The effects of cyclones on a tropical weed eradication program

Simon J. Brooks[1] and Mick Jeffery[2]
[1] Tropical Weeds Research Centre, Biosecurity Queensland, Department of Agriculture and Fisheries, PO Box 187, Charters Towers, Queensland 4820, Australia
[2] Biosecurity Queensland, Department of Agriculture and Fisheries, PO Box 20, South Johnstone Queensland, 4859 Australia
(simon.brooks@daf.qld.gov.au)

Summary Weed infestations managed by the nationally cost-shared Tropical Weeds Eradication Program have been affected by the passage of two severe tropical cyclones: Severe Tropical Cyclone Larry in 2006 and Severe Tropical Cyclone Yasi in 2011. The timing of the cyclones coincided with vegetative phases of most target weeds' life-cycles. Destructive winds severely damaged the tropical forest vegetation and produced masses of vegetative debris, impeding site access and slowing ground survey operations. This resulted in immediate delays to survey and weed control schedules. Changes in seedling recruitment patterns may only be apparent in program reporting after one or two years while other effects may arise over 3 or 4 years. There are immediate and longer term effects of cyclones particularly on the staff required to meet annual surveillance targets and protect the cost-share investment to date.

Keywords Surveillance, disaster, Miconia, Mikania.

INTRODUCTION

The nationally cost-shared 'National Tropical Weeds Eradication Program' (NTWEP) commenced in late 2003 and currently targets *Limnocharis flava* (L.) Buchenau, *Miconia calvescens* DC., *Miconia racemosa* (Aubl.) DC., *Miconia nervosa* (Sm.) Triana and *Mikania micrantha* Kunth. Most infestations occur between the towns of Daintree (16°S) and south of Ingham (19°S) along the far north Queensland tropical coast and adjacent Atherton Tablelands. BOM (2018a) expect an average of 4.7 cyclones a year to form in the Coral Sea and Gulf of Carpentaria area. These cyclones tend to form between 5 and 15°S and reach maximum intensity between 10 and 20°S. Single infestations of *M. nervosa* and *M. racemosa* were not near the paths of recent severe cyclones. The effects of two cyclones on the target weeds and the eradication program are summarised below to provide guidance for responding to future extreme natural events.

Severe Tropical Cyclone Larry Cyclone Larry crossed the north Queensland coast with the centre of the 25 km-diameter eye passing near Innisfail on the morning of the 20 March 2006, and continued over the Atherton Tableland while weakening (BOM 2018b, CTS 2018). This was a severe category 4 cyclone with gusts estimated up to 230 km h^{-1} (CTS 2018). Destructive winds (>170 km h^{-1}) extended approximately 50 km from the centre between Babinda and El Arish (Figure 1). The core of this cyclone passed over *M. calvescens* and *L. flava* infestations; other *M. calvescens*, *L. flava* and *M. micrantha* locations were affected by destructive winds.

Severe Tropical Cyclone Yasi Cyclone Yasi crossed the north Queensland coast near South Mission Beach on the 3 February 2011 (Figure 1). With estimated sustained winds of 218 km h^{-1} and gusts up to 285 km h^{-1} this category 5 cyclone produced destructive winds extending over 130 km south of Innisfail (BOM 2018c). The most destructive winds passed over *M. calvescens*, *M. micrantha* and *L. flava* infestations.

EFFECTS ON WEEDS

The native range of all the eradication target species includes some tropical areas of Central, South America and the Caribbean where species have evolved with selective pressures from large scale disturbances, such as landslides and cyclones, and smaller scale disturbances, such as tree and branch falls. The effects observed on the three eradication target species with multiple infestations in the areas directly impacted by the two cyclones vary depending on their biology. Heavy rainfall is seasonally common in the tropics so any effects are not exclusively cyclonic, and could include erosion and exposure of buried seed. All species form a persistent soil seedbank but seed dispersed into an unsuitable habitat can be exhausted.

Limnocharis flava Both cyclones passed over known and (at the time) unknown infestations but there have been no large or direct consequences observed on this anchored aquatic herb. *Limnocharis flava* can reproduce by seed and vegetatively all year round (Figure 2). However, known infestations were visited by

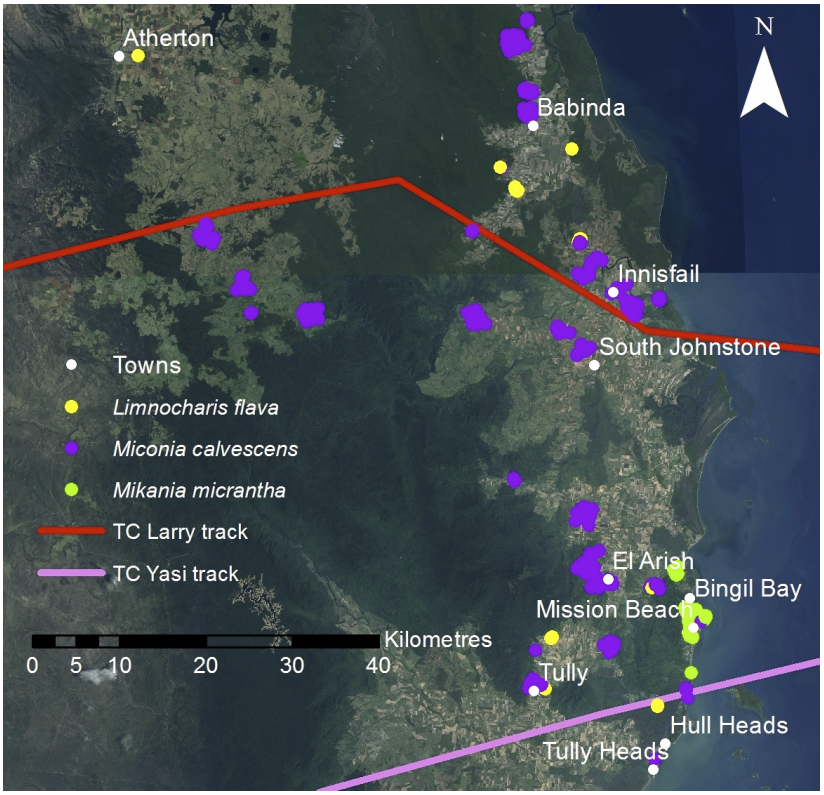

Figure 1. Tracks of Severe Tropical Cyclones Larry (2006) and Yasi (2011) over all known infestations as of December 2017. Points are not to scale and include non-naturalised locations on the far north Queensland coast.

field crews every four weeks, which prevents flowering stalks from maturing and negates the formation of vegetative plantlets on the flowering stalk (Weber and Brooks 2013). Unmanaged infestations are unlikely to produce wind dispersed seed into a narrow aquatic habitat, as flowering stalks bend towards the water as papery follicles mature (Weber and Brooks 2013). This species favours margins of still, shallow water and appears to be limited by faster flowing creeks and rivers with rockier substrates. Soil or plant-borne seeds have to reach a suitable habitat and occasional pre- and post-cyclone downstream surveys have not revealed seed spread specifically related to cyclones. New infestations are usually linked to cultivation. This species forms a persistent seed bank so heavy rainfall events could lead to local seed spread through slow moving water in suitable habitats, such as dam or drain overflow, flood back up and coastal inundation.

Miconia calvescens The response of *M. calvescens* plants to the cyclones may vary depending on the life stage. Cyclones can produce a large volume of leaf litter, but small seeded Miconia species are considered to be 'litter gap demanders' and thus prefer areas with less litter (Murphy *et al.* 2008, and references therein), or it may take some time for the litter to break down to allow seed germination. Murphy *et al.* (2008) recorded *M. calvescens* seedlings six months after cyclone Larry, with peak establishment nine months after the cyclone and higher seedling growth rates in more-damaged plots. However, larger tree fall gaps are less suitable habitat (Meyer 1998). Established seedlings that survive the cyclone may respond quite quickly to increased light levels (Murphy *et al.* 2008), while larger saplings can recover from trunk damage. Field crews measure the height and diameter of large plants encountered in the field (Brooks and Setter 2014) and 3.6% of 2413 records are badly damaged stems (from a variety of causes), these plants have a distinctly high ratio of basal diameter (cm) to height (m) (S. Brooks, unpubl. data). Although saplings and trees can recover the defoliation, a height reduction

may influence their detection from the ground or air, with plants taking years to regrow to the height of the recovering rainforest canopy and maturity.

The native tropical vegetation has evolved with cyclones as a selective pressure, however a subset of invasive species including *M. calvescens* are more persistent in the rainforest environment after cyclones (Murphy *et al*. 2014). Meyer (1998) considers a series of six cyclones across Tahiti in 1982–1983 to have revealed the underlying *M. calvescens* incursion and promoted plants into the damaged native forest canopy. This 'revelation' was considered to be due to the favourable growth conditions rather than cyclone induced spread of *M. calvescens*. The low frequency of fruit production (7 cases) in February and March (Figure 2) has restricted cyclone related dispersal with spread patterns consistent with frugivore dispersal. New *M. calvescens* infestations between 2012 and 2014 are thought to have resulted from cultivation: the last new infestation was in 2014.

Mikania micrantha This species has a strongly seasonal flowering behaviour, commencing in April and May, so seed was not present on vines at the times of either cyclone (Figure 2). *Mikania micrantha* also readily reproduces from stem fragments with a single node. The destructive core of cyclone Yasi passed over *M. micrantha* infestations at Mission Beach and near Bingil Bay. This area was surveyed several times after cyclone Yasi and 20 new management areas were recorded in the six months to the end of December 2012, but this is thought to have resulted from ground searches expanding northwards. Some *M. micrantha* infestations are accessible to vehicles so there are opportunities for dispersal of soil borne seed and vegetative fragments during this event and subsequent clean-up operations.

Cyclone Yasi created a lighter environment for germination from the soil seed bank and *M. micrantha* seedling growth, and there was 274 ha of additional survey of cyclone disturbed infestations in 2011–2012 financial year. Unfortunately there was also a large increase in mature *M. micrantha* plants between August and December 2012, these plants were found across 17 known management areas. Although *M. micrantha* is renowned as a rapidly growing species, it still took 18+ months for the vines (from seed or stem fragments) to reach a detectible size and maturity. It is possible that more recruitment commenced in 2011–2012 wet season than immediately after the cyclone as mature plants were recorded in the second half of 2012. There were increases in emergence and growth for two years after cyclone Yasi and some of these plants were hard to detect and prevent maturing.

EFFECTS ON PROGRAM RESOURCES

The eradication program builds annual budgets, usually three years in advance, on the basis of search rates, frequency and area, summed for each target species. Operational scheduling for the available workforce is then based on the survey frequency for each species. There are annual 'wet season' disruptions due to heavy rain, preventing surveys for up to a week, but not dramatically altering the vegetation and search rates like cyclones do. The NTWEP has some ability to re-allocate some resources in the event of a cyclone, however there is only a small amount of flexibility built into the field survey schedule. Large problems with the search rate, extent or frequency of one species can influence the resources available for other species.

Cyclones bring an immediate disruption to field survey schedules, beyond the normal wet season delays. Cyclone Yasi bought at immediate loss of approximately 70 work days or 2 weeks operations for

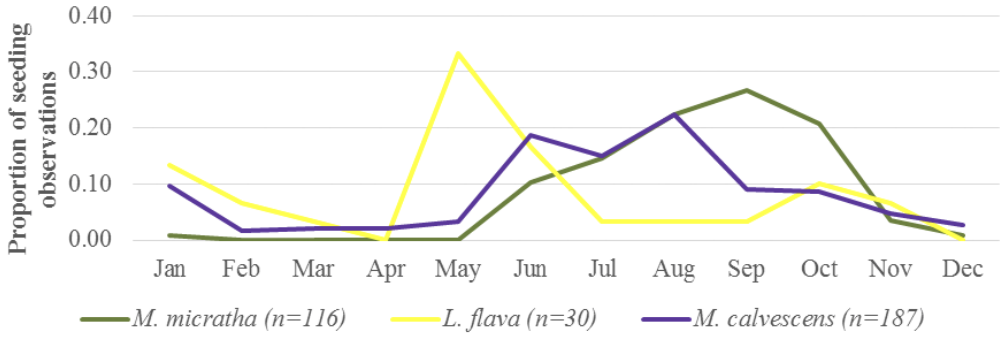

Figure 2. Proportion of seeding observations by NTWEP field crews, per month pooled for all infestations (2003–2017), including discovery records.

staff based at South Johnstone. Both cyclones caused damage to roads and property, with some staff unable to work immediately. There is also damage and disruptions to offices and program coordination activities. The eradication program had well-equipped, local field staff and vehicles that were diverted to assist with broader recovery activities. With infestations primarily occurring on privately owned land, contact with rural landholders affected by the cyclone needs to be carefully managed to maintain long term access. These factors particularly affect the schedule and the frequency of program activities. Even if the survey frequency for *L. flava* (4 weeks) and other species (*M. micrantha*, *M. racemosa* and *M. nervosa*) 3–4 times a year is not badly affected, these species collectively account for 20% of programs recorded annual survey effort (S. Brooks unpubl. data). *Miconia calvescens* infestations are surveyed at lower frequency (16–24 months) but to cover an annual search area target over 4000 hectares, different portions of infestations need to be surveyed throughout the year, which consumes 80% of the programs search effort. Cyclone Yasi impacted over a quarter of the *M. calvescens* survey area.

Destructive winds severely damaged the tropical forest vegetation and produced masses of vegetative debris. While landscape features can become more visible, the field crew's familiarity with infested areas and site accessibility is dramatically altered. Significant field resources were required to re-establish access to survey the rainforest around infestations. After cyclone Yasi this was estimated at two months' work for six staff or contractors. There is also a reduction in ground survey rates, after cyclone Larry crew search rates for *M. calvescens* dropped from 0.7 ha person^{-1} day^{-1} to 0.3 ha person^{-1} day^{-1} in cyclone affected vegetation. Beyond the immediate impedances of woody trunk and branch debris, regrowth of plants including the native palm *Calamus australis* Mart. (lawyer cane) and the exotic shrub *Rubus alceifolius* Poir. (giant bramble) slowed surveys for up to four years.

Cyclones have bought a reduction in in-kind contributions from program stakeholders and more focus on activities such as public access (road and track) clearing and feeding endangered wildlife, with less resources available for weed control beyond public access tracks. After cyclone Larry, three additional field crew were employed for a few months for track cutting. The NTWEP received an extra $300,000 over 2 financial years after cyclone Yasi, primarily for field workers, vehicles and equipment. Both cyclones also bought the need for increased weed identification and spread prevention training and information for workers on clean-up crews. After receiving ID training after cyclone Larry, a local contractor recognised a new *M. micrantha* patch several years later. After cyclone Yasi, NTWEP staff spent time producing and sharing maps of infestations for agencies coordinating clean up contracts.

FUTURE CYCLONES

The program will be managing infestations of target species into the 2030s (Jeffery and Brooks 2016) so it is highly likely that one or more cyclones will impact some infestations over this time frame. It is only possible to predict the timing, location and intensity of cyclones a day or two in advance (certainly not years), which limits effective forward planning. The broad impacts, identified above, will vary across species, infestations and within infestations due to the orientation of the land and the wind strength and direction(s). With field crews based in three locations (Mossman, Cairns and South Johnstone) the effects of a cyclone may directly impact one or two crews. With many unknown factors it is impossible to pre-determine the specific costs to the program. However, these past events provide guidance as to the types of impacts and time frames likely to arise from future cyclonic events as summarised below.

Cyclones Larry and Yasi severely disrupted the NTWEP workforce, scheduling, reduced site access and lowered the field search rates. There will be a short to medium term need to catch up or keep up the visit schedules and re-establish site access. This can only be done through additional field workers as soon as is practicable. The effect of vegetation disturbance on the search rates can continue and have direct and flow-on influences up to four years later, particularly for *M. calvescens*. The first few years after the cyclone may also be accompanied by increases in the search frequency or area, and control costs. Cyclones will bring a need to supply weed identification and spread prevention information and training, and maps. There is the potential for propagule movement during clean-up activities that need to be managed as part of the post cyclone weed seed spread prevention activities.

The natural spread of target weeds associated with cyclones has been limited by the time of the year and the requirement for viable seed to arrive in a suitable habitat. Future events should focus on locally-suitable habitats for *L. flava* that could be reached by slow moving shallow flood waters, as well as maintaining survey frequencies. Future cyclones will slow the *M. calvescens* searches and influence growth and detection rates. Similar effects would be expected at the *M. calvescens* and *M. racemosa* infestations near Kuranda and the *M. calvescens* and *M. nervosa* infestations near Whyanbeel. There was *M. micrantha* recruitment noted around known infestations after both cyclones,

so there could be an increase in search area if mature plant discoveries extend the survey buffer.

The dramatic changes in tree canopies and light and provided enhanced opportunities for weed seed germination and seedling growth and while this can impact program reporting, it is useful for accelerating progress towards eradication. Similarly seed rendered unviable or dispersed into an unsuitable habitat also acts to deplete the population. Cyclones are a normal part of the tropical environment for native and exotic plants but have dramatic short to medium term impacts on both the vegetation and the people that survey it. Therefore the effects of cyclones on weed eradication programs need to be taken into account by policy makers in terms of adjustment to milestones and their timeframes. Flexible funding models are needed to cope with increased expenditure to re-establish site access, account for slower surveys and changes in survey frequency over several years. Eradication programs will need allowances to change performance criteria to account for the impacts of cyclones or other natural disasters.

ACKNOWLEDGMENTS

The data presented has been collected by numerous dedicated field workers in the National Tropical Weeds Eradication Program and stakeholder agencies.

REFERENCES

BOM, Bureau of Meteorology (2018a). Tropical cyclones in Queensland. http://www.bom.gov.au/cyclone/about/eastern.shtml (accessed 17 April 2018).

BOM, Bureau of Meteorology (2018b). Severe Tropical Cyclone Larry description. http://www.bom.gov.au/cyclone/history/larry.shtml (accessed10 April 2018).

BOM, Bureau of Meteorology (2018c). Severe Tropical Cyclone Yasi description. http://www.bom.gov.au/cyclone/history/yasi.shtml (accessed 10 April 2018).

Brooks, S.J. and Setter, S.D. (2014). Issues and solutions for researching weed eradication target species. Proceedings of the 19th Australasian Weeds Conference, ed. M. Baker, pp. 255-8. (Tasmanian Weed Society, Hobart).

CTS Cyclone testing station – School of Engineering, James Cook University Townsville (2018). Newsletter October 2006. https://www.jcu.edu.au/cyclone-testing-station/publications/newsletters (accessed 10 April 2018).

Jeffery, M. and Brooks, S.J. (2016). Eradication in the tropics: constantly changing and adapting. Proceedings of the 20th Australasian Weeds Conference eds R. Randall, S. Lloyd and C. Borger. pp. 23-7. (Weeds Society of Western Australia, Perth).

Meyer, J-Y. (1998). Epidemiology of the invasion by *Miconia calvescens* and reasons for a spectacular success. Proceedings of the First Regional Conference on *M. calvescens* control, eds J.Y. Meyer and C.W. Smith, pp. 72-7. (Papeete, French Polynesia).

Murphy, H.T., Brooks, S.J., Bradford, M.G., Metcalfe, D.J. and Westcott, D.A. (2008). Recruitment and growth dynamics of *Miconia calvescens* (Melastomataceae) in tropical forest impacted by Cyclone Larry. Proceedings of the 16th Australian Weeds Conference, eds R.D. van Klinken, V.A. Osten, F.D. Panetta and J.C. Scanlan (Queensland Weeds Society, Brisbane).

Murphy, H.T., Metcalfe, D.J., Bradford, M.G. and Ford, A.J. (2014). Community divergence in a tropical forest following a severe cyclone. *Austral Ecology* 39, 696-709.

Weber, J. and Brooks, S.J. (2013). The biology of Australian weeds 62. *Limnocharis flava* (L.) Buchenau. *Plant Protection Quarterly* 28, 101-13.