Recruitment and growth dynamics of *Miconia calvescens* (Melastomataceae) in tropical forest impacted by Cyclone Larry

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Summary *Miconia calvescens* DC. is a shade-tolerant, fleshy-fruited tree native to tropical Central and South America. The species is currently recorded as invasive across the Pacific and in several areas in north Queensland where it is the target of a national eradication program. In the Pacific its emergence as a severe invasive is linked to disturbance, most notably in Hawaii and Tahiti. Severe category 4 Cyclone Larry crossed the north Queensland coast in March 2006, impacting rainforest habitats over a large area. We established 11 monitoring plots over an existing miconia infestation in an area extensively damaged by this cyclone and monitored recruitment, growth and mortality of miconia every three months. We also compare pre- and post-cyclone growth rates of retained miconia individuals in the infestation. Our results demonstrate the potential for miconia to persist as the forest recovers from the cyclone and we discuss the implications of this for management of miconia in the Wet Tropics.

Keywords Disturbance, litter load, hurricane, rainforest, weed, Wet Tropics.

INTRODUCTION

The invasion of the Australian Wet Tropics rainforests by *Miconia calvescens* DC. (Melastomataceae; henceforth miconia) poses a major threat to native biodiversity. This native tropical American species is a serious invader in the tropical Pacific, including the Hawaiian and Tahitian Islands, where it forms extensive monospecific stands and dense thickets that have essentially taken over large tracts of rainforest habitat (Meyer 1998a). Miconia is considered by scientists and land managers to be the worst plant pest in these two Polynesian archipelagos and potentially the most damaging weed of rainforests of Pacific islands (Meyer 1998a, Medeiros *et al.* 1997).

Miconia embodies many of the traits which make for a successful invader. The species is a small tree that grows to between 4–15 m (Meyer 1998b, Medeiros *et al.* 1997) and can persist in both high and low light environments (Csurhes 1998). It produces small, many-seeded, fleshy-fruits (Meyer 1998a) that are accessible to nearly the entire range of frugivores present in tropical forests, enabling its ready dispersal over short- and relatively long-distances (Murphy *et al.* in press (a), Westcott and Dennis 2006). Miconia is a declared Class 1 weed (the highest priority category) in Queensland (*Land Protection [Pest and Stock Route Management] Act* 2002) and the target of a national eradication program.

Severe category 4 Cyclone Larry crossed the north Queensland coast in March 2006, causing massive disturbance to rainforest habitats from Tully to Cairns and west to the Atherton Tablelands. This cyclone caused extensive defoliation, loss of major branches and multiple treefalls resulting in a significantly more open canopy (Metcalfe *et al.* in press). The widespread and massive disturbance caused by cyclones appears to provide ideal conditions for rapid recruitment and spread of invasive species.

We report here the results of ongoing monitoring of recruitment, growth and mortality of miconia in an area severely damaged by Cyclone Larry.

MATERIALS AND METHODS

The study site is located 1 km west of the township of El Arish, in North Queensland (17°48'S, 145°59'E). The site is on the fringes of a rural-residential /farming area, is partly located on private property and extends into Japoon National Park and the Wet Tropics World Heritage Area. Vegetation at the site has been mapped as 7.11.1a Simple-complex Mesophyll Vine Forest by the Queensland Environmental Protection Agency. The source of the miconia infestation is a few trees originally planted at the site by local landholders in about 1978 from nursery stock.

Monitoring growth Following the initial control work carried out at the site in 2004, a small plot of 15 immature trees and seedlings were retained and measures of height and basal diameter were recorded approximately every three months from September 2004. Growth was measured over a total of 500 days pre-cyclone and, to date, over 458 days post cyclone. This plot was in a sheltered west facing mid-slope

position, so that during the cyclone most foliage was removed from the trees, but only one stem was fractured (but recovered).

Monitoring recruitment Eleven 50 × 20 m plots were established in the study site in the two months following the cyclone. The plots are located with increasing distance (up to 1 km) from the original miconia source plants. Thus seven of the plots are located within the recorded extent of the infestation, while four are located beyond the extent of any individuals recorded at the time of plot establishment. The distance between the two most distant plots is approximately 1.3 km. Plots were located to encompass the range of cyclone damage conditions in the area, which was assessed by means of the Bradford-Unwin Damage Scale (Metcalfe *et al.* in press). Plots were located in areas with damage scores of 1.5 – 'severe and common disturbance' (five plots); 2 – 'severe and localised disturbance' (two plots); 2.5 – 'moderate disturbance' (two plots); and 3 – 'moderate to slight disturbance' (one plot). In each plot, nine 2 × 2 m quadrats were established (99 quadrats). Three quadrats were assigned to each of three treatments: (1) as is, uncleared i.e., no treatment, (2) partially cleared with only coarse debris removed, and (3) fully cleared of leaf litter and debris down to the soil layer.

All native and invasive angiosperm seedlings in each quadrat were labelled with an aluminium tag. At each survey period all existing tags were located, the identification confirmed, the height (or mortality) recorded, and any new recruits were tagged. Monitoring was conducted approximately every three months.

RESULTS

Growth At the commencement of monitoring retained miconia plants ranged from 0.19 to 3.4 m in height and 0.3 to 3.2 cm basal diameter. Average height and diameter growth rates increased significantly after the cyclone (Paired samples t-test for height $t = -4.072$, $df = 14$, $P < 0.01$; diameter $t = -3.867$. $df = 14$, $P < 0.01$) (Figure 1).

Recruitment Over the course of the post-cyclone monitoring period we recorded a total of 17 new miconia seedlings recruiting across six plots and eight quadrats. The earliest recorded recruitment occurred approximately six months after the cyclone (October 2006) and recruitment of miconia peaked at nine months post-cyclone before declining (Figure 2). Only one new recruit has been recorded in the last six months (to October 2007).

Miconia recruitment was concentrated around three plots (accounting for 12 of the 17 individuals) near where mature individuals had previously been recorded. No individuals recruited in plots beyond the known extent of the infestation. Five of the eight quadrats were 'fully cleared', one was 'partly cleared' and the remaining two were 'uncleared'.

Over the monitoring period two of the 17 individuals died. Height growth rates of recruiting seedlings ranged from 0.001–0.053 m 30 days^{-1} with a mean of 0.014 m 30 days^{-1}. Seedling growth rates were higher for seedlings recruiting in more severely damaged plots (i.e. damage score 1.5, nine seedlings, mean 0.018 m 30 days^{-1}) compared with more moderately damaged plots (damage scores 2 and 2.5, eight seedlings, mean 0.01 m 30 days^{-1}), though the difference was not significant (One-way ANOVA, $P = 0.277$).

DISCUSSION

The spectacular success of miconia in Tahiti is often attributed to the six hurricanes that hit the Society Islands between December 1982 and April 1983.

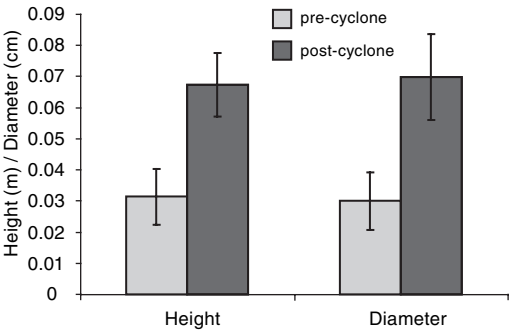

Figure 1. Average (± 1 std dev) height and diameter increase per 30 days in pre- and post-cyclone period for 15 miconia plants.

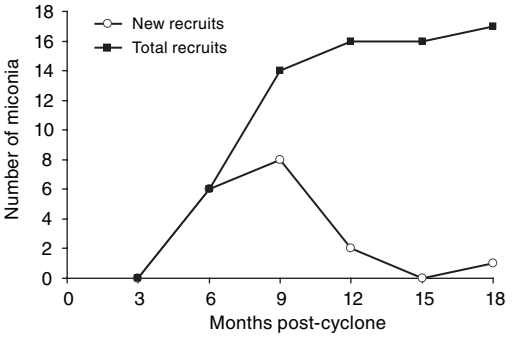

Figure 2. Number of new recruits and cumulative number of recruits in the 18 months post-cyclone.

P. Birnbaum (1991, 1994 in Meyer 1998a) reported that the cyclones explained the 'demographic explosion of miconia', and that 'the speed of the invasion then became astonishing'. Meyer (1998a) suggests, however, that the cyclones acted more as a 'revealer' of the miconia invasion than as a 'detonator'. Meyer maintains that while the increased light in the understorey allowed for rapid growth of miconia seedlings, this was preceded by earlier and massive dispersal and establishment.

Our results also indicate a rapid response in growth rates of existing miconia plants to the opening of the canopy caused by the cyclone. Furthermore, the significantly more open canopy, combined with rapid growth rates, may enable miconia plants in cyclone affected areas to reproduce earlier if left unchecked. Meyer (1998b) reports that miconia only flowers when its branches reach full light.

Our results also suggest a surge in recruitment of miconia in the period 6–9 months following the cyclone. However, these results are not conclusive since we have no pre-cyclone data and the recruitment may be associated with other favourable abiotic conditions. Ongoing monitoring of canopy closure in relation to recruitment at the site will clarify whether the recruitment is likely in response to an open canopy or a favourable growing season.

Miconia recruited more readily in quadrats cleared of cyclone debris. The species produces small fruits which produce large numbers of tiny (ca 0.65 mm) seeds which may be smothered by large litter loads. Metcalfe and Turner (1998) also found high litter loads inhibited germination of small-seeded species in a closed forest in Singapore.

The relatively low mortality and high growth rates of miconia suggest an ability to persist and compete with native species as the rainforest recovers from the impact caused by Cyclone Larry. Further monitoring will determine whether increasing shade from recovery of remaining canopy trees eventually results in a slowing of growth rates.

We have also found that other invasive species at this site recruit most readily in the most damaged plots on fully cleared quadrats and that woody invasives generally show relatively low mortality (Murphy *et al.* in press (b)). The experience in Tahiti demonstrates the importance of the ongoing eradication program with a particular focus in areas of the infestation damaged by cyclones. Disturbances which result in canopy gap formation without the high litter loads associated with cyclones probably present the most ideal conditions for the rapid recruitment and spread of miconia.

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