Eradication in the tropics: constantly changing and adapting

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Summary The National Tropical Weeds Eradication Program targets *Limnocharis flava*, *Mikania micrantha* and three *Miconia* species in Queensland and northern New South Wales. Over the 15 year life of the project, improvements have been made across a range of areas including surveillance methodologies, data collection and analysis, and community engagement. A summary of progress to eradication for each of these species is presented.

Keywords Eradication, *Limnocharis flava*, *Miconia* spp., *Mikania micrantha.*

INTRODUCTION

Biosecurity Queensland, a business group of the Queensland Department of Agriculture and Fisheries, is responsible for managing the National Tropical Weeds Eradication Program (NTWEP). This is a nationally cost-shared program that commenced in late 2001 and targets five species of highly invasive weeds which originate from tropical America: *Limnocharis flava* (L.) Buchenau, *Miconia calvescens* DC., *Miconia nervosa* (J.E.Smith) Triana, *Miconia racemosa* (Aubl.) DC., and *Mikania micrantha* Kunth.

SURVEILLANCE

How often? As eradication is the management objective, it is vital that any surveillance activities detect plants before they become reproductive. Through 15 years of successes and failures, the NTWEP has developed a range of methods to ensure we have the best possible chance of halting any future replenishment of the soil seed bank.

Firstly, scientific research has been undertaken to establish the time to reproductive maturity for most of the species within the program (Brooks and Setter 2014). For example, *M. calvescens* can produce fruit after four to five years (Murphy and Brooks 2010), while *L. flava* can flower in 46 days (Brooks *et al.* 2008). Surveillance visits for each of these species need to be scheduled accordingly. The program allows for two or more visits to an infestation within the time to reproduction period, which means every 16 months for *M. calvescens* and every three weeks for *L. flava.*

The aim is to have enough visits to an infestation to take into account:

(a) that detectability will improve with increasing plant size; and
(b) that field teams usually do not detect 100% of the plants in a complex rainforest landscape every time they traverse through. This needs to be balanced with cost so that unnecessary 'over' surveillance does not occur.

The NTWEP has increased the site revisit frequency over the past five years for most species with positive results. In 2011, the average revisit interval for *M. calvescens* sites was 29 months which had reduced to 16 months by the end of 2014 (S. Brooks unpublished data). This has correlated with a reduction in mature plant detections from 2.5/100 ha searched in 2010–11 to only 0.6/100 ha searched in 2015–16.

Technological edge In 2008 the NTWEP commenced using newer model GPS units which could provide an accurate location under dense rainforest in steep terrain (Brooks and Jeffery 2010). Prior to that, there was no accurate way to relocate previously treated sites. Not only did these GPS units provide very accurate plant locations for the first time, but they also allowed the ability to record a tracklog of where each survey team member surveyed each day (Figure 1).

These tracklogs are utilized for several purposes, including: the ability to check the thoroughness of surveillance; the creation of Geographical Information System (GIS) polygons to record the exact daily surveillance area completed; and a means of estimating the average time required to survey for each species in different terrain types. The latter information has been used to generate very accurate estimates of resources and related budget bids.

The NTWEP GPS units are also pre-loaded with locational data of previously found plants. This provides a visual reminder to teams undertaking surveillance to be extra vigilant when passing through these locations.

The other technological development has been the utilization of UAVs (un-manned aerial vehicles) to detect plants from the air. Eventually this will

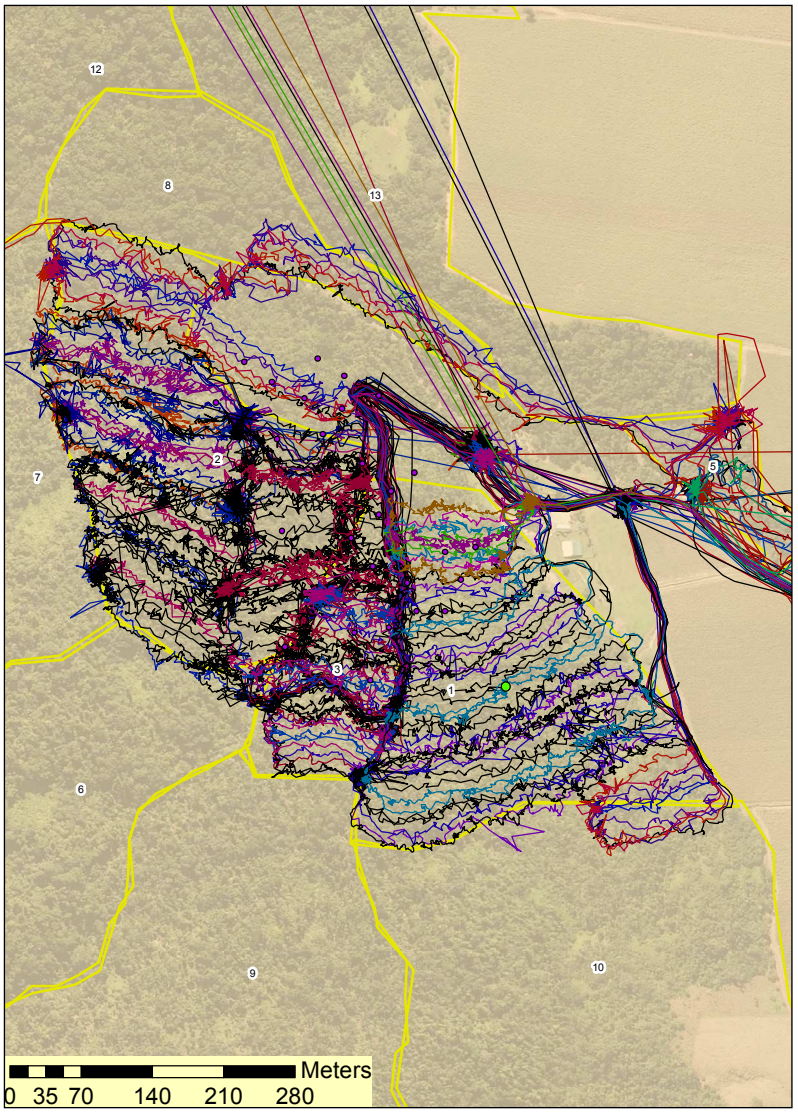

Figure 1. GPS tracklogs of ground survey coverage for *M.calvescens* within pre-determined GIS surveillance polygons.

replace manned helicopter flights (see separate paper at this conference). Over the past three years CSIRO have developed a UAV which has been trialed in north Queensland rainforests to detect the rainforest invader, *M. calvescens*. The UAV carries a camera payload which captures images every two seconds. In a small comparative trial, the UAV flew an area which had received helicopter surveillance two weeks prior and detected a much larger number of plants than a helicopter with three spotters on board. The NTWEP has recognized the greater detection ability, reduced cost and much higher safety of UAVs, and will move all of its aerial surveillance to drones during 2016-17.

Where to search? For known infestations, the NT-WEP targets surveillance to the most likely areas of dispersal. Bird and wind dispersal kernels are generated from all detections of mature plants of the *Miconia* species or *M. micrantha*, and extensive downstream searches are undertaken for all species. Ground teams

will search all surrounding suitable habitat out to radius of 1 km for *M. calvescens* (Murphy *et al.* 2008) and 200 m for *M. micrantha.*

Searching more broadly across north Queensland, or northern NSW in the case of *M. calvescens*, is reliant on a community engagement program which utilizes a range of techniques to educate both trained weed officers, and the general public (Brooks and Galway 2008) to help determine the extent of the incursions. For the more easily identifiable species such as *M. calvescens*, television commercials and social media have been used to reach a large audience. The NTWEP maintains a collection of live specimens of all species which is taken around the region to 'toolbox talks' of field staff from a wide variety of land management agencies, including National Parks, local government and Green Army. These specimens are also on display at all regional agricultural and garden events so that the public can see and touch the plants.

DATA MANAGEMENT

Consistent and comparable A wide range of data is collected on GPS units and data sheets which are later entered into the Tropical Weeds Database.

To assist with comparability across all sites, a static grid of one hectare management units has been overlaid on GIS mapping. All data recorded within these units are now pooled and progress to eradication is statistically analyzed every six months using plant presence and absence from each unit. This has allowed the NTWEP to compartmentalize large infestations into smaller management units, and will allow portions of sites to progressively meet the criteria for area freedom. An infestation is classified as eradicated if, after a period equating to the species' seed bank longevity (with no known input into the seed bank from adult plants), consistent monitoring has not detected seedling emergence for at least five consecutive years. This strict eradication criterion requires the Program to revisit sites for some species for over 20 years.

To provide an accurate mapping of plant distribution, any new plants of any species located at least 30 m away from a previously known site are recorded as a new site. This chosen spatial scale provides an excellent representation of plant density and distribution on GIS, but also provides fine scale locational data which is used to guide field teams via their GPS units. Each time teams then revisit these sites, they record whether any plants are present or not, remembering that the recording of nil presence is an essential part of showing progress to eradication.

The database is also interrogated monthly to inform surveillance scheduling. By checking visitation records to each management unit, it is possible to reprioritize surveillance for the month ahead to ensure all sites are visited at the required frequency to minimize the occurrence of reproductive plant relapses.

PROGRESS TO ERADICATION

Limnocharis flava The only aquatic species targeted in the NTWEP, *L. flava* occurs in locations which provide relatively easy access and detection. The visitation frequency for this species is every three weeks. Viable seed has been retrieved from one infestation for the past 12 years (S. Brooks unpublished data). No new sites have been detected since May 2015.

Of the known infestations, we are dealing mostly with the residual seedbank, and over 63% of management units had no seedling regeneration during 2015 (Table 1). The estimated year of complete eradication of *L. flava* from Australia is 2029.

Mikania micrantha This vine species is the most problematic to detect as it co-habits a rainforest landscape with hundreds of other vine species. The NTWEP has a specialist team of experienced *M. micrantha* spotters which is dedicated to the detection and removal of this species alone.

As this species has a high light requirement, it tends to dominate cleared areas, rainforest edges and canopy gaps. Two category five cyclones have struck the region in the past ten years and have provided optimum conditions for *M. micrantha* growth. Nonetheless, the NTWEP has reasserted control over this elusive invader, with excellent progress being made across the region. In Ingham, where *M. micrantha* was first detected in 1998, no plants have been detected since February 2014. In the other main area of distribution, Mission Beach, no germination was detected at 63% of known management units during 2015 (Table 1). This species appears to have a shorter seed longevity than the other species in the Program, but will still take at least until 2030 for eradication to be declared.

Miconia calvescens The rainforest tree, *M. calvescens* is the largest component of the NTWEP, with a surveillance area of over 4000 hectares per annum. As the fruit of this species is bird dispersed, most of the surveillance and control occurs in dense tropical rainforest on steep slopes, a large portion of which is within the Wet Tropics World Heritage Area.

This species had a limited legal trade prior to its declaration in 1996. Consequently, it has taken over 20 years to track down all of the plants that were purchased and planted in tropical gardens in north Queensland and subtropical gardens in northern New South Wales (Brooks and Jeffery 2010). With a seed longevity of at least 16 years (Brooks and

Setter 2012), this species will take the longest time to eradicate from Australia, with an estimated end point of 2039.

The species has a number of features which will assist its eradication. Firstly, it is easily identifiable due to its very large leaves with bright purple undersides. This not only assists field staff to detect it in the rainforest, it also allows it to be spotted from the air once it is over two metres in height, and is readily identifiable by the general public. The NTWEP regularly uses multi-media campaigns targeting this species due to the high level of positive reports we receive from the public (Brooks and Galway 2008) and the fact that many infestations originate from cultivated garden specimens (Brooks and Jeffery 2010). Secondly, the species has the longest pre-reproductive period of all the species, of at least four years (Murphy and Brooks 2010). This allows on ground and aerial surveillance a number of opportunities to detect plants before they set fruit.

An increase in surveillance resources which commenced in 2011 and improved again in 2015 has seen a much higher visit frequency to *M. calvescens* infestations. This has led to a decline in mature plant detections, now down to 0.6 plants per 100 hectares searched. At the majority of infestations the NTWEP is now just dealing with the persistent seed bank. During 2015, no germination was detected at 43% of sites (Table 1) and 99.5% of plants that the ground teams found were seedlings.

Table 1. Number and status of management units (1 ha) for each target species at the end of 2015. Units are in monitoring phase when plants are not detected for a year or more.

Species	Total units	% in monitoring
Limnocharis flava	62	63
Miconia calvescens	771	43
Miconia nervosa	28	39
Miconia racemosa	45	44
Mikania micrantha	83	63

Miconia nervosa* and *M. racemosa These two rainforest shrub species are each restricted to single locations in Far North Queensland. The densities of both species have reduced significantly, with only the occasional mature plant detected each year. The seed banks are in decline (S. Brooks, unpublished data), with a large portion of each of these locations demonstrating no seedling regeneration in 2015 (Table 1). As both of these species are co-located within *M. calvescens* infestations, teams search a far wider area surrounding these small infestations to confirm no further spread beyond the prescribed dispersal buffers. Both of these species are tracking well towards eradication, but a long seed life will mean it will be 2034 before area freedom is declared.

PROGRAM REVIEW

Independent assessment Every three years the NTWEP hosts a full week visit by a team of independent experts who are tasked to critically assess all aspects of Program performance. This process has been welcomed by the NTWEP as an opportunity to strengthen aspects that may require improvement, and to recognize progress and continual evolution of the program.

The last program review in 2013 was the first to set the same strict performance milestones for each species which would trigger an immediate review by the national Consultative Committee for Exotic Pest Incursions if any is not met each year. These milestones focus on three main aspects: (a) ensuring infested area decreases over time; (b) total extent is not expanding; and (c) that reproductive plant detections decline on a year to year basis.

For a program that has been running since 2001 and will not see the first of its species reach eradication before 2029, these performance milestones are necessary to ensure the large investment of time and resources allocated to each of these five species is achieving the intended results.

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