Progress in the eradication of *Miconia calvescens* from Australia

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Summary *Miconia calvescens* (Miconia) is a target of the nationally cost-shared National Tropical Weeds Eradication Program which commenced in late 2003. *Miconia calvescens* infestations have been found in wet tropical areas between the Whyanbeel Valley and Tully in north Queensland, as well as in southeast Queensland and northern New South Wales. Updates to the methods for measuring eradication and progress towards removing this rainforest invader from a challenging environment in some of the wettest parts of Australia are presented below.

Keywords tropics, declaring eradication, rainforest, Miconia

INTRODUCTION

Miconia calvescens DC. (Miconia) is a small, invasive, shade tolerant, frugivore dispersed, rainforest tree. With attractive bicoloured leaves the plant has been cultivated as a botanical curiosity in tropical and subtropical areas and become invasive outside its native Central and South America (Brooks and Jeffery 2010). *Miconia calvescens* is one of the targets of the National Tropical Weeds Eradication Program (NTWEP) in Australia. This program also targets multiple infestations of *Limnocharis flava* (L.) Buchenau and *Mikania micrantha* Kunth, and single locations of *Miconia racemosa* (Aubl.) DC. and *Miconia nervosa* (SM.) Triana. Single infestations of the Miconia shrubs co-occur within two large *M. calvescens* infestations (Jeffery and Brooks 2016). Survey and control of *M. calvescens* utilizes over 75% of NTWEP resources.

The historical and practical field aspects of *M. calvescens* incursion, as well as the last update on eradication progress, were presented by Brooks and Jeffery (2010) and Jeffery and Brooks (2016). Many of the subsequent changes in the NTWEP are documented in internal reports or presentations, so updates to the NTWEP methodology and *M. calvescens* eradication progress data are presented.

ERADICATION FIELD METHODS

Field crews survey areas of intact forest types around 1000 m from waypoints known or suspected to have had at least one mature *M. calvescens* recorded. The survey extends outwards to 1500 m in fragmented vegetation types such as riparian areas amongst agricultural land uses. Different portions of larger infestations are surveyed on different days, months, or years. The survey frequency is approximately 24 months but varies between 12 to 36 months, depending on the number of plants controlled. Two-yearly intervals allow two opportunities to detect a small proportion of fast-growing plants before they mature, with average growing plants taking 6 to 8 years to mature (S. Brooks unpublished data). To cover over 3000 ha of ground surveillance a year, surveys are conducted year-round but concentrated in the cooler and drier months between April and October each year with additional seasonal workers. Field surveys are conducted by Biosecurity Queensland staff, casual labour contractors, and Rous County Council (under contract) with in-kind support from local government and Queensland Parks and Wildlife Service.

ERADICATION REPORTING METHODS

Presence or absence is one of the parameters derived from field records collected at points within infestations. A new unique site identification is issued for any plant found more than 30 m away from all previously recorded sites. For the purposes of program reporting, site records are aggregated into static one-hectare cells (100 m x 100 m), generated as a 'grid layer' across the entire incursion. These cells are used in NTWEP reporting as 'management areas', they are not survey units. From 2010, eradication progress reporting changed from an infestation-based system to a grid-based system of management areas. Field data collected from 2003 to 2010 was re-analysed on the finer reporting scale. The management area system allows NTWEP reporting to be spatially consistent over time. The term 'loci' is still used for broad scale reporting, these are discrete occurrences of *M. calvescens*, more than 2 km apart.

At the end of each financial year, in every management area, point records are summarized to allocate a 'control phase' status where plants are present, or 'monitoring phase' status where plants are absent. Management areas only enter a monitoring

phase when all records in the last 12 months show plants were absent, so progression is via evidence of absence. The time that management areas have been in the monitoring phase is categorised as 'years in monitoring phase'. If plants are recorded in a management area which is in the monitoring phase, then it relapses to a control phase, for a minimum of 12 months. The number of years of monitoring before a relapse is tallied to determine 'monitoring relapse' data. As the *M. calvescens* revisit frequency is greater than 12 months, management areas that do not have a visit recorded in the previous 12-months default to the control or monitoring status that they were in the previous reporting period. The status of management areas remains in control (default) until there are absence records, but years in monitoring phase can accrue between visits. Once management areas reach the sixth year in the monitoring phase they are classified as 'provisionally eradicated' for the purpose of eradication reporting.

The NTWEP has also started using the 'time since last reproduction' as a measure of eradication progress (Brooks and Jeffery 2018b). In cases where no seed production has been observed the discovery date is used to calculate time since last seed production. The time since last seed production (or discovery) accrues annually unless there is a seed production event (reproductive escape) causing the management area to suffer a 'reproductive relapse'. The last reproduction data is determined at the end of each financial year from a single (discovery or reproductive relapse) date for each management area. The last detection and last reproduction or discovery data have the same sample size and appear similar (Table 2) but are calculated differently. The data presented are examples from annual reporting to cost-share partners to the end of June 2021.

BROAD ERADICATION PROGRESS

There are three large loci in north Queensland with more than 100 management areas each (Table 1). The remaining naturalized infestations cover between 1 and 82 management areas and are considered small loci. Non-naturalized occurrences such as potted, garden or nursery specimens are single site identification waypoints that occupy one management area each. There are records of cultivated specimens from public gardens in Sydney, Melbourne, Brisbane, Mt Tamborine and Townsville. Single large garden specimens become a small locus if additional plants are detected.

There have been no new loci or potted specimens in north Queensland since December 2014. The NTWEP has conducted extension and awareness activities during this time. These include TV advertisements, social media posts, landholder mailouts, newspaper articles, public displays of potted specimens, targeted group presentations (also with live specimens) and stakeholder awareness sessions. These activities have generated reports of garden plants and plants near known infestations, so they are important to build regional delimitation confidence. Four processes for detection of new infestations were identified by Brooks and Galway (2008). In the intervening years, the proportions have not changed dramatically with 46.6% of new *M. calvescens* loci detected by workers in a weed related field, 43.8% by information from the public and 9.6% from tracing information, mostly historically such as botanical garden records.

Table 1. Number and type of *Miconia calvescens* infestations in Australia to June 2021.

Infestation type	State QLD	NSW	Total management areas
Large loci	3		417
Small loci	30	5	695
Non naturalised specimens*	21	10	33**

*Includes botanical gardens, nurseries, and potted specimens, plus two locations in Melbourne. **Four historical botanical garden specimens are not in the management area database.

In the last six years, three locations (currently considered garden specimens) have been identified in northern New South Wales, including two in 2020–21. Across both states it will be important to maintain the capacity to detect unmanaged infestations, that originate in cultivated situations. That capacity currently remains with trained professional officers and members of the public. Given the detection effort that has been maintained, low numbers of non-naturalized locations increase confidence that the extent of the incursion is known.

TRENDS IN MANAGEMENT AREA DATA

Of the 1141 management areas 63.7% had progressed to a monitoring stage, plant absence for more than a year by June 2021 (Table 1). There was a 5-year surge in discovery of new management areas from 2012–13 (Figure 1). This corresponded with an increase in field resources and field crews were instructed to record new site waypoints every 30 m to define infestations as the 'grid layer' was fully implemented. This was also the time increased seedling emergence was recorded after Tropical Cyclone Yasi (Brooks and Jeffery 2018a). Over the last four years, annual totals of newly discovered management areas have continued to taper, with most

new areas discovered in the vicinity of known areas. In 2020–21 there were 28 new management areas recorded, with 20 of these sharing a boundary or a corner with a known management area, and 6 were within 1 km of a previously known point. Two new occurrences were in New South Wales, and more than two kilometres apart.

Figure 1. Discovery of new *M. calvescens* management areas (1 ha each) and the percentage of management areas with plants (control phase) at 12 monthly intervals. Some areas were being managed when the program commenced.

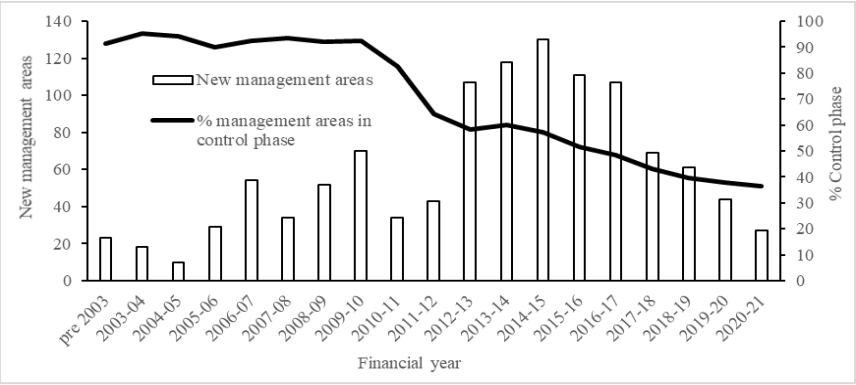

Table 2. Summary of years in monitoring phase and years since last mature plant was detected or the management area was discovered for 1141 *M. calvescens* management areas as of June 2021.

Years	Management areas categorized by years in monitoring phase	Management areas categorized by years since last reproduction or discovery
0	414 (control phase)	28
1	109	50
2	83	64
3	118	71
4	93	116
5	81	115
6	84	135
7	37	112
8	25	108
9	39	47
10	27	44
11	13	95
12	6	51
13	6	34
14	0	27
15	1	17
16	2	6
17	1	11
18+	2	10

Typically, new *M. calvescens* management areas have small seedling counts which suggest periodic recruitment from past frugivorous dispersal, rather than the presence of locally mature plants. Only 26.6% or 304 of 1141 management areas had mature plants present at discovery. As such, the last reproduction or discovery column in Table 2 largely reflects the discovery patterns evident in Figure 1, with a surge 4 to 8 years ago. Fruiting and potentially mature plants (based on the basal diameter measurement) have been detected at a rate of between 0 and 0.4% of known cells in the last five financial years (data not shown). These reproductive relapses have only had negligible impact on the NTWEP search areas and did not require additional resources.

Many of the new management areas added since 2012 have low plant numbers, a short control phase and have progressed to monitoring from 2015 onwards. This progression to the monitoring phase, shown by the declining % control line in Figure 1, has continued to balance or outpace new and relapsing management areas.

NTWEP annual reporting includes the total proportion of management areas in long term monitoring (6 years +) and deemed provisionally eradicated for the purpose or reporting to the cost-shared partners. This was 243 management areas (14.6%) in June 2021 (Table 2) and has grown consistently since 2014. The number of management areas approaching six years monitoring should continue to see this value grow. The longer management areas spend in monitoring phase the less likely plants are to reoccur (a monitoring relapse event). More than 91% of relapse events (518 cases) have occurred from the first five years of monitoring, and there are two cases over 8 years of monitoring.

These counts may increase as the long-term monitoring sample size grows and with surveys years apart. *Miconia calvescens* seedlings can also grow very slowly in the forest understory and effectively form a difficult to detect 'seedling bank' (S. Brooks unpublished data).

DISCUSSION

Aspects of the reporting data highlight the biological reality of eradicating this species. Many of the loci have been effectively managed for 10 to 15 years, during which the discovery of new management areas has continued. This protracted discovery phase in areas surveyed previously, with no recent mature plant records and close to known management areas results from the sporadic germination from the soil seedbank. *Miconia calvescens* forms a persistent soil seedbank, which is impossible to sample at low densities and inherently variable over a small scale, let alone the scale and complexity of the current field operational area. As such the NTWEP is developing multiple criteria to consider reductions in visit frequencies and eventually no visits. For example, Table 1 shows subsets of management areas with more than 10 years in the monitoring phase and more than 16 years since the last reproduction or discovery. In addition to the progress data, management areas will have to be considered in spatial groups rather than isolation. Further criteria include NTWEP confidence in the frequency, extent and recency of surveys and associated absence surveillance records. Within loci, adjacent management areas return a range of values for last reproduction and monitoring parameters. Such that any decision on declaring eradication is based on combinations of field observation experience, data and program research.

Further NTWEP refinements include more nuanced planning of ground searches. Once fully implemented this will see field surveys planned with habitat suitability layers and susceptibility information derived from time since last mature data.

To date, no new *M. calvescens* loci have been found through direct survey, reflecting the disparate nature of infestations resulting from the cultivation of plants. Unmanned aerial vehicles continue to be investigated to detect plants around known infestations, particularly on the margins in combination with the development of an AI (Artificial Intelligence) model. The NTWEP has been developing the capacity to collect and automatically screen aerial rainforest imagery for *M. calvescens* leaves as part of an AI system development.

The program is addressing the challenges of detecting all occurrences of this small tree in gardens or rugged terrain, via extension and awareness activities and from the ground or remotely from the air. The longevity of the soil seed bank and a wide potential dispersal buffer means the eradication program remains a long term and intensive proposition. The overall progress made towards the eradication of this serious tropical weed is prompting discussions about the type and duration of resources that are deployed to survey areas with continuous records of plant absence.

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