

# Review of Four Tropical Weeds Eradication Program - September 2010

Rachel McFadyen<sup>1</sup>, Jean-Yves Meyer<sup>2</sup> and Samantha Setterfield<sup>3</sup>

<sup>1</sup> Consultant (PO Box 88, Mt Ommaney Qld 4074; rachel.mcfadyen@live.com.au);

<sup>2</sup> Délégation à la Recherche, Government of French Polynesia, B.P. 20981, Papeete, Tahiti. Email: [jean-yves.meyer@recherche.gov.pf](mailto:jean-yves.meyer@recherche.gov.pf)

<sup>3</sup> Associate Professor, Faculty of Education, Health and Science, Charles Darwin University Darwin, NT 0909.

## EXECUTIVE SUMMARY

- The 4 Tropical Weeds Program is assessed as highly successful. The program has achieved most of the goals set in 2006 and has greatly improved data collection, community awareness, and survey efficiency.
- There is excellent collaboration with Queensland National Parks and Wildlife Service and with Regional Councils in Far North Queensland, and a significant contribution of in-kind resources from these groups (chiefly field staff time but including logistical support).
- There has been significant progress towards eradication of all 6 weeds. Eradication of mikania, limnocharis, *Miconia nervosa* and *M. racemosa* is now relatively close.
- Current data collection and analysis is excellent and provides the basis for measuring progress to eradication.
- Eradication for all 6 weeds is both technically feasible and is the most cost-effective management method for these weeds, with a strongly positive NPV over 20 years.
- To achieve eradication, continued financial support will be required for a further 10 to 15 years.
- Current funding levels are not adequate to achieve eradication of all 6 weeds
- The panel therefore recommends a significant increase in funding for the next 5 years, to be followed by a further review.
- There is significant private benefit from the eradication of these weeds to the sugarcane, grazing, forestry, horticulture and tourism industries in northern Australia. We recommend an assessment by the National Biosecurity Management Group of possible industry support.
- If increased funding is not available, future management of the two minor *Miconia* species, *Clidemia hirta* and *Limnocharis flava* should be handed to state and local government, allowing the direction of all funds to the two remaining weed species *Miconia calvescens* and *Mikania micrantha*.
- Increased resources must be urgently directed towards stopping the spread of *M. calvescens* into inaccessible terrain in the Daintree National Park.
- A mechanism is needed to pay bonuses to field staff for work in difficult and dangerous conditions, together with a guarantee of employment beyond the end of each funding period for key staff.

## Terms of Reference

*The review team using the records of the Four Tropical Weeds Eradication Program including the 2006 program review, information available from Tropical Weeds Eradication Program staff, collaborators and other stakeholders, and the outputs of economic assessments and predictive models, the framework and definitions from National Environment Biosecurity Response Agreement (NEBRA) including consideration of alternative stakeholder contributions models:*

### *Current*

1. *Evaluate progress towards eradication of the six target species included in the program*
2. *Evaluate the benefits of the current program to all relevant sectors and the extent to which all relevant sectors currently support and contribute to the program*

### *Future*

3. *Evaluate future options and objectives (eg eradication or alternative containment scenarios)*
4. *Recommend the preferred future management objective*
5. *Recommend how progress towards the achievement of this future management objective should be measured*
6. *Identify any changes to the stakeholders who should be investing in the future program*

## **CURRENT PROGRESS TOWARDS ERADICATION**

Progress towards eradication for each of the six target weeds is measured against the three key criteria: delimitation, ie have all infestations (loci) been discovered; control of reproduction, ie has production been successfully prevented at all loci; and eradication of all individuals including seedbank, ie is the seedbank of viable seed reducing and on-course to elimination (Panetta and Lawes 2005). Against these criteria, the program as a whole is clearly on-track, although progress is not even across the six weeds.

Overall, the review team were impressed by the energy and dedication of the staff of the Four Tropical Weeds Eradication Program (4TW), and by the greatly improved data handling methods adopted over the last four years. It was also clear that there was good integration of control activities, including surveys, between staff of the 4TW and staff from Queensland National Parks and Wildlife Service (QPWS) and from the local governments involved. Data recording by both QPWS and regional council staff has also greatly improved although it is not yet consistently up to the high standard of the 4TW. All records of 'found' plants are properly entered but records of areas surveyed (track logging) may not be complete. Data management is now excellent, with all ground and helicopter surveys made by 4TW staff entered into the database, and all new plants found by anyone similarly entered. The database is then analysed by research staff to generate information on progress to eradication against the Panetta -Lawes criteria (2005) and against other economic and invasion models available.

It was also clear that the task has clearly greatly increased over the four years since the last review in 2006, with the continued discovery of new infestations of some of the weeds and, in particular, continued spread of *Miconia calvenscens* into very difficult rainforest terrain in the Daintree and other National Parks. In recognition of this, the 4TW program budget was increased to \$701,000 for 2010/11 (from approx. \$500,00 in 2008/09 ie a 40% increase). Using carryover unspent funds, field staff numbers were increased to 8 for the 2010 dry season. Some permanent staff positions were created in 2008; up till then all staff had been on short-term contracts. However, all stakeholders consulted, and the panel, agree that the budget is still not adequate to fund timely surveys of all six weeds in the program, and as a result, not all infested areas were surveyed during the recommended periods. Because of the shortfall in resources, only limited extended surveys could be conducted for *Miconia calvenscens*, mikania vine and the two minor *Miconia* species. For *M. calvenscens*, approximately 200 ha of the area scheduled for survey in 2009/10 was not in fact surveyed. In part, the resource shortfall was due to the continuing discoveries of new infestations

of *M. calvescens*, including in northern NSW and southern Queensland, and the resulting increased area requiring survey and control.

Community education and communication is also excellent, especially the emphasis on education and training of National Parks and Local Government staff whose work takes them out into the countryside and rainforest. This includes, for example, Queensland Health staff who regularly search gardens as part of anti-dengue mosquito control programs. Opportunities have also been taken to get information into local media including television where possible, in the absence of resources for paid advertisements. For example, a 4TW flyer with information and illustrations of *M. calvescens* was on public display at the Information Centre at Kuranda and no doubt at other similar public information centres. In the last 4 years, many discoveries of new infestations have come from people trained to recognize the target weeds through workshops run by the 4TW. In fact, in recent years nearly all new discoveries have come from recognition of the weeds by weed officers and members of the public trained through these workshops, and no discoveries are now coming in from targeted searches or 'trace-backs' (Brooks and Galway 2008). This is now the only weed community awareness and education program delivered to the community in FNQ, as the Weed Spotter coordinator position in FNQ ceased early in 2010.

During our site visits it was clear that great care is being taken by all staff to prevent spread of the weeds through the movement of people and vehicles while making surveys and control visits, with meticulous washdown of boots at each site and of vehicles when these enter contaminated areas. The success of these measures is confirmed by the absence of any new infestations that can be linked to personnel or program vehicles, despite the very small seeds involved (eg. *M. calvescens* seeds are only 0.5mm diameter).

In discussions with staff, it became obvious that recruitment and retention of field staff is a major problem, and staff recruitment activities take up significant time for the Project Coordinator. The work is difficult, demanding and frequently dangerous, in hot wet conditions, in very steep terrain with many stinging and spiny plants, where attack by leeches and disease-bearing ticks and mosquitoes is constant. Unemployment in the area is generally low and alternative employment without these disadvantages is often available. Rigid policies within DEEDI and, in particular, within Biosecurity Queensland, mean that staff are not offered any kind of bonus in recognition of the difficult conditions, even where such bonuses are granted by other (and competing) employers. For example, FNQ is a very high rainfall area (up to 4000 mm/ yr) and local governments give double pay for working in the rain, or pay a substantial wet weather allowance, while 4TW staff get no extra pay. Travel allowances when staying away from the South Johnstone base are not generous but at least these allow staff to earn some extra money. As a result, there is a significant problem with absenteeism when teams are working closer to the base, as the work is just as difficult but the effective 'take-home' pay is much less, especially once travel costs to and from homes are factored in. Furthermore, the current policy of Biosecurity Queensland Control Centre (BQCC), who now manage the 4TW program, is to employ staff only on contracts limited to the length of the funding commitment, in this case to 30 June 2012. This means that if the decision to extend funding is delayed, staff will have no guarantee of on-going employment. As their finishing date approaches, even key experienced staff will seek other employment, and these people cannot be easily replaced.

**2. Benefits** of the 4TW can only be evaluated by comparison with the potential costs of the six weeds if the program were to cease. Unfortunately, estimation of future costs is necessarily general in nature, and subject to all the uncertainties of climate change, future changes in agricultural practices and land use, and, above all, the difficulty of placing a dollar value on the

unique biodiversity of the rainforests of northern Australia. Proper economic assessments of the potential costs of these weeds would be a major exercise which the Review Panel has neither the expertise nor resources to undertake. We have therefore relied on the cost estimates in the Weed Risk Assessments undertaken by the Queensland Government for each weed, and, where available, on economic data from other countries invaded by these weeds. Similarly, we have made no attempt to estimate the financial value of the biodiversity of the threatened national parks. We note however that both the rainforests of the Wet Tropics of Far North Queensland (FNQ) and the Great Barrier Reef (GBR), which would be directly affected by stream flow and sediment changes in eastern flowing rivers resulting from changes in the rainforest vegetation consequent on invasion by *M. calvescens*, have been designated as World Heritage areas, ie their biodiversity assets have been determined as of significant value to the whole world as well as to the nation of Australia.

In Hawaii, the dollar value of lost biodiversity and impacts on water flow (including increased erosion and sedimentation) directly attributable to invasion by *M. calvescens* are estimated to be \$377 million per year if control is not undertaken and the weed spreads to infest the total suitable land of 405,000 ha. The NPV cost of doing nothing is estimated at US\$7.6 billion for the two affected islands of Maui and Oahu, which contrasts with the NPV cost of US\$47 to US\$69 million (over 50 years with a 3% social discount rate) of the current eradication and containment policy (Burnett et al 2007). In FNQ where the current infested area is much smaller than in Hawaii (2,200 ha versus 16,400 ha) and the potential infestation area much greater (entire rainforest areas from northwest WA to northern NSW), the benefit/cost ratio of eradication is correspondingly enormous.

Three of the weeds (mikania vine, limnocharis and *Clidemia hirta*) directly threaten agriculture in the north to different degrees, and the industries threatened are sugarcane (worth \$2 billion annually in 2010), cattle grazing in high rainfall areas, the banana industry (worth \$200 m in 2010) and tropical fruit crops. Extra costs from control measures against these weeds are difficult to estimate but would be significant. The stakeholders involved are discussed under each weed. Local governments would also incur extra costs in maintaining drains for flood control and mosquito control; this is discussed under the particular weed.

With regard to the issue of sectors currently supporting the 4TW program, it is clear that there is widespread community support for the program throughout Far North Queensland. The program brings significant benefits to the region: it maintains public awareness of weed issues in general; brings significant money into the region; and employs and trains unskilled labour including a significant proportion of Indigenous Australians. Staff learn skills in meticulous careful work, GPS use, data collection and WHS skills, which they then take with them if they move into employment with local or state government (four such transfers in 2 years). In our site visits we saw no evidence of hostility among landholders or the general public, and widespread support for the program even where this involved regular team surveys on private land and restrictions on the sale and planting of otherwise desirable ornamental plants. Some landholders are also providing support through their own time in controlling seedlings and re-growth in infestations on their property. Significant support in in-kind resources is being provided by the QPWS and by the local governments (Cairns Regional Council, Cassowary Coast Regional Council, Hinchinbrook Shire Council, Tablelands Regional Council and Townsville City Council), through the provision of staff, vehicles and materials for surveys and control activities within the affected National Parks and local council lands. These staff work together with the 4TW teams as well as independently, and clearly add greatly to the effectiveness of the program. They are locally based, know their local area and generally have a long-term commitment to the preservation of the local

environmental assets. Council staff are involved in local revegetation and rehabilitation projects, so are familiar with the ecology and habitats in their region. QPWS had a total operating budget of \$10 million in the Wet Tropics area, and allocated \$149,000 to management of Class 1 weeds across Queensland in 2009-10. The movement of staff in both directions between the 4TW, QPWS and regional councils provides improved continuity of employment for staff as well as preservation of the regional skills pool. For example, local councils have seen the value of helicopter surveys for certain weeds and are now using these themselves, which additionally helps maintain the pool of helicopter pilots and weed spotters skilled in this specialized field.

The dollar value of this extra support in 2009/10 has been estimated at \$144,000 from Biosecurity Queensland, \$150,000 from QPWS and \$53,000 from regional councils, which compares well with the \$632,000 budget of the 4TW program. However, local councils work through a Community Planning process, due for review by the end of 2011, and ratepayer support cannot be taken for granted. Currently some of the councils are undertaking more management of declared weeds than is strictly required under state legislation, and this is always vulnerable to cost-cutting pressures. Continued community education is therefore important.

## **CURRENT PROGRESS AND ESTIMATED BENEFITS FOR THE SIX WEEDS**

***Clidemia hirta* (clidemia):** the delimitation criterion has been achieved, as the weed is present at only one site and no new infestations have been found since the initial discovery in 2001. However, control of reproduction has not been achieved as mature plants continue to be found each year. In response, the 4TW program has increased visit frequency to ensure plants are found before fruiting commences. However, the total area is now 240 ha core plus 264 ha forest area and extended survey area, and the core area at least should be completely surveyed every 6 months but resources are not adequate for this. Large numbers of seedlings are found every year with no measurable reduction, therefore although seed longevity is not known (at least 4 years in Hawaii [Smith 1985]), it is clear the seed bank must be long-lived and surveys will have to continue for many years to come. There is a good level of landholder support and in-kind assistance from regional council staff. The affected site is relatively easy to access and survey, but the need for frequent visits means that at current levels this weed is using 18% of total 4TW field resources over the year and current levels will not be sufficient to achieve eradication. Based on overseas experience in Hawaii and other Pacific nations, surveys need to be extended beyond the 500 m buffer zone and prioritization given to forest patches and edges as against open grassland.

Clidemia is a serious weed in pastureland, forest plantations, roadsides, trails, streambanks, and plantations (rubber and cocoa in Fiji) in the Pacific Islands, and is rarely found in intact rainforest understorey (except in low-statured and semi-open canopy in Hawaiian native forests). It is not eaten by livestock and is therefore a weed of grazing lands. Benefits of eradication therefore accrue to the grazing, forestry and tropical fruit industries, who currently do not contribute to the program.

***Limnocharis flava* (limnocharis):** delimitation has not been achieved as new sites are still being reported - three new ones in 08/09, and four in 09/10, all however within 1 to 2 km of existing known areas. Control is being achieved, ie half of the loci are in contained water features where there has been no spread, and only a few are in sites where seedling emergence is continuing. There is no evidence of continued reproduction once an infestation has been discovered. Resources used are 4% of total, mostly in repeat visits and downstream surveys, and site access is easy. No general surveys are undertaken, and discovery relies on the general public and trained staff awareness. There is considerable support from local council staff.

If left uncontrolled, limnocharis would have severe biodiversity impacts on wetland habitats but not in the fast-flowing streams typical of the rainforest zone. It would have a severe impact by choking drains and channels, possibly as severe as that of water hyacinth *Eichhornia crassipes* and without the control now exerted on water hyacinth by the introduced biocontrol agents. This would severely impact on agriculture in low-lying areas that require free-flowing drains, such as sugarcane, bananas, and cattle grazing, as well on local governments who have to maintain drains for flood and mosquito control.

### ***Miconia calvescens***

This is the largest of the six weeds, in actual size, threat posed, and proportion of the resources used. Currently there are three large loci and >50 small infestations known, and control of these uses 64% of the field staff resources (all agencies). New loci are still being found, seven in 08/09, three in 09/10, and a further two in northern NSW in Sept 2010, so delimitation has not yet been achieved. The extent of two of the three larger loci continues to increase, with mature (potentially fruiting) plants found at several sites including outside the current 500 m buffer zone. Reproductive plants have been found at Whyanbeel and in the adjacent Daintree NP however, no mature (reproductive) plants have been found in other two large loci in the last 12 months. The continued emergence of seedlings (albeit in reduced numbers) at the Julatten site, where no fruiting plant has been present for >10 years, indicate that seed must survive in the soil for at least 10 years, and the eradication program will therefore have to continue for at least this time. On the other hand, helicopter searches at the El Arish site (including over a 1.5 km buffer zone) did not discover any new fruiting plants beyond the 500m buffer ie delimitation at this site has been successful and eradication is feasible.

Progress is being made in the smaller loci, several of which are now in the monitoring phase, ie no new seedlings have been found for several years. New infestations and plants are being found as a result of increased public awareness and education, including among local government and QPWS staff. Helicopter surveys using skilled and experienced pilots and spotters have proved an excellent method even in intact dense rainforest. A significant finding is that *M. calvescens* seedlings in dense rainforest remain slender with small leaves and grow straight up until they break through the canopy into sunlight. They then develop the typical large leaves as growth speeds up until flowering may occur. This means that flowering and fruiting does not occur until trees are exposed to sun for at least a few hours per day, eg in tree-fall gaps and on the edge of gullies, cliffs or streams, and therefore may be detected in helicopter surveys before fruiting takes place.

The community education program has been very successful for this species, with most new loci found by community and pest management workers who had attended training days or seen extension material.

The site of greatest concern is that at Whyanbeel adjacent to the Daintree NP. At this site, a total of 27 mature trees have been recorded to date (with possibly more present at the time of initial control works). The total infestation extent at present is 424 ha of which 310 ha is in the National Park. A helicopter survey in July 2009 detected five mature *M. calvescens* plants, some up to 1.5 km into the NP. This added an additional 180 ha that needs to be surveyed for presence of *M. calvescens*. All suitable habitat within the infestation needs to be surveyed within each two-year period so that missed plants do not reach fruiting age of 4 to 5 years. If spread here is not halted it could become irreversible, as the terrain is extremely difficult and steep and the only tracks are those constructed by 4TW and QPWS staff. Once plants spread into areas beyond a day's travel

for the ground team, then bush-camping would be required and there would no longer be any capacity to carry out any injured team member. Construction and maintenance of a helicopter landing site might be needed, with all the associated costs. Furthermore, if seedlings establish on the cliff faces to the west and south-west of the existing site, successful control of these plants might be impossible even using helicopters. It is therefore an urgent priority is to find and remove all mature plants in the intact rainforest areas before seed are carried further into the NP. More helicopter surveys are needed, with the buffer area searched extended to 1.5 km.

**Benefits:** it is clear from the experience in Tahiti and Hawaii that uncontrolled invasions by *M. calvenscens* have major negative impacts on biodiversity (see Burnett et al 2007, Meyer et al 2008), both directly through loss of plant and animal species in rainforest and indirectly through increased erosion leading to increased sediment onto the Great Barrier Reef. The affected industry is tourism, as both the Wet Tropics and the Barrier Reef are World Heritage sites and most tourists to the region come for the 'natural' experience of intact ecosystems, with their associated native biodiversity. The Australian and Queensland Government and agricultural industries currently spend significant sums on reducing sediment loads onto the Barrier Reef, and these loads would be enormously increased if miconia infestations became general in the forested mountainous country up-river. Data from Hawaii indicate that erosion and sediment load from miconia-infested hillsides is greatly increased compared to that from intact rainforest, due to the lack of undergrowth beneath the trees and the concentrated rainfall run-off from the very large leaves.

***Miconia nervosa*:** the review panel did not see this plant but, based on the data presented, the eradication program is going well. There is one locus only, with no new infestations and no mature plants found since 2008. Seedling numbers are still high, which indicates that seeds remain viable for a long time and surveying will have to continue for many years until the complete depletion of the soil seed bank. However the infestation area is in the middle of a site being searched for *M. calvenscens* and additional costs are not large, currently 3% of the total 4TW budget.

***Miconia racemosa*** is also present at only one locus and no new ones have been found. However, mature reproductive plants continue to be found, 2 in 2009 and 1 in 2010. A very large number of seedlings germinate each year and although this has reduced significantly in the last two years, the seed bank is still large and is likely to be long-lived. Regular searches of the area take about 2% of the total 4TW budget. However, experimental tagging of some of these seedlings has demonstrated very poor growth and survival, ie the plant does not seem to grow well in the rainforest understorey even where a creek had resulted in canopy gaps.

The impact of these two plants, *M. racemosa* and *M. nervosa*, were they to be left uncontrolled, is difficult to assess as they are not invasive anywhere else in the world. However it might not be great, as there are other native and exotic melastomes of similar habit growing in the Wet Tropics area, eg *Tristema mauritianum* which is widely naturalized in the area, is not controlled but does not seem to cause any significant negative impacts. This species, native to Madagascar and East Africa, is a weed in La Réunion and Mauritius (Mascarenes Is.) where it is considered of low priority/management importance, ranking only 28 out of 33 invasive plants (Baret et al. 2006)

***Mikania micrantha* (mikania):** progress towards eradication of this species is very good (Brooks et al 2008). Only one new infestation has been discovered over the past 5 years, and seven of the 15 sites are now in the monitoring phase, ie plants are no longer found. Overall, very few reproductive plants have been found in the last 2 to 4 years. The total infestation area is only 102 ha over the 15 sites. Repeated surveys are needed as this vine is reproducing vegetatively and is

difficult to spot when non-flowering in dense under-storey (needs a 'trained eye' to distinguish it from other vine species present in the same area). Searches for mikania cost about 9% of the overall 4TW budget.

Mikania is now the main weed of coconut and banana plantations in Fiji, in a very similar climate and habitat, and is a pest of plantation crops in SE Asia: coconut, cocoa, tea, teak and rubber. If mikania were to be left uncontrolled in Australia, the main impacts would be on the horticulture, plantation, forestry and sugarcane industries. The biodiversity impact is likely to be small, as the plant could only grow in forest gaps and edges and after cyclone damage where it would be in competition with a wide variety of native vines of similar habit. Persistence of mikania in intact rainforest is probably low judging from experience in Asia and the Pacific.

## FUTURE

With regard to point 5, the excellent data collection and analysis currently in place is sufficient to measure progress towards eradication for all six weeds, using the eradication criteria of Panetta and Lawes (2005) and the search models developed by CSIRO scientists (Murphy et al 2008). Research time for the analysis of this data must continue to be made available, preferably through the continuation of Biosecurity Queensland staff. Data should also continue to be made available to research collaborators including overseas groups for further analysis and comparison with other eradication programs worldwide.

**Points 3, 4 and 6:** Eradication of all six weeds is feasible and should remain the overall objective. As previously described, a proper evaluation of the potential losses from these weeds should they become widespread has not been undertaken. However it is clear that losses would total many million dollars each year, and therefore **continuation of the eradication program, even if expenditure was increased to \$1.5 million per year and maintained for 10 or more years, is the most cost-effective management method, with a very large benefit/cost ratio.**

Of the six weeds, the closest to eradication is undoubtedly **mikania**. The delimitation criterion has been met, ie no new infestations located since 2006, and seven out of 15 sites are now in the monitoring phase ie no new plants found for some years. Seed longevity is not great, between 3 and 5 years, and local eradication has been achieved at some smaller sites (Brooks et al 2008). At the current level, which is probably sufficient, the program against this weed requires 9% of the total 4TW program budget and this is easily justified by the potential cost of this weed if allowed to escape. However, the main threat is to agriculture and there should be some direct financial support from agricultural industries in particular banana growers, tree fruit growers and forestry.

Eradication of **limnocharis** is also probably feasible (Brooks et al 2008) although there are continued problems with adequate delimitation, ie new infestations continue to be found. However, eradication should be achievable if no new sites are found in the next 5 years, and adoption of containment as the management objective would require the same actions and not reduce the resources required. The numbers of new plants germinating at the Feluga site is reducing, with few found after 2008, ie 4 yrs from the last fruiting plant, which suggests the seed bank may be exhausted in a few more years.

Control of known sites seems to be satisfactory except at Centenary Lakes, Cairns Botanical Gardens, where public access urgently needs to be managed. At the present time, there is open public access from a parking area on a road and from main access paths. No on-site information is provided to the public, and there is no limitation on people collecting water lilies or other plants

from affected lakes, and thereby taking limnocharis seed and seedlings back to water features in their homes many kilometres away. Access to the lakes should be blocked or at least reduced and detailed on-site signage installed, warning people that the soil is contaminated by seed of a noxious invasive weed and providing information on the weed and its appearance. This needs to be implemented immediately by the 4TW program working with the Cairns Regional Council who are responsible for the Botanic Gardens.

Given that the potential impact of this weed would be greatest on the grazing, sugarcane and banana industries, there should be some direct financial contribution from these industries. The Cairns Regional Council is already contributing significant resources, but needs to immediately action controls on access to Centenary Lakes.

Eradication of **clidemia** is judged to be not achievable with the present level of resources (18% of the total 4TW budget), as mature plants are still being found. The frequency of survey and control visits have to be increased (to survey all core areas every six months) and will have to be maintained at this higher level for several years. Seed longevity is at least 4 years based on data from Hawaii, which is confirmed by the continued high number of seedlings emerging each year. The program will therefore have to continue for at least 5 more years of removing plants (control phase) followed by an additional 5 years of monitoring. Further, the short time to maturity of the plants means that a program of surveying the whole infested area every 6 months will have to be maintained throughout, as a single missed plant managing to produce seed would prolong eradication for many more years.

We therefore support **continuation** towards the goal of eradication with an increased level of expenditure, but we believe that financial support needs to be sought from the primary producers who will be the main beneficiaries of the eradication of this weed.

***Miconia nervosa* and *M. racemosa*:** progress towards eradication is good for both of these weeds. The delimitation and control criteria are both met, in that no new infestations have been found and there is now no reproduction occurring. It is therefore a matter of continuing to maintain control activities until the seed bank has been exhausted. However, the evidence is that this will take at least ten years with no reduction in the resources required. We recommend that information on seed longevity and time to maturity be sought from overseas collaborators in the countries of origin of these plants, and also more detailed information on the types of habitat the plants occupy.

We recommend that the eradication program against these two weeds continue at the present level, so long as additional resources can be found to fund increased activity against *M. calvescens*. However, if resources are limiting, we would recommend ceasing all work under the 4TW program on these two weeds, ie further control and monitoring should be handed over to the relevant state and regional authorities, and the 5% of the total budget saved should be directed to the eradication of *M. calvescens*.

We recommend that Biosecurity Queensland investigate the possible use of the fungal pathogen *Colletotrichum gloeosporioides f.sp. miconiae* released in Hawaii and Tahiti, which is highly specific to *Miconia* species. Testing against native melastomes would be required and could be undertaken in Tahiti or in secure quarantine. If suitable, the fungus could be used as a soil drench against both these species, as it causes high seedling mortality (ca. 70%, Meyer et al. 2008) and is therefore ideal for use in relatively restricted areas with a large long-lived seed bank.

*M. calvescens*: eradication should be feasible (Hester et al 2010) and is the desirable objective but additional resources are required. With the current 4TW budget, prioritization of sites results in some areas not receiving sufficient surveys. In particular, the research models demonstrate a need to search a buffer zone of 1500 to 2000 m around every mature fruiting plant found (Murphy et al 2008) rather than the 500 m official buffer zone for intensive ground survey used at present. CSIRO research (H Murphy pers comm.) shows that 95% of seed falls within 500 m of the fruiting tree but 5% can fall up to 1000 m away. E Spotswood (UC Berkeley) (pers. comm. 2010) who has been studying bird diets in miconia forests in Tahiti and Moorea believes that where fruit doves, are present (as they are in the Wet Tropics of FNQ) the maximum dispersal distance would be several km. However, CSIRO research in FNQ rainforests suggest that bird dispersal is not more than 500m and bat dispersal up to 1500m (D Westcott pers comm.). Therefore a buffer of 1.5km would be more appropriate than 500m. The actual discoveries of plants on the ground support the need to search at least 1000 to 1500 m from a known seed source. Computer modeling demonstrated that the ideal buffer to achieve successful eradication was 2000 m, and 1500 m is suggested as a compromise. This would greatly increase the area to be searched, and each new discovery also increases the area. The current 4TW budget makes no allowance for increased survey effort due to the discovery of new loci. To survey and control all infestations, including those found during helicopter searches in 2009 and 2010, with thorough ground surveys in the 500m buffer, extended survey along gullies to 1km, and full helicopter surveys out to 1.5km around all sites of mature plants, will require a very significant increase in the 4TW budget.

If resources are inadequate for the full needs of the program (as at present), prioritization is needed. Top priority must be given to eradication of sites bordering on inaccessible World Heritage rainforest such as the Daintree NP adjacent to the Whyanbeel site (see earlier comments). The total infestation at this site at present is 424 ha of which 310 ha is in the National Park, plus an additional 180 ha from the plants found by the helicopter survey in July 2009, plus additional area if the buffer zone is increased to 1500 m. All suitable habitat within this must be surveyed every two years at least so that missed plants do not reach fruiting age of 4 to 5 years (sexual maturity in *M. calvescens*). If this is not done, further spread could become irreversible, as the terrain is so difficult that crews would have to be helicoptered in, requiring construction and maintenance of helicopter landing sites and significant extra costs. It is therefore an **urgent priority** to find and remove all mature plants in the intact rainforest areas. More helicopter surveys are needed, at this site and others, with the buffer area searched extended to 1500 m.

If resources are limiting, the smaller loci in agricultural land could be transferred to the Regional Councils for management, with the 4TW program continuing to remove mature plants discovered by the public or otherwise, but undertaking no searches for seedlings at this time. However the community education effort must be maintained as it has been very successful for this species, with nearly all new infestations being found by the general community or by council and government workers who have received training or extension material.

*M. calvescens* is a major threat to the intact rainforests of the Wet Tropics World Heritage Area, especially if cyclone frequency and/or intensity are increasing with climate change. Through the potential impact on erosion and sediment run-off, this weed is also a major threat to the tourism and biodiversity values of the Great Barrier Reef. The tourism industry should therefore be making some contribution to the 4TW program. The main stakeholder in these two World Heritage areas is the Australian nation through the national and state governments. The Queensland Government contributes directly to the 4TW budget and Queensland PWS also contributes very substantial on-ground resources of staff and equipment, including maintenance of the network of tracks used by ground survey teams, and without this assistance much of the work

in the National Park areas would be impossible. We believe an additional contribution from the national government through the Department of Sustainability, Environment, Water, Population and Communities (DSEWPC) would be appropriate, as a reflection of their role as major stakeholders in the protection of these national assets.

Helicopter surveys are clearly critical for the detection of mature trees in intact rainforest as well as in riparian areas on agricultural land. Additional funding is needed to fund increased surveys, and then to fund the on-ground control of any plants found. A contingency component is also required to fund additional surveys required if new infestation loci are found, eg those recently found in northern NSW.

## RECOMMENDATIONS

1. Eradication of all six weeds is both feasible and highly cost-effective, with the anticipated NPV of benefits from eradication far exceeding the NPV of the current costs even if the program continues for a further 10 or 20 years. Therefore eradication of all six weeds remains the preferred future management objective.
2. However, current resources are not sufficient to achieve eradication, and an **immediate increase** to \$1 to \$1.5 million per year (with CPI adjustment in following years) is needed.
3. Given the very high return on investment from eradication, there needs to be a commitment to continue the program for a further 10 or even 15 years, with review every 5 years. The cost can be expected to reduce in the last few years.
4. Measurement of progress towards eradication is currently excellent and should be continued, using the current data collection, analysis and presentation methods.
5. Given that much of the benefit from the eradication program accrues to the agricultural industries in FNQ and other tropical areas of Australia, particularly horticulture, tree crops, sugarcane and grazing, these industries should be contributing to the program, the amount to be determined according to the NEBRA model.
6. *M. calvescens* is unquestionably the worst of the six weeds in its potential impact, which will be primarily on biodiversity in the rainforest and increased sediment load in the rivers running to the Great Barrier Reef. The benefits from its eradication therefore accrue in part to the tourism industry in northern Australia, which should be contributing to this program. In recognition of the World Heritage status of both the Wet Tropics area and the Great Barrier Reef, an additional contribution should also come from the Australian government through DSEWPC, comparable to the funding for the on-going control of *Mimosa pigra* in Kakadu.
7. If additional resources cannot be obtained, we recommend that the 4TW program concentrate on the two weeds mikania and *M. calvescens*. Mikania is a very serious weed in Fiji and other Asian and Pacific nations and is close to eradication, with relatively short-lived seed. The program against this weed should therefore continue.
8. The potential harmful impact of the other four weeds is much smaller relative to that of *M. calvescens*. In the event therefore that resources are limiting, we recommend that the 4TW program hands the continued eradication program against these weeds over to the State and

local councils, and re-directs the resources freed (27% of the total) to increased surveys, both helicopter and on-ground, against *M. calvescens*.

9. We recommend that ways be found to pay bonuses to field staff for time spent in control work in difficult terrain. Further, there should be a commitment of additional funding for at least 12 months in the event of any termination of the program, so that permanent staff have some guarantee of employment beyond the end of the financial year in each funding period.

## REFERENCES

Baret S, Rouget M, Richardson, DM, Lavergne C, Egoh B, Dupont J, and Strasberg D. 2006. Current distribution and potential extent of the most invasive alien plant species on La Réunion (Indian Ocean, Mascarene islands). *Austral Ecology* 31, 747-758.

Brooks SJ, Panetta FD and Galway KE (2008) Progress towards the eradication of mikania vine (*Mikania micrantha*) and limnocharis (*Limnocharis flava*) in northern Australia. *Invasive Plant Science and Management* 1, 296-303.

Brooks, S.J. and Galway K.E. (2008). Processes leading to the detection of tropical weed infestations during an eradication program. *Proc of the 16th Australian Weeds Conference*.

Burnett K, Kaiser B and Roumasset J (2007) Economic lessons from control efforts for an invasive species: *Miconia calvescens* in Hawaii. *Journal of Forest Economics* 13, 151–167

Hester SM, Brooks SJ, Cacho OJ and Panetta FD 2010 Applying a simulation model to the management of an infestation of *Miconia calvescens* in the wet tropics of Australia. *Weed Research* 50, 269-279.

Meyer J-Y, Taputuarai R and Killgore EM (2008) Dissemination and impact of the fungal pathogen *Colletotrichum gloeosporioides* f. sp. *miconiae* on the invasive alien tree *Miconia calvescens* (Melastomataceae) in the rain forests of Tahiti (French Polynesia, South Pacific). *Proceedings of the XII international symposium on biological control of weeds, La Grande Motte, France* (ed. by M.H.Julien, R.Sforza, M.C.Bon, H.C.Evans, P.E.Hatcher, H.L.Hinz and B.G.Rector). CAB International Wallingford.

Murphy HT, Hardesty BD, Fletcher CS, Metcalfe DJ, Westcott DA, Brooks SJ. (2008) Predicting dispersal and recruitment of *Miconia calvescens* (Melastomataceae) in Australian tropical rainforests. *Biological Invasions* 10, 925-936.

Panetta FD 2007 Evaluation of the performance of weed eradication programs: containment and extirpation. *Diversity and Distributions* 13, 33-41.

Panetta FD and Lawes R. 2005. Evaluation of weed eradication programs: the delimitation of extent. *Diversity and Distributions* 11: 435-442.

Smith CW (1985) Impact of Alien Plants on Hawai'i's Native Biota. In: Stone, Charles P. and Scott, J. Michael, eds. *Hawai'i's terrestrial ecosystems: preservation and Management*. Cooperative National Park Resources Studies Unit, University of Hawaii, Manoa.