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

Miriam W. Goosem
and Stephen M. Turton

Rainforest CRC

Cooperative Research Centre for Tropical Rainforest Ecology and Management

WEED INCURSIONS ALONG ROADS AND POWERLINES IN THE WET TROPICS WORLD HERITAGE AREA

THE POTENTIAL OF REMOTE SENSING AS AN INDICATOR OF WEED INFESTATIONS

Miriam W. Goosem[1,2] and
Stephen M. Turton[1,2]

[1] Rainforest CRC
[2] School of Tropical Environment Studies and Geography,
James Cook University, Cairns

Established and supported under the
Australian Cooperative Research Centres Program

ISBN 0 86443 764 1

Published by the Cooperative Research Centre for Tropical Rainforest Ecology and Management. Further copies may be requested from the Cooperative Research Centre for Tropical Rainforest Ecology and Management, PO Box 6811, Cairns QLD 4870, Australia.

This publication should be cited as: Goosem, M. W. and Turton, S. M. (2006) *Weed Incursions Along Roads and Powerlines in the Wet Tropics World Heritage Area.* Cooperative Research Centre for Tropical Rainforest Ecology and Management. Rainforest CRC, Cairns (190 pp).

Revised June 2006. Previously released in August 2002 as an unpublished report to the Wet Tropics Management Authority, Cairns.

For copies of this report, visit:
www.rainforest-crc.jcu.edu.au

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

(Ref. Contract No. 613)

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.

ACKNOWLEDGEMENTS

Many people have made contributions towards the completion of this project.

We would especially like to acknowledge the Wet Tropics Management Authority and the Rainforest CRC for their financial contributions (WTMA $50,780; Rainforest CRC $31,500).

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