			c
Rhodomyrtus macrocarpa		o										
Schefflera elliptica					o							
Smilax calophylla									o		o	
Symplocos cochinchinensis			o						o			
Tetrasynandra laxiflora			o									
Toechima erythrocarpum									o			
Xanthophyllum octandrum									o			

REHABILITATION SITE 2. NON-HIGHWAY SIDE TRANSECTS

17°36.899S 145°46.188E
14/06/02

Key:

	To one metre from Stake	To five metres from Stake
dominant	D	d
common	C	c
occasional	O	o
rare	R	r
introduced species	*	*

Site	-20 Metres						-15 Metres					
REHABILITATION SITE 2	Abundance Rank						Abundance Rank					
Species	Canopy	Sub-canopy	Under-storey	Ground-cover	Vine	Epipyte	Canopy	Sub-canopy	Under-storey	Ground-Cover	Vine	Epiphyte
**Ageratum conyzoides*				D						C		
**Crassocephalum crepidioides*										O		
**Erechtites valerianifolia*				O								
**Melinus minutiflora*				C						C		
**Ageratum conyzoides*				d						c		
**Crassocephalum crepidioides*				o						o		
**Erechtites valerianifolia*				c						o		
**Melinus minutiflora*				c						c		
**Panicum maximum*				o								
**Solanum mauritianum*			o									
**Solanum torvum*				c								
Acacia celsa	r						r					
Alphitonia petriei	r						r					
Elaeocarpus grandis	r						r					

Site	-10 Metres						-5 Metres					
REHABILITATION SITE 2	Abundance Rank						Abundance Rank					
Species	Canopy	Sub-canopy	Understorey	Ground-cover	Vine	Epiphyte	Canopy	Sub-canopy	Understorey	Ground-cover	Vine	Epiphyte
*Ageratum conyzoides				C						C		
*Crassocephalum crepidioides				O								
*Melinus minutiflora										C		
*Ageratum conyzoides				c						c		
*Crassocephalum crepidioides				o						o		
*Melinus minutiflora				o						c		
Acacia celsa	r						r					
Alphitonia petriei	r						r					
Elaeocarpus grandis	r						r					
Ichnocarpus frutescens										o	o	

Site	0 Metres						5 Metres					
REHABILITATION SITE 2	Abundance Rank						Abundance Rank					
Species	Canopy	Sub-canopy	Understorey	Ground-cover	Vine	Epiphyte	Canopy	Sub-canopy	Understorey	Ground-cover	Vine	Epiphyte
*Melinus minutiflora				C								
*Panicum maximum				C					R			
*Sida rhombifolia				O								
Chionanthus ramiflora									O			
Cryptocarya murrayi										O		
Endiandra globosa									O			
Neolitsea dealbata										O		
Piper novae-hollandiae								O	O		O	
Rubus probus				O								
Solanum viridifolium										O		
Synima cordierorum										O		
Tetrasynandra laxiflora									O			
*Triumfetta rhomboidea				o								
Beilschmiedia tooram									o			
Bowenia spectabilis				o								
Carnarvonia araliifolia									r			
Castanospermum australe									o			
Cissus vinosa					c							
Cryptocarya murrayi								c				
Diploglottis smithii								c				
Doryphora aromatica									o			
Dysoxylum parasiticum									o			

Site	**0 Metres**						**5 Metres**					
REHABILITATION SITE 2	**Abundance Rank**						**Abundance Rank**					
Species	**Canopy**	**Sub-canopy**	**Understorey**	**Ground-cover**	**Vine**	**Epiphyte**	**Canopy**	**Sub-canopy**	**Understorey**	**Ground-cover**	**Vine**	**Epiphyte**
Endiandra insignis									o			
Epipremnum pinnatum												O
Glochidion harveyanum									o			
Helicia nortoniana									r			
Ichnocarpus frutescens					o							
Litsea leefeana								o				
Melicope xanthoxyloides			c									
Melodinus australis											o	
Melodorum uhrii									r		r	
Myristica globosa									c			
Neolitsea dealbata									o			
Niemeyera prunifera									o			
Pandorea pandorana					o							
Pilidiostigma tropicum									o			
Piper novaehollandiae					o							
Polyalthia michaelii									o			
Polyosma hirsuta									r			
Polyscias australiana								o				
Rockinghamia angustifolia									r			
Sarcopteryx martyana									o			
Schefflera elliptica											o	
Solanum viridifolium			c									
Syzygium gustavioides							d					
Tetrasynandra laxiflora									o			

Site	8 Metres						12 Metres					
REHABILITATION SITE 2	**Abundance Rank**						**Abundance Rank**					
Species	**Canopy**	**Sub-canopy**	**Understorey**	**Ground-cover**	**Vine**	**Epiphyte**	**Canopy**	**Sub-canpy**	**Understorey**	**Ground-cover**	**Vine**	**Epiphyte**
Aglaia tomentosa				O								
Apodytes brachystylis								O	O	O		
Arthropteris palisotii											O	
Cardwellia sublimis			O	O								
Cissus vinosa		O			O							
Cryptocarya murrayi								O		C		
Diospyros sp. Millaa Millaa									R			
Ichnocarpus frutescens					O							
Ixora baileyana				O						O		
Melicope xanthoxyloides			O									
Oberonia titania						O						
Piper novae-hollandiae											O	
Polyscias australiana			O	O								
Synima cordierorum				O				O	O	O		
Tetracera nordtiana	O				O							
Acmena graveolens									o			
Apodytes brachystylis									o			
Atractocarpus hirtus				o								
Beilschmiedia tooram		o										
Brombya platynema	o	o	o									
Calamus australis				o								
Castanospermum australe	c		o	o								
Castanospora alphandii									o			
Citronella smythii								o	o			
Desmos goezeanus					o							
Diospyros sp. Millaa Millaa									o			
Doryphora aromatica	o	o										
Guioa lasioneura			o									
Haplostichanthus sp. Topaz			o									
Litsea leefeana			o									
Myristica globosa			o									
Niemeyera prunifera		o	o					o	o			
Pilidiostigma tropicum			o									
Pitaviaster haplophyllus									o			
Pleuranthodium racemigerum			o									
Ripogonum album											o	
Sarcopteryx martyana			o									
Schefflera elliptica					o							
Sloanea macbrydei			o									
Symplocos cochinchinensis var. *pilosiuscula*	o	o	o									

Site	16 Metres						20 Metres					
REHABILITATION SITE 2	**Abundance Rank**						**Abundance Rank**					
Species	**Canopy**	**Sub-canopy**	**Understorey**	**Ground-cover**	**Vine**	**Epiphyte**	**Canopy**	**Sub-canopy**	**Understorey**	**Ground-cover**	**Vine**	**Epiphyte**
Aglaia tomentosa			O									
Argyrodendron peralatum			O									
Arthropteris palisotii												O
Beilschmiedia tooram				O						C		
Carronia protensa											O	
Cryptocarya murrayi										O		
Diospyros sp. Millaa Millaa			O									
Hypserpa decumbens					O							
Ixora baileyana				O								
Mischocarpus stipitatus			O									
Myristica globosa			O									
Niemeyera prunifera									O	C		
Pitaviaster haplophyllus				O								
Pothos longipes												O
Toechima erythrocarpum				O								
Aglaia tomentosa		o	o						c			
Antirrhea tenuiflora									o			
Apodytes brachystylis		o	o									
Ardisia pachyrrhachis			o						o			
Argyrodendron peralatum		o	o					c				
Arthropteris palisottii												c
Asplenium australasicum												c
Beilschmiedia bancroftii									o			
Beilschmiedia tooram		o	o						c	c		
Blechnum cartilagineum										o		
Bowenia spectabilis										o		
Calamus australis								c	c		c	
Calamus caryotoides									c		c	
Carronia protensa								o			o	
Castanospermum australe	c											
Daphnandra repandula	o	o	o									
Desmos goezeanus											o	
Endiandra globosa		o										
Epipremnum pinnatum						o						
Haplostichanthus sp. Topaz									c			
Ixora baileyana				o					c			
Linospadix micrcocarya				o								
Linospadix minor										c		
Morinda umbellata											c	
Niemeyera prunifera									c			
Pseuduvaria villosa									o			
Rhaphidophora australasica						o						c
Rockinghamia angustifolia	o	o					o					

Site	16 Metres						20 Metres					
REHABILITATION SITE 2	Abundance Rank						Abundance Rank					
Species	Canopy	Sub-canopy	Understorey	Ground-cover	Vine	Epiphyte	Canopy	Sub-canopy	Understorey	Ground-cover	Vine	Epiphyte
Salacia disepala											o	
Synima cordierorum		o	o									
Syzygium cormiflorum			o									

Site	25 Metres						30 Metres					
REHABILITATION SITE 2	AbundanceRank						Abundance Rank					
Species	Canopy	Sub-canopy	Understorey	Gground-cover	Vine	Epiphyte	Can-py	Sub-canopy	Understorey	Ground-cover	Vine	Epiphyte
Alpinia modesta										O		
Atractocarpus hirtus			O									
Bowenia spectabilis										O		
Calamus australis		O	O		O							
Cryptocarya mackinnoniana				O								
Endiandra leptodendron				O								
Ixora baileyana										O		
Linospadix minor				O								
Niemeyera prunifera			O	C				O	O	C		
Psychotria sp Utchee Creek										R		
Rhodomyrtus macrocarpa				O								
Siphonodon membranaceus												
Syzygium cormiflorum			O									
Xanthophyllum octandrum									O			
Aglaia tomentosa			c					o	o	o		
Argyrodendron peralatum			o									
Atractocarpus hirtus			o	o								
Beilschmiedia bancroftii							o					
Beilschmiedia tooram			c									
Brombya platynema		c										
Calamus australis		o	o		o							
Carronia protensa				o	o							
Castanospermum australe			c	c								
Cryptocarya angulata			c									
Cryptocarya grandis			o									
Cryptocarya mackinnoniana		c					c		o			
Delarbrea michieana									o			
Diospyros sp. Millaa Millaa									c			
Diplazium dilatatum				o								
Doryphora aromatica									o			
Dysoxylum papuanum			o	c								

Site	25 Metres						30 Metres					
REHABILITATION SITE 2	AbundanceRank						Abundance Rank					
Species	Canopy	Sub-canopy	Understorey	Gground-cover	Vine	Epiphyte	Can-py	Sub-canopy	Understorey	Ground-cover	Vine	Epiphyte
Haplostichanthus sp. Topaz			o						o			
Helicia nortoniana			o									
Ixora baileyana				c								
Mischocarpus stipitatus									o			
Myristica globosa				o								
Neolitsea dealbata			o									
Niemeyera prunifera		c	c						o			
Pararistolochia australopithecurus									r		r	
Pittosporum rubiginosum			o									
Polyalthia michaelii									o			
Pseuduvaria villosa			o									
Synima cordierorum				c								
Wilkiea angustifolia			o									
Xanthophyllum octandrum									o			

Site	50 Metres						100 Metres					
REHABILITATION SITE 2	Abundance Rank						Abundance Rank					
Species	Canopy	Sub-canopy	Understorey	Ground-cover	Vine	Epiphyte	Canopy	Sub-can-opy	Understorey	Ground-cover	Vine	Epiphyte
Argyrodendron trifoliolatum									O			
Bowenia spectabilis				O								
Calamus australis		O	O		O			O	O		O	
Castanospermum australe										C		
Cryptocarya angulata				O								
Cryptocarya murrayi			O									
Endiandra monothyra									O			
Niemeyera prunifera				O								
Rockinghamia angustifolia									O	C		
Toechima erythrocarpum		O										
Acronychia vestita							o	o				
Aglaia tomentosa				c					o			
Apodytes brachystylis										o		
Argyrodendron trifoliolatum								c				
Asplenium australicum												c
Atractocarpus hirtus									o			
Austrobaileya scandens			r		r							
Austromyrtus dallachiana								o	o			
Austrosteenisia stipularis							o	c	c	c	c	
Beilschmiedia bancroftii			o									

Site	50 Metres						100 Metres					
REHABILITATION SITE 2	Abundance Rank						Abundance Rank					
Species	Canopy	Sub-canopy	Understorey	Ground-cover	Vine	Epiphyte	Canopy	Sub-can-opy	Understorey	Ground-cover	Vine	Epiphyte
Beilschmiedia tooram		o	c					c				
Blechnum cartilagineum										o		
Bowenia spectabilis				c						c		
Brombya platynema		c						c	o			
Calamus australis			o		o							
Calamus caryotoides				c	c							
Carronia pedicellata										o	o	
Castanospermum australe							o	o	o			
Citronella smythii	o											
Cryptocarya angulata	o											
Cryptocarya murrayi			o									
Desmos goezeanus										o	o	
Diospyros sp. Millaa Millaa			r							r		
Diploglottis smithii										o		
Doryphora aromatica	o	c	c				o	o	o			
Endiandra globosa										o		
Endiandra insignis								o	o			
Eupomatia sp. Noah Head									o			
Ficus pleurocarpa	r					r						
Flindersia bourjotiana	o											
Franciscodendron laurifolium							o					
Freycinetia excelsa		o	o		o							
Haplostichanthus sp. Topaz			o									
Helicia nortoniana										o		
Ixora baileyana				c								
Lasianthus strigosus									o			
Linospadix microcarya										c		
Linospadix minor				o								
Litsea leefeana										o		
Melicope xanthoxyloides										o		
Niemeyera prunifera		o	c						o			
Opistheolepis heterophylla									o	o		
Pilidiostigma tropicum									o			
Pothos longipes		c	c			c		o	o			c
Pseuduvaria villosa			r					o	c			
Randia tuberculosa			r									
Raphidophora australasica		c	c			c						
Salacia disepala											o	
Schefflera actinophylla	r					r						
Siphonodon membranaceus									o			
Sloanea macbrydei	o											
Tetrasynandra laxiflora	o											
Toechima erythrocarpum		o										
Wilkiea angustifolia										o		

Site	50 Metres						100 Metres					
REHABILITATION SITE 2	Abundance Rank						Abundance Rank					
Species	Canopy	Sub-canopy	Understorey	Ground-cover	Vine	Epiphyte	Canopy	Sub-can-opy	Understorey	Ground-cover	Vine	Epiphyte
Xanthophyllum octandrum		o						o				