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Weed Response to Cyclones in the Wet Tropics Rainforests

– Impacts and adaptation –

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Weed response to cyclones in the Wet Tropics rainforests

Impacts and adaptation

by Helen T Murphy, Dan J Metcalfe, Matt G Bradford and Andrew J Ford

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Foreword

Tropical Cyclone Yasi, a category five storm, which hit the North Queensland coast near Innisfail in February 2011, had a devastating impact on numerous communities and industries in the region. It also left a swathe of damage through rainforest regions, opening the way for incursion by numerous weed species.

A previous review of weeds activity in rainforest areas around Innisfail following Cyclone Larry in 2006 found that an increased amount of forest litter and debris on the ground helped to minimise the spread of smaller herbaceous weeds.

That review found the natural regenerative powers of the rainforests helped keep weeds to a minimum, with many native species regenerating quickly which suppressed extensive weed regrowth.

However, larger woody weeds and vines were found to be more persistent, which has longer-term implications for the recovery of the native rainforest species and the forest composition.

Climate change scenarios predict an increasing frequency of intense cyclones in the tropics. This review and its recommendations will help inform the response of policy makers and land managers.

This project is one of thirty-nine funded in Phase 1 of the National Weeds and Productivity Research Program, which was managed by the Australian Government Department of Agriculture, Fisheries and Forestry (DAFF) from 2008 to 2010. The Rural Industries Research and Development Corporation (RIRDC) is now publishing the final reports of these projects.

Phase 2 of the Program, which is funded to 30 June 2012 by the Australian Government, is being managed by RIRDC with the goal of reducing the impact of invasive weeds on farm and forestry productivity as well as on biodiversity. RIRDC is commissioning some 50 projects that both extends on the research undertaken in Phase 1 and moves into new areas. These reports will be published in the second half of 2012.

This report is an addition to RIRDC's diverse range of over 2000 research publications which can be viewed and freely downloaded from our website www.rirdc.gov.au. Information on the Weeds Program is available online at www.rirdc.gov.au/weeds

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Craig Burns
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Executive Summary

What the report is about

This paper summarises the results of nearly four years of weed monitoring near Innisfail, Queensland, in the wake of Cyclone Larry and discusses the implications for weed management.

It highlights the potential impacts of post-cyclone weed invasion on native species succession and diversity.

Who is the report targeted at?

This review is targeted at the policy makers and environmental land managers in communities on the Queensland tropical coast which are vulnerable to cyclones.

Background

The destruction caused by Severe Tropical Cyclone Larry in March 2006 led to the creation of ideal conditions for the rapid recruitment and spread of invasive weeds in the rainforests of northern Queensland.

This project represents the continuation of a monitoring program that began shortly after Cyclone Larry crossed the Queensland coast. Between April 2006 and December 2008 researchers monitored the recruitment, growth and mortality of native and invasive species every three to four months in ninety-nine 2 by 2 metre quadrats over a 45-hectare site near El Arish, south of Innisfail. In addition, researchers documented weed communities in 62 transects across 36 sites in the Wet Tropics Bioregion, taking in a range of different cyclone severity levels and environmental contexts.

Aims/objectives

Climate change scenarios predict an increasing frequency of intense cyclones in the tropics. If the future impacts of cyclones are to be reduced, it is essential to understand the dynamics of weed invasion following cyclones and the long-term effects of weeds on forest composition and structure.

Methods used

In order to assess the existing weed load in rainforest habitat in the Wet Tropics and the impact of Cyclone Larry in promoting the establishment and spread of weeds, surveys were conducted in rainforest areas, both across and along the cyclone track, within 12 months of the cyclone occurring and again about three years later. There was also regular monitoring of the recruitment, growth and mortality of all native and invasive species in ninety-nine 2 by 2 metre quadrats in an area extensively damaged by the cyclone.

Results/key findings

Both the landscape-scale and the local-scale data confirmed initial speculation about the transient nature of most of the weed flora in rainforest habitats following a severe cyclone.

Although it appears that the most severe cyclone damage provides ideal conditions for weed recruitment, the very high litter and debris loads that result present a major barrier to establishment.

Three to four years after the event, canopy disturbance remained similar but both the abundance and the diversity of weeds had declined. This appears to be primarily the result of continued regrowth or regeneration of native species.

However, larger woody trees and vines are more persistent and reproduce so long as the canopy remains relatively open. As light levels decrease with time the level of mortality of these species will probably increase. In the meantime, however, the effect of the presence of these species is to usurp space, reducing the rate of recruitment and succession of native species in the understorey.

If another cyclone causes significant disturbance before the canopy recovers, these fast-growing and early reproducing shrubs will have the capacity to spread rapidly through the landscape and increase their contribution to the weed community.

Implications for relevant stakeholders

The report's findings have implications for environmental land managers and policy makers in considering how they counter weed incursions in tropical rainforest environments after cyclones.

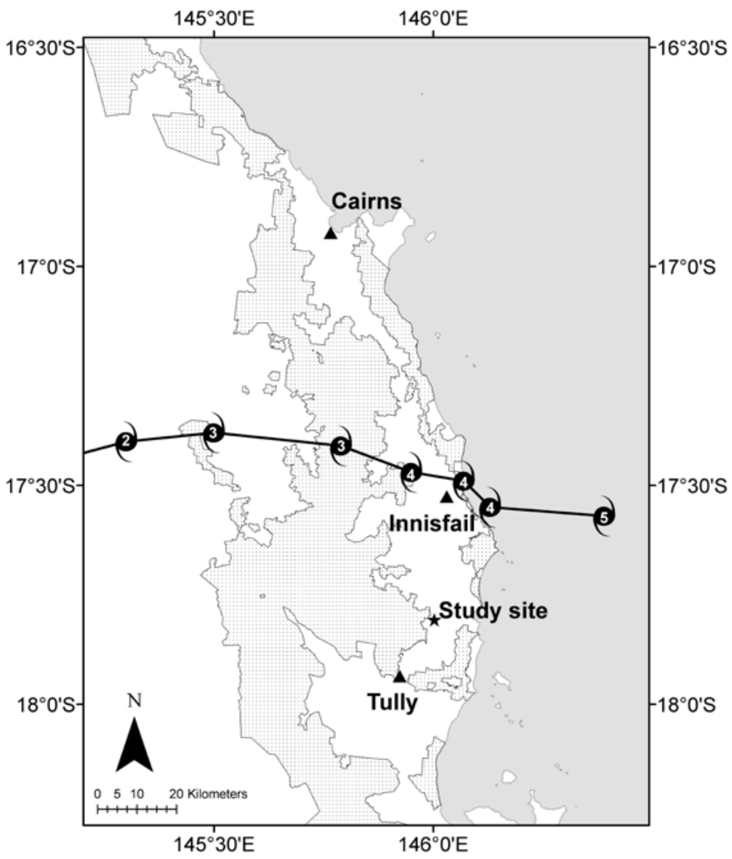
Recommendations

The observed nature of the weed incursion following Cyclone Larry has implications for policy makers and environmental land managers in determining how they respond to future cyclones, and which weeds they target in their activities. Although herbaceous weed species appear abundant and widespread initially, most are transient. Woody trees and shrubs, while being less obvious initially, are relatively persistent in comparison, and this is where the management effort should focus.

Introduction

Cyclones have an important influence on the dynamics of the rainforests of the Wet Tropics Bioregion of Australia. The prevailing winds in the region are from the south-east, but tropical cyclones can cross the coast from a variety of directions. When they do, high wind speeds, localised gusting, very high rainfall and storm surges can affect the vegetation. Cyclones and the associated rainfall cause tree falls, loss of tree limbs and landslips; less commonly, they can lead to canopy shredding, removal of most of the leaves on standing trees, and exposure of the understorey to high levels of light (Metcalfe et al. 2008). This exposure can lead to mass recruitment of light-demanding species, among them weed species. An understanding of the long-term implications of these major disturbances in terms of invasion, and subsequently the composition and structure of tropical forests, will be vital for predicting changes in the distribution of native species and in community structures and ecosystem function.

Severe Tropical Cyclone Larry—a category 4 or marginal category 5 tropical cyclone with an estimated central pressure of 915 hectopascals—crossed the coast of north Queensland on 20 March 2006, travelling west. Maximum wind gusts at landfall exceeded 290 kilometres an hour; very destructive winds formed a radius of 40–50 kilometres and destructive winds extended 120 kilometres (Davidson 2006; BOM 2007). As Figure 1 shows, the cyclone crossed the coast near Innisfail, traversed the Wet Tropics Bioregion and left as a category 3 cyclone. Among the rainforests affected were the fragmented remnants on the coastal floodplains, the largely intact extensive forests of the coastal range, and the fragmented forests of the southern tablelands (see Figures 2a and 2b).



Note: Shaded area represents the Wet Tropics World Heritage Area.

Figure 1 Location of the study site, at El Arish, and the track taken by Cyclone Larry

Figure 2 Damage sustained at El Arish field site as a result of Cyclone Larry

Source: Travis Sydes.

In order to assess the existing weed load in rainforest habitat in the Wet Tropics and the impact of Cyclone Larry in promoting the establishment and spread of weeds, we conducted surveys in rainforest, both across and along the cyclone track, within 12 months of the cyclone occurring and again about three years later (see Metcalfe et al. 2010). We also regularly monitored the recruitment, growth and mortality of all native and invasive species in ninety-nine 2 by 2–metre quadrats in an area extensively damaged by the cyclone (see Murphy et al. 2008, 2010).

This paper summarises the results of nearly four years of monitoring and discusses the implications for weed management. It also highlights the potential impacts of post-cyclone weed invasion on native species succession and diversity.

Methodology

Landscape-scale weed surveys

In order to determine the existing weed load in rainforest habitat in the Wet Tropics Bioregion and assess the impact of Cyclone Larry in promoting weed establishment and spread, we conducted surveys in 2006 both across and up the cyclone track and repeated those surveys in 2009. Each survey consisted of a 200-metre transect walked through the selected forest area, scanning the vegetation 2.5 metres either side for weeds, to achieve a 0.1-hectare survey area. Paired sites were located 200 to 500 metres away from each other. Data were collected in 25-metre-long sections (that is, eight quadrats per transect): the level of canopy disturbance, inhibitors of weed establishment (thick piles of debris or smothering growth of native vines or herbs), the number, identity and phenological state of all non-native species, and the broad classes of native species regenerating were recorded. In 2006 a total of 62 transects from 36 sites were surveyed (496 quadrats). In 2009 a total of 51 transects from 31 sites were re-surveyed (408 quadrats). Some sites could not be re-surveyed because of problems with access.

Local-scale recruitment of weeds

In the past four years we have monitored the recruitment, growth and mortality of all native and invasive species in an area extensively damaged by the cyclone. The study site is 1 kilometre west of the township of El Arish, at 17°48’S and 145°59’E. Partly located on private property, the site extends into Japoon National Park and the Wet Tropics World Heritage Area. The entire area of the study was extensively damaged by Cyclone Larry, although the degree of damage varied considerably over relatively small scales, particularly depending on aspect.

Eleven 50 by 20–metre plots were established in the study area, in areas ranging from severely damaged with multi-directional impacts and extensive tree damage to those characterised mostly by extensive defoliation. The level of damage to each plot was assessed as per Metcalfe et al. (2008). Nine 2 by 2–metre quadrats were established in each plot (total n = 99); three quadrats in each plot were assigned to each of three litter treatments—(1) as is, uncleared (that is, no treatment); (2) coarse woody debris removed; and (3) fully cleared of leaf litter and debris down to the soil layer.

All angiosperms and gymnosperms in each quadrat were labelled with a numbered aluminium tag. We identified all seedlings to genus level, and to species wherever possible, and estimated their height. At each survey period all tags were relocated, the identification confirmed, and the height (or mortality) recorded. All newly emerged seedlings were tagged and identified, and their height was estimated. Leaf litter and debris were removed from fully cleared quadrats (treatment 3) and woody debris from partially cleared quadrats (treatment 2) at each survey period. Monitoring was done every three to four months initially and in the last year every six months. The results reported here are for the first 11 surveys in the three-and-a-half years following the cyclone—that is, initial set-up (first survey, T1), second survey (T2), and so on, through to the 11th survey (T11).

Results

Landscape-scale weed surveys

In 2006, 39 of the 62 transects (62.9 per cent) had weeds present. Of the 496 quadrats across all transects, 148 (29.8 per cent) had weeds present. Weed diversity and abundance were highest in the most disturbed sites (that is, those with the lowest level of canopy cover). By 2009 only 17 transects (33.3 per cent) had weeds present, although the transects had often been heavily invaded, and 107 quadrats (26.2 per cent) had weeds in them. Weed persistence was greatest at the most disturbed sites.

In 2006, 4137 individual plants of 23 species of weeds from 13 families were encountered across all transects (see Table 1). *Crassocephalum crepidioides* (thickhead) and *Solanum mauritianum* (tobacco bush) were the most abundant species; six species were represented by only one individual. In 2009, 516 individual plants of 11 species of weeds from eight families were recorded: *Ageratum conyzoides* (bluetop) and *Rubus alceifolius* (giant bramble) were the most abundant species; four species were represented by a single individual.

Table 1 Weed species encountered, dispersal mode, life form and abundance, 2006 and 2009

Species	Family	Dispersal mode	Life form	No. 2006	No. 2009
Pityrogramma calomelanos var. *calomelanos*	Adiantaceae	Wind	Fern	1	0
Ageratum conyzoides ssp. *conyzoides*	Asteraceae	Wind	Herb	247	208
Chromolaena odorata	Asteraceae	Wind	Herb	3	0
Cirsium vulgare	Asteraceae	Wind	Herb	2	0
Crassocephalum crepidioides	Asteraceae	Wind	Herb	1633	4
Emelia sonchifolia var. *sonchifolia*	Asteraceae	Wind	Herb	129	0
Erechtites valerianifolia forma valerianifolia	Asteraceae	Wind	Herb	68	0
Praxelis clematidea	Asteraceae	Wind	Herb	10	0
Sonchus oleraceus	Asteraceae			1	0
Harungana madagascariensis	Clusiaceae	Vertebrate	Tree	121	1
Centrosema pubescens	Fabaceae	Passive	Vine	1	0
Hyptis capitata	Lamiaceae	Passive	Herb	12	1
Sida rhombifolia	Malvaceae	Passive	Herb	1	0
Tristemma mauritianum var. *mauritianum*	Melastomataceae	Vertebrate	Shrub	178	1
Miconia calvescens	Melastomataceae	Vertebrate	Tree	19	19
Passiflora edulis	Passifloraceae	Vertebrate	Vine	5	0
Passiflora subpeltata	Passifloraceae	Vertebrate	Vine	2	1
Phytolacca octandra	Phytolaccaceae	Vertebrate	Herb	11	0
Rubus alceifolius	Rosaceae	Vertebrate	Vine	92	257
Solanum americanum ssp. *nutans*	Solanaceae	Vertebrate	Shrub	40	0
Solanum capsicoides	Solanaceae	Vertebrate	Shrub	1	0
Solanum mauritianum	Solanaceae	Vertebrate	Shrub	1131	19
Solanum seaforthianum	Solanaceae	Vertebrate	Shrub	8	3
Solanum torvum	Solanaceae	Vertebrate	Shrub	37	0
Camellia sinensis	Theaceae	Vertebrate	Shrub	1	1
Lantana camara var. *camara*	Verbenaceae	Vertebrate	Vine	15	2

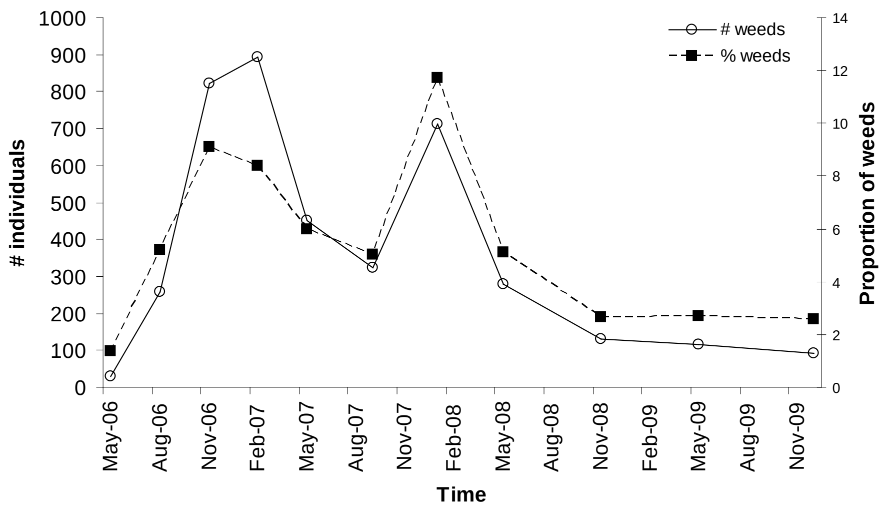
Transects ranged in altitude from 10 to 1210 metres. Weed diversity generally decreased with altitude. The mean altitude of transects with weeds was 514 ± 67.5 metres (n = 39), while the mean altitude of non-weeded transects was 854 ± 71.8 metres (n = 23). The mean weed abundance was highest in lowland forest (126 ± 251.7), followed by highland forest (45 ± 81.4) and then upland forest (4 ± 5.6).

Local-scale weed recruitment, growth and mortality

In the three-and-a-half years following the cyclone we recorded recruitment of a total of 2243 individuals from 14 weed species across the ninety-nine 2 by 2–metre quadrats. The entire database (that is, natives and weeds) consisted of 19 477 individuals from about 289 species (4 per cent of individuals in the database could be identified only to genus level), 187 genera and 79 families. Weeds thus made up nearly 12 per cent of total recruits.

Two peaks of weed recruitment occurred, one in the summer of 2006–07 and one in the following summer (see Figure 3a). The recruitment peaks were almost entirely prompted by herbaceous species (among them *Ageratum* sp., *Crassocephalum crepidioides* and *Erechtites valerianifolius*—see Figure 3b). Woody weeds (among them *Rubus alceifolius*, *Miconia calvescens* and *Solanum* spp.) occurred in much lower numbers but were persistent throughout the period of the study and had low mortality rates. Weed species were more abundant in the most severely damaged quadrats (see Figure 4a) and in the quadrats that had been fully cleared of litter and debris (see Figure 4b).

(a)



(b)

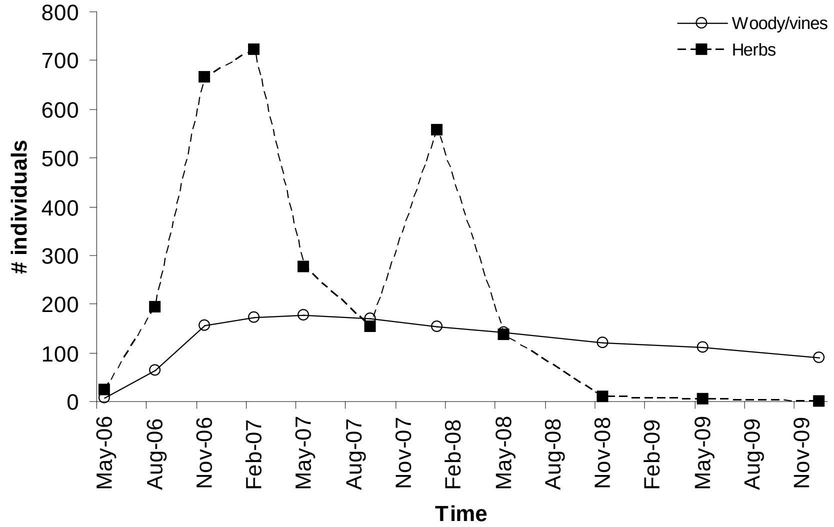
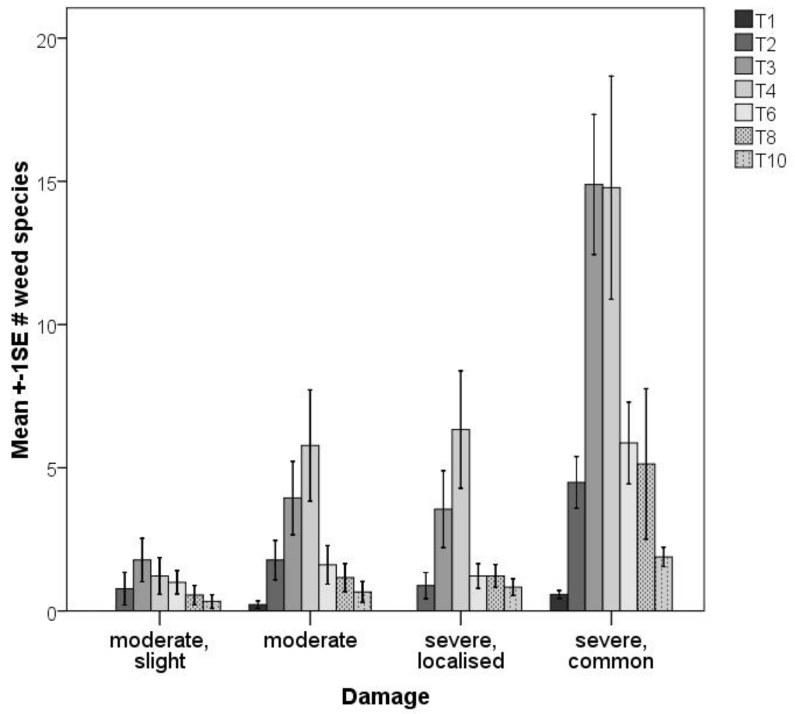


Figure 3 Weed recruitment since the cyclone: (a) all species combined and (b) herbaceous and woody species

(a)



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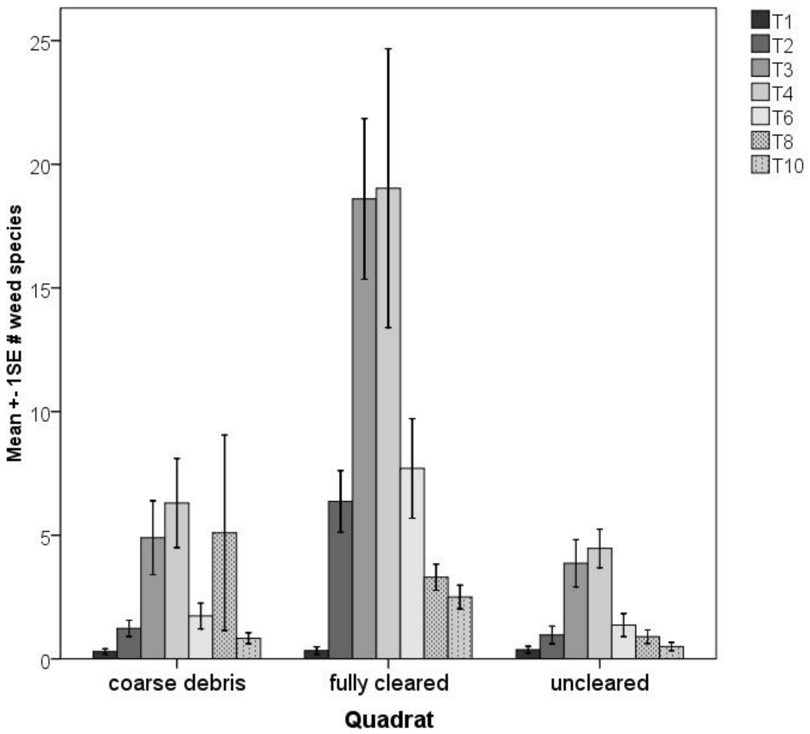

Note: Not all monitoring events are shown.

Figure 4 Number of weeds with (a) damage level and (b) quadrat treatment over time from initial set-up (T1) to T10

Conclusions and implications for management

Severe Tropical Cyclone Larry caused extensive damage throughout the study region. Some areas in the lowlands lost nearly 100 per cent of their canopy (Metcalfe et al. 2008). In such areas weed diversity and abundance were high, although there was considerable variation, largely in response to the suppression of weed recruitment either by dense piles of debris or by aggressive regeneration of native species.

Both the landscape-scale and the local-scale data confirm our initial speculation (Murphy et al. 2008) about the transient nature of most of the weed flora in rainforest habitats following a severe cyclone. Three to four years after the event canopy disturbance remained similar but both the abundance and the diversity of weeds had declined. This decline in abundance and diversity appears to be primarily the result of continued regrowth or regeneration of native species. Gingers and allies, ferns and a number of scandent or scrambling shrubs and palms—in addition to vigorous vine regrowth—rapidly suppressed seedlings and smaller statured herbs. At the landscape scale, 10 of the 14 species that disappeared between 2006 and 2009 were herbaceous, the others being small shrubs. By the third year the amount of light reaching the forest floor had been very much reduced, largely because of resprouting of existing live shrubs and trees and rapid growth of native recruiting pioneers. Our results suggest that by this time conditions are no longer suitable for weed recruitment. Furthermore, although it appears that the most severe cyclone damage provides ideal conditions for weed recruitment, the very high litter and debris loads that result present a major barrier to establishment.

The obvious implication for post-cyclone weed management is that, although herbaceous weed species appear abundant and widespread initially, most are transient. Woody trees and shrubs, while being less obvious initially, are relatively persistent in comparison, and this is where the management effort should focus. For example, the *Solanum* shrubs are all highly light demanding and will probably persist and reproduce so long as the canopy remains relatively open. As light levels decrease with time the level of mortality of these species will probably increase. In the meantime, however, the effect of the presence of these species is to usurp space, reducing the rate of recruitment and succession of native species in the understorey.

Furthermore, if another cyclone causes significant disturbance before the canopy recovers, these fast-growing and early reproducing shrubs will have the capacity to spread rapidly through the landscape and increase their contribution to the community. Rapid growth of scrambling species and vines (such as *Rubus*) after cyclone disturbance has also been shown to inhibit the recruitment of native species, creating the phenomenon of ‘strangled gaps’ in tropical forests. These scrambling species and vines might persist for tens to hundreds of years, retarding the succession response of native species and dramatically altering the structure and composition of the forest in the longer term.

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Climate change scenarios predict an increasing frequency of intense cyclones in the tropics. This review and its recommendations will help inform the response of policy makers and land managers.This report is part of the National Weeds and Productivity Program (NWPRP), which is funded to 30 June 2012 by the Australian Government with the goal of reducing the impact of invasive weeds on farm and forestry productivity as well as on biodiviersity.

RIRDC is managing the 2010–2012 stage of the NWPRP. All RIRDC research investments in this stage of the Program are oversighted by the Weeds R&D Advisory Committee in accordance with the National Weeds and Productivity Research Program R&D Plan 2010-2015 that has been approved by the Minister for Agriculture, Fisheries and Forestry.

Solutions to weeds in Australia require a long-term, integrated, multi-stakeholder and multi-disciplinary approach. RIRDC is seeking project applications that involve collaboration between stakeholder groups, and where possible, including external contributions both monetary and in-kind.

This review is an addition to RIRDC's diverse range of over 2000 research publications which can be viewed and freely downloaded from our website www.rirdc.gov.au.. Information on the Weeds Program is available online at www.rirdc.gov.au/weeds.Most of RIRDC's publications are available for viewing, free downloading or purchasing online at www.rirdc.gov.au. Purchases can also be made by phoning 1300 634 313.

Photos:
Front cover - Daintree canopy
Back cover - damage sustained at El Arish field site as a result of Cyclone Larry

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