

**THE WINSTON CHURCHILL MEMORIAL TRUST**

**THE SWIRE GROUP CHURCHILL FELLOWSHIP  
2004**

**INVESTIGATING THE MANAGEMENT, CONTROL  
AND MONITORING OF THE INVASIVE WOODY  
WEED SPECIES, *Psidium cattleianum* IN NATIONAL  
PARK AREAS IN USA, NEW ZEALAND,  
MAURITIUS & ILE DE LA REUNION**

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## 1. Precis and Acknowledgements

This report details the findings from the 2004 Swire Group Churchill Fellowship visit to New Zealand, USA and Mauritius investigating the management, control and monitoring of the invasive woody weed species *Psidium cattleianum* (red guava). Specific areas of study included:

- The development of a biological control for guava by the US Forest Service and the US Geological Survey
- Monitoring methodologies employed by US National Park Service to determine effectiveness of treatment and rates of recruitment of weed species
- The mapping and monitoring program of incipient weeds operated by the Maui Invasive Species Committee
- Record keeping, data management and methods used for the weed eradication program at Raoul Island (NZ)
- The range and effectiveness of treatment options used in each country
- The management approach to the treatment of guava and other invasive weeds in each country, ranging from eradication (NZ) to control in designated areas (US & Mauritius) to no active management (US and Mauritius)
- The social & cultural implications of guava control (US and Mauritius)

My visit to these Indo-Pacific islands and the invaluable experience I gained would not have been possible without:

- The financial assistance given to me by the Swire Group Winston Churchill Fellowship 2004.
- The support of the Lord Howe Island Board in granting my leave to undertake the Fellowship and their assistance with preparations prior to departure and during the Final Report writing on return.
- The warm hospitality freely offered by members of National Parks organisations in each country together with other government agencies and non-government organisations. It was the open and friendly discussions and the sharing of experiences with these staff that made my Churchill Fellowship so rewarding.
- My family Geoff and Tom without whom I would sink. They are a constant source of love, happiness and encouragement. And to my brother Bernie and his family, who calmed my nerves and made a great Sydney base, before and during the Fellowship.

## 2. Executive Summary

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### **Fellowship objective**

To investigate the management, control and monitoring of the invasive woody weed species *Psidium cattleianum*

### **Findings**

The overwhelming finding from this tour was the perilous state of the ecology of the islands of Hawaii, Mauritius and La Reunion. From the literature, it would appear that many, if not most of the volcanic islands of the sub-tropical region of the Indo-Pacific are in a similar state, with only very small areas of native forest remaining and the process of invasion by the introduced weeds overcoming management efforts.

Guava is significant among a suite of alien species which now dominate almost the entire landscape of these island states and nations (apart from those areas under agriculture, principally sugar cane production). The devastation of coastal and lowland ecosystems is almost absolute, due to a longer history of disturbance. Currently, slightly more intact upland ecosystems are facing a huge wave of threats which will overtake them, unless significant effort is maintained, over a very long time frame. Losses to biodiversity are immense, with hundreds of plant and animal species extinctions since the time of settlement of these islands (Mac, et al. 1998). However, the extinction and destruction rate has risen exponentially over the last 200 years. Many of the remaining life forms are not yet extinct, only because they are being propagated in nurseries or remnant animal populations are kept on offshore islands or breeding facilities.

The success of guava as an invasive weed has been attributed to its ability to invade undisturbed forest, its broad environmental tolerances, prolific fruit production, copious vegetative reproduction through suckering, efficient seed dispersal, allelopathic properties (the ability of leaf litter to inhibit the growth of other species) and the absence of natural enemies (Denslow, pers. comm.).

Guava infestations have reached their climax in the upland forests of Mauritius, where the understorey of the forest is so densely infested by guava that it is almost impenetrable. There is no chance for the native species to compete. Jean Claude Seuathian from the Mauritian Wildlife Foundation refers to the last stands of Mauritian forests (which cover only 2% of the total land area) as “dead forests”. The native forest

trees emerge above a total “carpet” of guava. The native trees are unable to regenerate as their seeds cannot germinate under the guava. Not only is there insufficient light on the forest floor to allow successful germination, but the guava leaf litter has toxic properties which inhibit germination of native plants. Inevitably, the existing mature native trees will die, and all that will remain is a mono-culture of guava. Remnants of the once magnificent native forest areas which have been cleaned of the guava constitute only 80 hectares of the park. These areas are referred to by Jean-Claude as “forests in boxes” – the only examples of intact native forests in Mauritius, which contain around 90% of the country’s endemic plant species. They are fenced to exclude feral animals. The general public is also not permitted since these areas are so precious.

Unlike Mauritius where guava has reached its maximum destructive extent, in Hawaii it is still expanding its range. Guava infestations are most serious between sea level up to 1,000m elevation, however, guava is now commonly found at elevations up to 2,000m and experts say it is likely to spread to even higher elevations. Therefore the full impacts of guava have yet to be realised because potential densities have not yet been reached over much of its range.

Like Hawaii and Mauritius, much of the coastal and lowland areas of Ile de la Reunion are given over to sugar production, but in most areas, lands not actively under cultivation are a completely derelict tangle of weed species. A notable exception is the forests in the south around St Phillippe. Again, as with Hawaii and Mauritius the least disturbed forest areas are found at higher elevations, and areas of relatively intact forests may be found in small areas above 2000m in the cirques in the interior of the island. Guava is currently less of a threat on Reunion, because of low numbers of one of the principal vector – pigs. The local inhabitants are avid hunters and the pig population has never attained a high level. Until recently, however, the island was also free of the red whiskered bulbul, which is a major vector on Mauritius. Now that this bird is firmly established on the island, guava will undoubtedly become more prevalent.

With all of these islands, in most areas, the alien weed species populations are now past a critical threshold and it is impossible for natural ecosystems to ever recover. Despite the latest technologies, biological controls, and in the case of Hawaii, access to the resources of one of the richest nations on earth - despite all this - thousands of communities and lifeforms are destroyed forever. No technology available to man can restore them. And the invasion is continuing, with coastal and lowland areas now all but totally destroyed, the last struggling remnants of upland forests areas are under serious attack. The governments of these countries are spending millions of dollars in an effort to save what remains of the “spirit” of their nations, the natural values of their land which forms a large part of their identity.

There can be no dollar value placed on the value of Raoul Island in the Kermadecs. Through the work of the NZ Dept of Conservation there is at least one example of a volcanic sub-tropical Pacific Island on the planet, with its ecology relatively intact. However, there is no permanent population on the island and special permission is required to land on the island

Lord Howe Island has a unique opportunity to offer an experience which is now lost to other sub-tropical islands in the world, an opportunity which could easily be forfeited unless we act responsibly. Where in the world can one easily access an inhabited sub-tropical island and witness an intact ecology, with most of its unique species still occupying their natural habitats? At Lord Howe Island, the alien weed species population is now widely dispersed and in some areas, in similar densities to that observed overseas. However, the forests have not yet fully succumbed and there is a real chance here to “turn the tide” and “clean” the island of its alien species. But only if we are vigilant, and make the long-term commitment to fight these pests. If we fail, the alien weed species will inevitably succeed as they have all around the world, and strip the island of its biodiversity and ecotourism values, adding Lord Howe Island to the long list of once magnificent ecotourism destinations fast heading for the ecological scrap heap.

### **Fellowship highlights**

1. Raoul Island, Kermadec Group, NZ – a two and half day voyage by ship from Auckland to the island. A volcanic sub-tropical island with many similarities to Lord Howe Island, managed by the NZ Dept of Conservation (NZ DoC). The weed eradication program operated by NZ DoC was inspirational.
2. US Geological Survey – Dr Lloyd Loope, Research Scientist provided an insightful background to the history of invasive species spread in Hawaii, the political realities of today and the focus of current management in Hawaii, namely biological control, quarantine, and early detection systems of incipient weeds.
3. Hawaiian Ecosystems at Risk – joined Philip Thomas to witness the total devastation of the coastal and lowland areas of east Maui by alien species. The Wailea coastal reserve was an uplifting exception, a thin strip of native and endemic coastal and lowland plants (many of which are endangered) managed by the Wailea Coastal Trust.
4. Maui Invasive Species Committee (MISC) – Inspected the facility at Makawao with Manager Teya Penniman. Their work focuses the intensive control of *Miconia calvescens*, an extremely invasive plant which has devastated large forest areas of Tahiti and is referred to as the “green cancer”. Now established on Maui, the area of known infestation covers some 5,265ha (13,000 acres). Current expenditure on control of this one weed is US\$1.6million per year. MISC believes eradication would be possible if funding remained at US \$1.6million for 6 years, and US\$1.2million for a subsequent 12 years (a total of US\$25.6million or AU\$34.1million over 18 years). Also accompanied Forest and Kim Starr of USGS, who demonstrated their mapping program of incipient weeds for the whole of Maui. From the results of their work, MISC has prioritised incipient weeds and targeted those for eradication, with several successful eradications to date. Obviously quick response to eradicate potentially serious weeds during early stages of invasion is a much more cost-effective option.
5. Haleakala National Park, Maui – Steve Anderson of US National Park Service detailed the program of management for the Kipahulu Valley Biological Reserve. This area is closed to public entry and is the main area intensively managed for alien species control within the park. Access is usually by helicopter.

6. Hawaii Volcanoes National Park, Big Island Hawaii – Inspected the park with Tim Tunison to observe major infestations of guava, ginger - *Heychyium gardnerianum*, faya - *Morella faya*, and a variety of grasses. Also inspected some Special Ecological Areas – areas within the park which are actively managed for alien species control, and rehabilitation. Also observed very rare and threatened plant species which have been cultivated in the nursery, which are intended for rehabilitation into these Special Ecological Areas.
7. US Forest Service – Spoke to ecologists Julie Denslow, Flint Hughes, Anne Marie la Rosa and Amanda Uowolo about the biology and invasive characteristics of guava, and the monitoring programs established prior to the release of biological control agent. Tracy Johnson described the process in the selection of the biological control agent for guava – *Tectococcus ovatus* (an insect, which forms galls on growing tips of the plant). He explained how the galls formed by the insect work to inhibit fruiting and also described guava in its native habitat, Brazil. It is expected the biological control will be available for release within 2 years, providing that objections, anticipated from the pig hunting lobby, are over-ruled.
8. Mauritian Wildlife Foundation (MWF) – Karl Jones & Michele Lionnet (Director & Executive Director of MWF) outlined the role of the MWF and major problems currently facing the preservation of native ecosystems. Informative exchange of information with Yacoob Mungroo (Flora Manager) & Vikash Tatayah (Fauna Manager).
9. Ile aux Aigrettes (MWF) – visited the island of Ile aux Aigrettes with Pierre de Boucherville Baissac. The island has been leased by MWF from the government. Coastal habitats, which are now extinct on the main island of Mauritius have been successfully rehabilitated here. Two rare bird species have also been re-introduced to the island – the Pink Pigeon and the Mauritian Fody. The weed program, and the visitor and interpretive facilities were exceptional. The island is an outstanding vehicle for the promotion of public awareness of the beauty of native Mauritian ecosystems and the dire situation that now faces them.
10. Mr Owen Griffiths – Private businessman with several large private conservation areas on Mauritius, Rodrigues and Madagascar. Mr Owens works closely with MWF and the National Parks and Conservation Service. Visited his property in the mountains near Mahebourg where a large forest restoration project is underway.
11. Ministry of Agriculture, Mauritius – invited by Dr . Rojoa & Yacoob Mungroo to inspect the Ministry’s nursery facilities where grafting and tissue culturing techniques are used to propagate very rare plants. The nursery also maintains a seed gene bank. Several of the plants being propagated are only known from 1 individual in the wild. We also inspected “Pigeon Wood”, a Conservation Management Area run jointly between National Parks and the MWF, where a field gene bank for upland species is also being developed.
12. National Parks and Conservation Service – met with Vishnu Bachraz and discussed management of the Black River Gorges National Park and the Offshore Islets National Park (which consists of 16 islets offshore from Mauritius and Rodrigues).
13. Black River Gorges National Park - Inspected Black River Gorges National Park (upland areas) with Jean Claude Seuathian (MWF). Extensive areas of total guava infestation were observed, and three of the eight Conservation Management Areas

which have been established within the Park were inspected. Also inspected the Research Facility located within the Park, jointly run by the University of Mauritius and the National Parks and Conservation Service.

14. Black River Gorges National Park - Inspected Black River Gorges National Park (lowland and gorge areas) with Jean Claude Seuathian (MWF). Visited the Park information centre.
15. Cirque de Mafate, Ile de la Reunion – 5 day hike through the cirque. Only one small area of moderately intact native forest was observed when crossing a high pass at around 2,000 metres elevation.

### **Seminars**

Seminar presentations of Lord Howe Island and our weed management strategy were made at:

Raoul Island, NZ DoC, New Zealand

Warkworth, NZ DoC, New Zealand

MISC, Maui, Hawaii

Hawaii Volcanoes NP, Big Island Hawaii

US Forest Service, Hilo, Big Island Hawaii

MWF, Vacoas, Mauritius

National Parks and Conservation Service, Reduit, Mauritius

Seminar presentations outlining the findings from the Swire Group Churchill Fellowship 2004 will be made at:

Lord Howe Island Central School, simplified version for the children, to heighten awareness of the global plight of island ecosystems and to encourage sustainable and sensible management of their island home.

Lord Howe Island Board, July 2005

Lord Howe Island Tourism Association, July 2005

15<sup>th</sup> Australian Weeds Conference, Adelaide, September 2006

### **Publications**

It is expected that one refereed article detailing the findings of this Churchill Fellowship and the strategies adopted for weed management on Lord Howe Island will be published. Several articles for popular magazines, such as *Australian Geographic* and the local newspaper, the *Lord Howe Island Signal*, are also intended.

### 3. Introduction

#### **Background**

Lord Howe Island (LHI) is a small volcanic island 750kms north-east of Sydney. It was formed around 7 million years ago and developed a unique ecosystem in isolation until its discovery in 1788. Since discovery, several animal species have become extinct, and there have been numerous alien species introductions, but large areas of the island have survived in a relatively intact state. It is 1635ha in size, has a permanent population of 350 people and with tourism as its main income earner, receives around 12,000 tourists per year. It is part of NSW and is administered by the Lord Howe Island Board under the *Lord Howe Island Act, 1953*. The island and its surrounds were declared a World Heritage Area in 1982 on the grounds of its superlative natural phenomena and its outstanding biodiversity values.

Around 70% of the island is Permanent Park Preserve managed by the Lord Howe Island Board. The remaining 30% of the island contains the settlement, special leases used for grazing purposes and areas for recreation and environmental protection.

#### **The Weed Threat to Lord Howe Island**

The major threat to the integrity of the LHI World Heritage Area is the loss of biodiversity values arising from alien species invasion. Of principal concern is a Guava *Psidium cattleianum*. Guava has been described by the IUCN as “the worst woody weed of subtropical island ecosystems in the world”. It, together with a number of other serious weed species including bitou *Chrysanthemoides monilifera* subsp. *rotundifolia* and bridal creeper *Asparagus asparagoides*, both of which are declared Weeds of National Significance for Australia, pose a serious threat to a range of island’s habitats. The extent of the problem is beyond the capacity of the local community to manage – additional personnel from “outside” is necessary to make significant change.

The weed incursions on Lord Howe Island have already degraded many habitats, and if left unchecked will result in irreversible loss of biodiversity. This has serious implications for the economic future of the island. As the rest of the world’s sub-tropical islands forfeit their uniqueness to a monotonously familiar carpet of the same weeds, Lord Howe Island has the potential to stand out more prominently as a unique destination. As competition becomes more intense in the “island” tourism market due to greater destination choice, fuel price rises and other factors, it is an intact ecosystem that will assume inestimably high value (*in addition* to ubiquitous palm trees, white sand beaches and blue lagoon waters).

Since the successful management of the weed problem requires a high degree of funding, it is essential that best management practices are utilised, to ensure hard won dollars are spent for the best possible outcomes. This Swire Group Churchill Fellowship allowed me to investigate guava and other alien species management in New Zealand, USA, Mauritius and Ile de la Reunion so that we can adopt the best aspects and develop the best available management regime on Lord Howe Island.

## **4. Guava and Alien Species Management Findings**

### **4.1 Control versus Eradication: The Raoul Island Experience, Dept. of Conservation, New Zealand**

The weed eradication program on Raoul Island has been operational for 10 years and was undoubtedly the most systematic and rigorous program observed. From a total combined weed population of many hundreds of thousands of individuals in 1994, total weed counts for the island's 14 target weed species are now counted in the hundreds. Almost all mature individuals of the target weed species have been successfully removed. Most weeds now found are seedlings or adolescents, suggesting that these individuals are arising from the soil seed bank, which will eventually be exhausted leading ultimately to eradication.

The record keeping and data management is very simple, but effective. New Zealand Department of Conservation (NZ DoC) have plotted the progress of weed control work in terms of numbers and age class of each weed species found, over the 10-year period, which reveals a dramatic and mostly consistent downward trend (Ambrose, 2004). This is in stark contrast to many other weed control programs, including Lord Howe Island, where trends are often in the reverse direction, meaning that the problem is worsening, despite control effort, suggesting less than optimum management.

Adopting a policy of eradication at Raoul Island has led to definite outcomes, with several plant species successfully eradicated to date, and populations of the remaining target species undergoing continuing declines. The adoption of such a philosophy for weed management on Lord Howe Island would lead to a reverse of the ever-increasing weed population resulting from an open-ended control approach.

### **4.2 Quarantine**

Authorities in both Hawaii and Mauritius could not stress highly enough the need for adequate quarantine. It is the absence of suitable quarantine measures up to date which has been largely responsible for their current crises. All agencies are working hard to try and tighten quarantine legislation in their country/state.

Very strict quarantine measures are in place for the transport of goods to Raoul Island. All equipment is packed in "clean" areas and sealed. All equipment is opened in secure areas on the island, to enable the destruction of any alien animal or plant if it did happen to stow away. Raoul Island is now proudly free of all alien animal species, including rats, and has elaborate systems in place to ensure it remains that way. Even though quarantine procedures are necessarily time consuming and costly, the costs to remedy any breach in the quarantine are inordinately greater.

Managers at Hawaii and Mauritius showed great excitement (and envy) at our situation at Lord Howe Island, where the LHI Board has ultimate quarantine control. No living organism may be imported to the island without the permission of the LHI Board.

Although we have had accidental introductions in the past, our new Quarantine Strategy is attempting to address this.

Our garden plant inventory was also highly regarded. It is widely accepted around the world that best weed management practice is:

- a) Prevent the weed from establishing (quarantine)
- b) If it does establish, have early warning systems in place so that the weed can be eradicated quickly before it becomes widely established

The Lord Howe Island Board has now established a good administrative framework for a quarantine system on the island with respect to plant importation. All intended plant imports must be advised to the LHI Board and a Weed Risk Assessment is conducted to determine the likely weedy potential of the plant. The plant is either accepted or rejected for import based on the assessment. It is important that the implementation of the quarantine system continues to be rigorously maintained and monitored.

Our garden plant inventory will provide a list of all the plants currently existing on the island, some of which may pose serious weed threats in the future. All of our current declared noxious weeds and the vast majority of our environmental weeds on the island began as imported garden plants, and our garden inventory will keep us one step ahead in the future. When these known problematic weedy plants are observed becoming established in the Permanent Park Preserve quick action can be initiated to stop their more widespread establishment. In this way we can prevent future episodes of garden escapes, such as we have witnessed with guava, ground and climbing asparagus, pittosporum, etc. Discussions with all experts overseas reinforced that these measures demonstrated excellent management and were essential for a successful weed management program.

### **4.3 Monitoring**

Monitoring is essentially the measurement of processes and their results over time. NZ DoC and US National Park Service and US Forest Service in Hawaii have monitoring programs in place. The following are some of the main reasons for monitoring:

- Keep up to date with changes in the ecosystems and communities under management
- Provide time-series measurements from which rate of process can be calculated eg: the rate of spread of weeds
- Provide a quantified record of the effectiveness of techniques used from which comparative cost effectiveness can be derived, and management adapted accordingly
- Provide a record of the on-ground results of management effort, eg: the total area of weeds treated
- Demonstrate to governments and funding bodies that programs are implemented, effective, critically assessed and adapted as necessary, to encourage continued support
- Provide information for exchange with other agencies/countries/situations to allow others to learn from others' experience – leading to widespread and rapid adoption of best practice

There were three common threads throughout all discussions

- that monitoring methods should be simple and efficient. There must be a compromise between scientific rigor (ie high levels of certainty) and cost effectiveness
- Methods must be able to be applied by non-specialist staff so that the program is resilient to changes in personnel
- Technique must provide results that can easily be interpreted by lay people so that the people doing the actual weed control work, and the community at large (not just the strategists) can see the result of their efforts.

#### **4.4 Treatment Methods**

The actual treatment which is used to control guava varied in each nation. At Raoul Island, treatment was primarily hand-pulling of adolescents and seedlings or the use of chemical treatment for mature plants. The herbicide used was *Vigilant* with an active constituent of Picloram, applied as gel without the need for mixing or using any additives.

In Hawaii, treatment was primarily cut and paste, or basal bark application. There is no standard application as climatic conditions vary substantially with elevation. Most common herbicide treatment using cut stump was 20% *Garlon 4* with active constituent of triclopyr ester, mixed with *Forest Crop Oil*, a vegetable oil ester. Scientific trials have shown that the use of undiluted *Garlon 4* on cut stump has an 80% kill rate (Pratt et al, 1994). However, cut stump treatment is problematical in wetter areas in Hawaii, as the slashed end of the guava plant can re-sprout. Other successful treatments used include basal bark applications of 2,4-D, picloram and triclopyr ester. At Hawaii Volcanoes National Park, staff also use triclopyr amine at 10% product in water (applied to cut stumps or frills).

In Mauritius, herbicide is not used in guava control. Trials have been conducted using herbicides, however, kill rates were very low and the use of herbicide has not been adopted to date by the National Parks and Conservation Service. Adult plants are physically removed using a lever system. This method is very effective in that it gives a high kill rate (number of plants treated that are actually killed), however, it is very time consuming and therefore not always practical. Consequently, only 80ha of the national park estate has been weeded (the areas contained within the 8 Conservation Management Areas (CMA's)).

Although many varied techniques are used in the treatment of guava, it would seem most prudent to adopt the most efficient and effective chemical treatment determined from published scientific trials. Trials showed that the use of undiluted *Garlon 600* applied to cut stump has the highest efficacy for guava kill.

#### **4.5 Rehabilitation**

The National Parks and Conservation Service in Mauritius has a very large native plant propagation program. They also work closely with other agencies such as the

Agricultural Service in the Ministry of Agriculture and the Mauritian Wildlife Foundation. The propagation program is focussed around the many species of endangered plants to safeguard them from extinction, as their native habitats are so highly degraded. However, plant propagation also includes a range of early colonisers which are used to rehabilitate newly weeded Conservation Management Areas such as Pigeon Wood.

Ile aux Aigrettes is a small island of 13ha, less than 1km off the south-eastern coast of Mauritius, has been leased by the MWF and is in the final stages of complete rehabilitation. The island is the only example of intact native coastal vegetation in the country. The MWF also has established a nursery at Ile aux Aigrettes using corporate funds from a large hotel situated on the coast opposite the island. MWF also have significant rehabilitation projects on Rodrigues, Round Island, Flat Island and several other small offshore islands. Working in cooperation with the National Parks and Conservation Service, their aim is to remove all feral animals, and alien weed species and rehabilitate the islands to a healthy native ecosystem and re-introduce endangered animal species.

On Raoul Island, a plant which was previously thought to be extinct *Hebe brevaricaemosa*, is propagated from seed. Juveniles are then re-planted in their native habitat beside walking tracks, with labels noting the date of planting.

In Hawaii Volcanoes NP there are rehabilitation projects within the Special Ecological Areas. There is an active volunteer program which involves student internships. A variety of projects are covered and include rehabilitation works, participation in monitoring programs and seed collecting.

In Hawaii Volcanoes NP rehabilitation sites and the species of plants to be used are determined by US National Parks staff. Each species of plant has a colour-coded tag on a wire stake. The stakes are placed in position throughout the rehabilitation site. The volunteers then undertake the planting according to the position and species identified by the wire stakes. Survivorship rates can also be determined by re-inspecting the plants at each wire stake after a nominal period.

The rehabilitation works observed focused primarily on propagation of very rare and threatened plants and their re-establishment into intensely managed park areas.

#### **4.6 Volunteer Program**

NZ DoC has very well organised and active volunteer programs right across the country and Raoul Island possibly has the most well established program of all. Volunteers are recruited each year for a 4-month period over winter (from April-May to August-September). Nine volunteers are generally recruited, and make a significant contribution to the over-all weed program. All expenses are covered (travel to and from the island and food and accommodation whilst on the island), but the volunteers offer their labour free of charge. This equates to a saving of almost NZ\$90,000.00 per year in salaries.

Applications are invited for volunteers and for most years, there are many more applicants than available places, as Raoul Island is a very “exotic” destination. The selection process is equivalent to that used when hiring staff.

US National Park Service in Hawaii also have volunteer programs, though not apparently as well developed and organised as NZ DoC. There are formal “Friends of the Parks” groups and additionally US National Park Service runs student internships, as mentioned above, which have proven very successful.

National Parks and Conservation Service in Mauritius have a field station situated in the park, run jointly with the University of Mauritius. Volunteers are engaged to assist with research projects on rare and threatened animal and plant species. There is no formal volunteer program established in the National Parks Service to assist with management, however, as Mauritius is also an attractive location, such a program would probably meet with success with international visitors. Establishment of a “Friends of Black River Gorges NP” could also prove beneficial.

Volunteer programs are an excellent way to achieve additional labour at greatly reduced costs, and can provide benefits to both parties, but require careful management and coordination.

#### **4.7 Public education**

The lack of public awareness and education was seen by all authorities (including Lord Howe Island) as a major impediment to successful alien species management. Local people were largely unaware of the native ecosystems they had lost or were rapidly losing. Since the major population centers were based on the coast or lowland areas in Hawaii, Mauritius and La Reunion, all natural environments in these areas were essentially destroyed so the locals generally had no feeling of empathy for their rapidly declining natural systems.

Additionally, as there was little awareness, introductions of new alien species are continuing. Managers see that tighter controls on quarantine are critical, but as there is little public concern, through lack of awareness, there is little political imperative.

The Mauritian Wildlife Foundation is embarking on a program of school talks, for students of all age groups, and providing those schools with 10-20 native plants to establish within their grounds. This program has met with great success. As one teacher sadly commented, “You’re bringing the forest to the children, not the children to the forest” as the children are not even aware the forests exist and in any case, most of the forest has been destroyed.

Visitors to Ile aux Aigrettes in Mauritius must be accompanied by a guide. Visitor groups are restricted to 20 each group, and the guide provides a high quality interpretive walk. Current visitation levels are 8,000 people per year, with management target set at

30,000 per year. Local Mauritians and school groups are encouraged and charges for these groups are significantly reduced below the normal charge levied on tourists.

Because the weed population on Raoul Island was so reduced, a demonstration weed garden was established to familiarise weeders with their target plants.

In all countries visited, public education efforts were focused on children.

#### **4.8 Cultural value of Guava**

In Mauritius, most of the local people equate the Black Rivers Gorges National Park with guava. The National Park is a major week-end destination for hundreds of Mauritian families, not so much to explore the park, but primarily to collect guava. In Hawaii, the local pig hunters regularly use guava thickets in State Forests as hunting areas. At Lord Howe Island, there are a small number of ladies who regularly collect the fruit for jams and deserts. For all of these people, removal of guava is not necessarily a good thing, despite its devastating impacts to native ecosystems.

The National Parks and Conservation Service and the Mauritian Wildlife Foundation are currently exploring several options to shift the guava harvesting from Black Rivers Gorges National Park, including the designation of Forestry Areas as guava collection areas, or designating a smaller area within the park for collection.

Clearly guava does have cultural value, but this needs to be balanced against its ability to totally devastate biodiversity values.

#### **4.9 Biological Control**

A biological control for guava is currently being developed in Hawaii with very promising results. The most likely candidate is an insect *Tectococcus ovatus* which forms galls on the growing tips of the plant. Fruiting and vegetative spread (through suckering) is significantly reduced, as the guava plant expends most of its energy in making galls around the insect. It is believed that the biological control will be ready for release in Hawaii within 2 years. As with all biological controls, it will not be the “final solution” to guava infestations, but will assist in overall management. However, there may be serious opposition to the release of the insect by the pig hunting lobby.

Pigs eat guava fruits and are a major vector of the seed. Pig hunters know they can find pigs in guava infested areas, therefore the use of a biological control agent which could reduce the populations of guava in Hawaii is not in their interest. The pig hunting lobby is quite powerful in Hawaii, and unfortunately could have significant influence on political resolve to allow the release of the biological control.



#### 4.10 Other Weed Species

Listed below are other weed species which were also observed to cause significant habitat destruction overseas and which are either incipient or not yet known to be present on Lord Howe Island.

SPECIES	COMMON NAME	SITUATION OVERSEAS	SITUATION LHI
<i>Miconia calvenscens</i> Melastomaceae	Miconia	“Green cancer” of forests of Tahiti, established on several islands in Hawaii, millions spent on control effort. Now established on New Caledonia	Does not occur on LHI, possible entry via cruise ships from Tahiti or New Caledonia.
<i>Hedychium gardnerianum</i> Zingiberaceae	Kahili Ginger	Completely dominates the understory of wet <i>Metrosideros</i> forests in Hawaii	<i>H. gardnerianum</i> not known to occur on LHI, but several other ginger species do occur. <i>H. roxburgii</i> has naturalised on Intermediate Hill, one known outbreak has been treated. Follow-up required.
<i>Clidemia hirta</i> Melastomaceae	Kosters Curse	Shrub – a serious pest in 16 countries including Hawaii & Fiji, dominating the understory in upland wet forests	Not known to occur on LHI. Authorities in Hawaii and Mauritius regard the family Melastomaceae as a major “enemy”. Any requests for import of any plants in this family should be very carefully assessed.
<i>Schinus terebinthifolius</i> Anacardiaceae	Red Pepper Tree	Tree which forms dense stands over large areas in moderately dry areas of Hawaii, Mauritius and La Reunion	Not known to occur on LHI. Import prohibited. Should be eradicated from island if discovered.
<i>Acacia mearnsii</i> Fabaceae	Acacia	Small tree which forms dense mono-specific stands over large areas in moderately wet areas of Hawaii and La Reunion	Not known to occur on LHI. Should be eradicated from island if discovered.
<i>Leucaena leucocephala</i> Fabaceae	Leucaena	Shrub which forms dense mono-specific stands over large areas in dry areas of Hawaii, Mauritius and La Reunion	Not known to occur on LHI. Prohibited from import.

<i>Prosopis pallida</i> Fabaceae	Mesquite	Highly invasive small tree covering extensive lowland areas in Hawaii, Mauritius and La Reunion	Not known to occur on LHI. Weed of National Significance for Australia
<i>Casuarina spp.</i> Casuarinaceae	Casuarina	Extensive areas in Hawaii, Mauritius and La Reunion. Also major problem in Florida.	<i>C. glauca</i> present in several known locations on LHI. Another species, (not yet confirmed) occurs in one garden at the south end of island. Not known to have naturalized in PPP.
<i>Ravenala madagascariensis</i> Streliziaceae	Travellers Palm	One of the major invasive weeds of Mauritius.	At least one population known on LHI on top of the road cutting nears Cobby's Corner. Should be eradicated ASAP
<i>Phyllostachys nigra</i> Poaceae	Bamboo	Huge monospecific stands occur in Hawaii at lower elevations	This species not known to occur on LHI, however, several other bamboo species do. <i>Arundinaria simonii</i> is now undergoing eradication. At least 2 leasehold properties are known to have bamboo in gardens. Still awaiting confirmation on ID's, but their removal should be encouraged.
<i>Acacia nilotica</i> Fabaceae	Prickly acacia	Large stands occur in the lowland areas of Mauritius and La Reunion	Not known to occur on LHI. Prohibited from import.
<i>Morella faya</i> Myricaceae	Faya	A major invasive weed for Hawaii, in upland wet rainforests. Forms dense mono-specific stands.	Not known to occur on LHI. Prohibited from import.
<i>Fucraea foetida</i> Agavaceae	Mauritian Hemp	A major invasive weed for Mauritius and La Reunion, particularly on steep hillsides, where mono-specific stands can occur.	Known on LHI from at least 3 locations – OceanView, Ned's Beach Road and Nicholl's. Eradication should be encouraged.
<i>Grevillea robusta</i> Proteaceae	Silky oak	Planted in the 1930's by Forestry in Hawaii, now a major pest.	Known to occur on LHI, in Steven's Reserve and several gardens. Has already naturalised in PPP and should be targeted for eradication.

<i>Lantana camara</i> Verbenaceae	Lantana	Dense infestations in lowland areas of Hawaii, Mauritius and La Reunion.	Known to occur at only a few locations on LHI on Transit Hill. Weed of National Significance for Australia. Should be targeted for eradication.
<i>Eucalyptus spp.</i> Myrtaceae	Eucalypts	Planted in the 1930's by Forestry in Hawaii and spreading slowly. Major pest in Florida.	Several species known to occur, with planted stands in Stevens Reserve, which have become naturalised. Should be targeted for eradication.
<i>Spathodea campanulata</i> Bignoniaceae	African Tulip	Large infestations in wetter lowland areas of Hawaii. Also a major pest in tropical north Queensland.	Not known to occur on LHI. Prohibited from import.
<i>Syzygium jambos</i> Myrtaceae	Rose Apple	Large infestations in wetter lowland areas of Hawaii and Mauritius.	Not known to occur on LHI. Prohibited from import.
<i>Schefflera actinophylla</i> Araliaceae	Umbrella Tree	Pest in Hawaii, Mauritius and La Reunion.	Known from several gardens on LHI and now naturalised in the PPP. Should be targeted for eradication.
<i>Cyathea cooperi</i> Cyatheaceae	Australian Tree Fern	A serious threat to upland fern forests and wet <i>Metrosideros</i> forests in Hawaii	Not known to occur on LHI. Prohibited from import
<i>Hiptage benghalensis</i> Malpighiaceae	Hiptage	Scandent shrub or creeper threatening upland forests in Mauritius.	Not known to occur on LHI. Prohibited from import.
<i>Tecoma stans</i> Bignoniaceae	Yellow Bells	Shrub, small tree – forms mono-specific stands on hillsides in Mauritius. Also present in Hawaii and La Reunion	Not known to occur on LHI. Prohibited from import
<i>Rubus argutus</i> Rosaceae	Blackberry Raspberry	Together with Kahili ginger, one of the most serious pest species in the understorey of wet <i>Metrosideros</i> forests in Hawaii and Mauritius	Not known to occur on LHI. Prohibited from import
<i>Polygonum capitatum</i> Polygonaceae	Pinkhead Smartweed	A scandent shrub which grows in Hawaii on bare lava flows at sea level to wet rainforests at 2,500m elevation	Not known to occur on LHI. Prohibited from import

<i>Tabebuia heterophylla</i> (syn. <i>T.pallida</i> ) Bignoniaceae	Pink Tecoma	Tree – very invasive in upland forest of Mauritius. Also present in Hawaii and La Reunion	Not known to occur on LHI. Prohibited from import.
<i>Ligustrum sinensis</i> Oleaceae	Privet	Small tree - very invasive in upland forest of Mauritius. Also present in Hawaii and La Reunion.	Occurs in many gardens on LHI. Not known to have become naturalised in PPP.

#### **4.11 Key Conservation Areas**

In both Mauritius and Hawaii, the park services have adopted a management practice of designating key conservation areas within the park. These are Conservation Management Areas in Mauritius and in Hawaii, Special Ecological Areas at Volcano NP and the Kipahulu Biological Reserve at Haleakala NP. Conservation management within the parks is focussed on these key areas, with little or no management of park lands outside these key areas. This approach is necessitated due to the scale of the alien species problems within the park, versus available resources to deal with these problems. Representative examples of major habitats have been determined and these areas alone are managed intensively. The general public are either prohibited entry or discouraged from entry into these areas.

Hawaii Volcanoes National Park estate totals 120,075ha, and the Special Ecological Areas within the park total 25,000ha, or 20% of the park estate. Haleakala National Park estate totals 11,430ha and the Kipahulu Biological Reserve totals 3,430ha, or 30% of the park estate. Even with a resource management operational budget of around US\$1 million per year each for Hawaii Volcanoes and Haleakala NP's, this is only sufficient to deliver adequate resource management to a small portion of entire park estate. Management has essentially retreated to these areas where staff can "hold the fort". It is hoped that the future release biological controls will greatly assist their management and allow conservation areas to expand.

In Mauritius, the Black River Gorges National Park totals 6,754 hectares, but only 80ha is intensively managed in 8 Conservation Management Areas (CMA's). National Parks in Mauritius does plan to increase this area by commencing clearing the intervening forest areas of guava this year and ultimately connect all the upland CMA's.

This approach to management, ie. Key Conservation Areas, is largely due to the advanced state of weed invasions in much of the national park estate, and the large size of the park estates relative to operational budgets.

On Raoul Island over 50% (1,500ha) of the island is intensively grid searched at least once every 12 months. All other accessible areas of the island are searched on a casual basis by staff during the course of their stay on the island. Management effort extends not only to the whole of Raoul Island, but also to adjacent off-shore islands. This long-term and consistent annual (and in some areas, bi-annual) treatment of weeds on Raoul Island has resulted in a continuing reduction of all targeted weed species with eradication of some species.

## 5. Conclusion and Recommendations

A great deal has been learnt through discussions with experts and first hand observations from these Indo-Pacific Island states and countries, which all share the same fundamental problem –the vulnerability of island ecosystems (which have evolved in isolation) to disturbance and biological invasions. Protection of oceanic island ecosystems clearly poses a critical challenge to managers. As Loope (1997) states, “the most crucial topic for international collaboration is that of slowing further biological invasions – which particularly involves learning from each other’s mistakes”. However, sharing in each other’s successes can also make great gains. The alien species eradication programs for Raoul Island and Ile aux Aigrettes both stand out as great successes for uninhabited islands. Lord Howe Island is now firmly established in the international arena, and has outstanding potential to demonstrate alien species eradication programs for a large **inhabited** island.

In order to achieve this success, there is an urgent need to expand the scope of the weed management program on Lord Howe Island. Our aim should be to treat all target areas of the Permanent Park Preserve and settlement area for noxious weed species within a 12-month period, then begin treatment again the following 12-month period and continue such a program for at least a 10-year cycle. The process of continual weed recruitment and invasion can **only** be broken by taking this long-term rigorous and systematic approach.

The benefits to the community – not just the local community but all Australians and the global community generally – is the attainment of a resource which is unavailable in any other part of the globe. While the world careers along on its generally destructive path over the next 10 years, Lord Howe Island will be one of the most spectacularly special and sought after destinations in the world. Only if we invest now will we achieve this end. If not, our fate will be the same as most other sub-tropical island ecosystems in the world (with the exception of Raoul Is, which is essentially inaccessible), and the opportunity to secure the long-term future of island residents, human and non-human, will have been squandered.

### **Recommendations will be made to the LHI Board**

Experience gained through this Swire Group Churchill Fellowship, as anticipated, has highlighted a number of areas for possible improvements to the current weed management practices at Lord Howe Island. Additionally, the Preliminary Draft of the Lord Howe Island Biodiversity Management Plan, identifies weed invasion and the introduction of pests, weeds and disease as major threats to the biodiversity of the island. The Biodiversity Management Plan has highlighted both the Weed Management Strategy and Quarantine Strategy as High Priority Components. Eleven specific recommendations will be made, which are assessed to have high technical merit. However, these recommendations will require consideration within the political and social framework of Lord Howe Island.

I will recommend that the Lord Howe Island Board take the following steps to achieve a best management practice for our weed management program:

- Consider the merits and feasibility of these recommendations in a social and political context
- Undertake revision of the current Strategic Plan to incorporate recommendations
- Release draft strategic plan to the public for comment
- Adopt the amended strategy.

### **Specific Recommendations to be made to the Lord Howe Island Board**

#### **Recommendation 1**

*That the Raoul Island weed management methodology and its data management protocols be adopted for use at Lord Howe Island.* Such a program would aim for all target areas to be searched for weeds at least once per year (this includes the settlement area). Additionally, it will require that the philosophy of weed management on LHI shift from weed control, where no lasting outcome is planned and expenditure is open-ended, to weed eradication. Additionally, the “cultural” or social aspect of weed management would feature, to ensure that the community is actively involved in overall weed management for the island. The aim would be to achieve a “tenure blind” weed management program with weed management issues being addressed on a cooperative basis. If the new strategy is adopted, a fully budgeted operational plan should be developed to commence in the 2006-2007 financial year.

#### **Recommendation 2**

*To continue development of the Quarantine Strategy and block all major pathways for alien species and to continue with the garden plant inventory for all island leases.* Both of these programs are currently endorsed by the LHI Board, and implementation should be maintained and monitored.

#### **Recommendation 3**

*That the LHI Board expand its Long Term Monitoring Program to determine both the impacts of guava and other alien weed species, and weed treatment work, on native plant communities and the effectiveness (kill rate) of weed treatment.* Continue to involve weed team staff at all levels of the monitoring program.

#### **Recommendation 4**

**A)** *That undiluted Garlon 600 be applied to guava cut stumps, based on the only known published scientific trials for guava treatment (Pratt, et al, 1994).* These trials showed this method to give the most effective kill rate for guava . If used in lower concentration, *Garlon 600* is recommended for mixing only with diesel, which can have deleterious effects on the applicator. Use of undiluted herbicide eliminates the need for the use of diesel, and for mixing, where errors can made in dose rates, and will ensure maximum uptake by the plant. *Vigilant* is the product of preference on Raoul Island, however, comprehensive scientific trials have not been conducted on this product for guava.

**B)** *That scientific trials be established here to accurately quantify kill rates for guava and other alien weed species under various concentrations of various herbicides at Lord Howe Island (including Vigilant). Trial time frame should be a minimum of 2 years, as studies have shown that guava, apparently dead at 9-14 months after treatment, can re-sprout after 21 months. Anecdotal reports suggest that it can take up to 4 years to be confident of guava mortality post-treatment. Results from the LHI trials should be published in a scientific journal, so that other practitioners particularly within Australia, can benefit from our experience.*

### **Recommendation 5**

**A)** *That a propagation program be established for Lord Howe Island's 8 declared endangered plant species, together with other rare plant species. Most of these species have a limited distribution on the island. Propagation will ensure a safe-guard for these plants in the event of some catastrophic disaster. Successful propagation methods should be documented. Where possible, these plants should be re-planted in their appropriate habitats in the park along trails, with small signs to heighten awareness of the status of the plant and the work of the LHI Board.*

**B)** *That the use of coded tags for rehabilitation works be trialled to facilitate recording of survivorship rates (see Recommendation under Volunteer Program concerning the development of holiday programs for environmental science students with research institutions).*

### **Recommendation 6**

**A)** *That the Lord Howe Island Board expand its current volunteer program, and formalise an ongoing yearly program, similar to that established for Raoul Island. The major impediment to successful weed treatment at Lord Howe Island is the lack of personnel to cover all areas of the Permanent Park Preserve and settlement area within a realistic time frame. As has been demonstrated at Raoul Island, volunteers can provide a significant source of labour at much reduced costs to the Board. The development of highly organised and sustained volunteer program could achieve dramatic results with respect to weed management for the island. However, while the labour component is free, the expanded volunteer program would incur some additional costs to the Board. The major components of these costs include:*

- *The recruitment of a Coordinator - Weed and Volunteer Program. A dedicated full time position is required to run and drive a successful intensive volunteer program and to manage the overall weed program. This role is currently undertaken jointly by the Environment/World Heritage Officer and the LHI Board's Botanist. Most of the costs of for this position are therefore currently being met by the Board, but an increase in expenditure of around \$20,000 per year for the dedicated full-time position would be required.*
- *Funding for airfares from Sydney and food costs for volunteers whilst on the island. Cost estimated at \$22,000 per year (for 20 weeks of voluntary labour per year)*
- *Some minor amendments to the LHI Board's research facility, so that longer term stays are more comfortable for volunteer groups (covered outdoor area, an additional shower and toilet). Cost estimated at around \$50,000*

On-going yearly costs therefore are \$44,000, with a one-off capital expenditure of \$50,000. In return, the LHI Board will receive free labour from the equivalent of 6 full time weeding staff for a period of 20 weeks, which would save the Board \$120-\$130,000 in paid labour. Volunteers are the most cost-effective way of achieving the main the resource desperately needed by the Board to run a successful weed management program, ie labour.

Advertisements for the volunteer program would be placed in national newspapers and suitable popular magazines, such as *Wild* and *Australian Geographic* for programs throughout the year.

**B)** *That the LHI Board approach research institutions to develop holiday programs for students enrolled in bush regeneration and/or environmental science courses.* This would ensure a reliable source of young, enthusiastic volunteers who will gain practical experience to assist them in their studies.

### **Recommendation 7**

**A)** *That the LHI Board expand its public education program concerning weed management issues affecting the island.* Quarantine and noxious weed control on leasehold land should feature and could be best achieved by the development of property management plans. Additionally, a two-year amnesty could be implemented, whereby major weed infestations on leasehold land would be treated free of charge by Board staff. Once infestations are reduced to a manageable level, continued treatment would then be undertaken by the leaseholder according to conditions set out in a property management plan. Weed management is a whole of community responsibility and unless we all work together, the best efforts of the Board will be severely compromised. A “tenure blind” cooperative approach to weed management should be developed and incorporated into the new Weed Management Strategy for Lord Howe Island.

**B)** *That a “weed garden” be developed, so that residents and visitors can readily recognise all our declared noxious and environmental weeds.* It would be developed in the same way as the island’s botanic garden, with interpretative signs for each weed species (however, fruit from all plants would be removed prior to maturation). The garden could be called: “Know your enemy – the Garden of Weeden”.

**C)** *That a series of school programs complimentary to the school curriculum, be designed in consultation with school staff.* Some excellent progress has been made to date (captive breeding enclosure for the endangered land snail, *Placostylis bivaricosus*, special activities during Weedbuster Week), but more could be done. The school children will be the leaders of the community tomorrow, and grounding in environmental awareness and responsibility will provide them with the fundamental background required to confidently manage the island to ensure its continued ecological integrity.

### **Recommendation 8**

*That the LHI Board develop a “community garden” for guava collection for local consumption.* This is concept has been successfully adopted on Norfolk Island. A public area could be designated with a grove of guava plants. This area would be managed by

the Board, the trees would be kept pruned and netted during the fruiting season. Any resident wishing to collect guava may do so from the community garden.

#### **Recommendation 9**

*That the LHI Board support the release of the biological control agent for guava in Hawaii if and when research is completed and the biological control agent found to be safe for release.* International support for the adoption of a biological control measure for this insidious Indo-Pacific island weed could aid the US decision-makers in Hawaii to make environmentally responsible decisions even with the expected strong opposition from the pig hunting enthusiasts. It would be prudent to monitor the effectiveness of the biological control post-release in Hawaii, with a view to assess the feasibility for application for use on Lord Howe Island.

#### **Recommendation 10**

*That the LHI Board move to ensure eradication of all occurrences of weeds outlined under point 4.10 from special and/or perpetual leases and public lands, in particular, Ginger, Casuarina, Silky Oak, Mauritian Hemp, Bamboo and Travellers Palm. These species are proven to be serious environmental pests in situations similar to that on Lord Howe Island.*

#### **Recommendation 11**

**A)** *That the LHI Board does not adopt a Key Conservation Areas approach.* The Permanent Park Preserve estate on the island totals 1,262 hectares (>1,500 ha when slope is taken into account) and almost the entirety of the Permanent Park Preserve is impacted by weed invasions at some level. The total of the island's habitats are therefore small by world standards. It would not make good management sense to sub-divide these already small habitats and expect them to survive, while ignoring other areas and allowing existing weed populations to expand unchecked.

**B)** *That the LHI Board review its overall management strategy and commitment to alien weed species invasions.* Weed control has been undertaken by the Board at various levels of intensity for the last 30 years. Expenditure for weed control programs has generally increased in more recent times, with an increase in both density and spread of weeds and as the seriousness of the problem has become more obvious.

It is conservatively estimated that over the last 30 years, costs to the community for the island's weed control program is around \$2.1million (based on \$70,000 per year over 30 years). It is also suggested that the overall weed problem on the island is now greater than it was 30 years ago, despite this control effort at a cost of \$2.1million. This assertion is based on the following rationale.

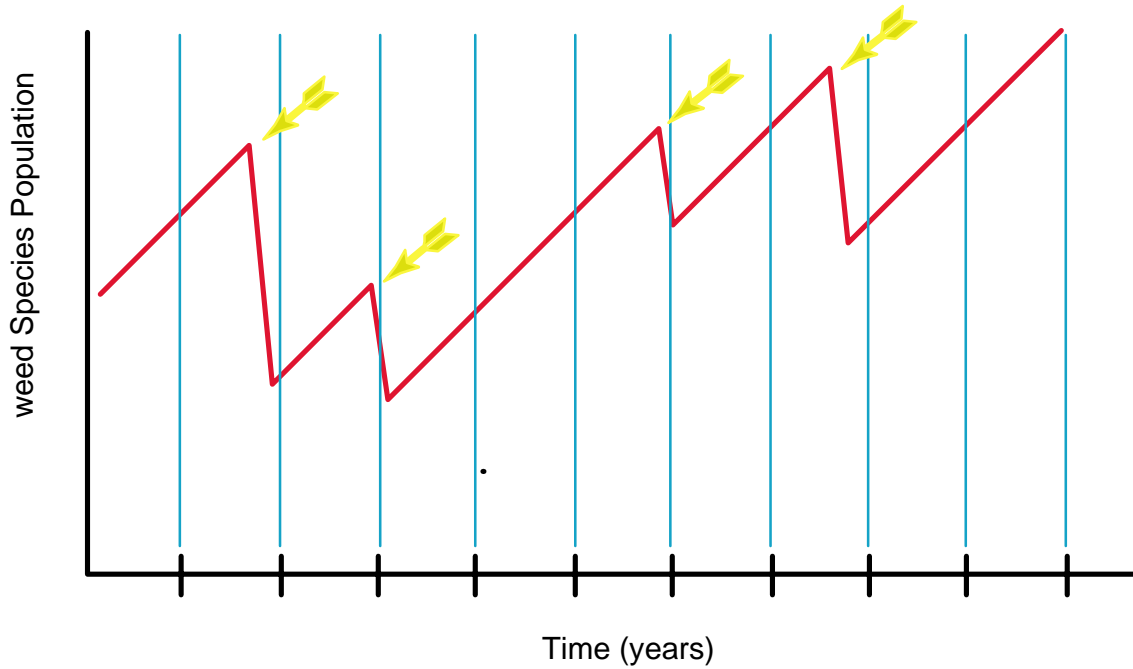
All of the island's noxious weed species reach maturity (ie. Bear fruit and therefore produce seeds) within 1-3 years of germination. Even when control work is undertaken on these noxious weeds, while mature individuals remain within the population that are capable of reproducing, a new population of weed plants will arise to replace those which were treated. Weed control in this instance, simply holds the weed population in check, depending on the frequency of re-treatment.

This effect is compounded if control work is not undertaken routinely on an annual basis. During the time when no control work is undertaken, the weed population reproduces unchecked, so that eventually the population will exceed that which initially existed prior to the very first treatment. Graph 1 illustrates this concept.

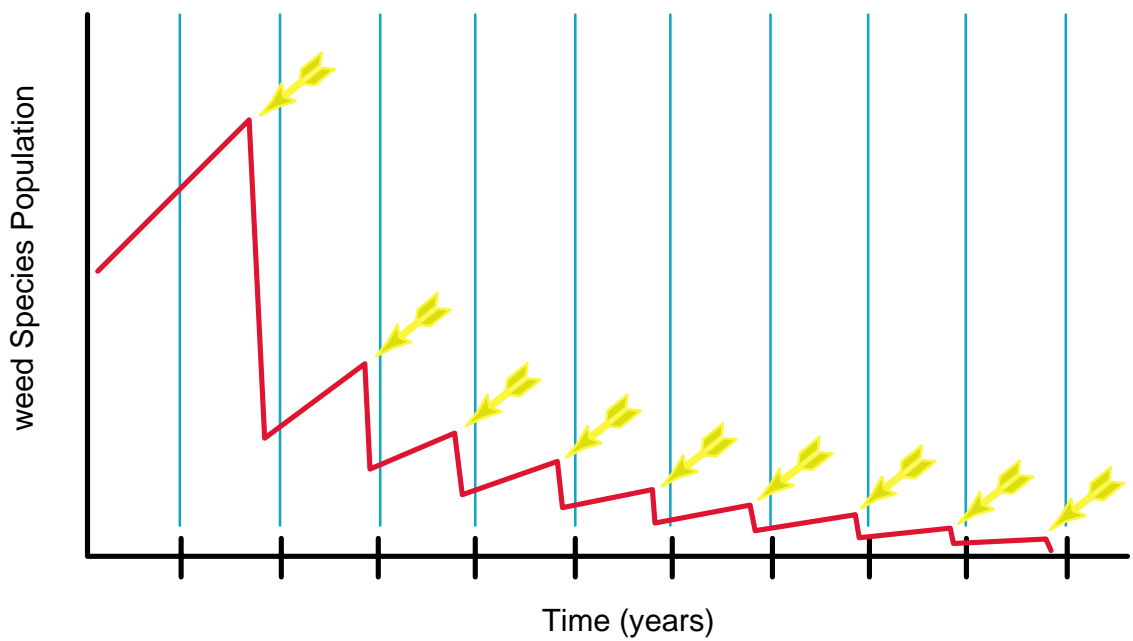
Annual treatment of weed populations is required to break the seeding cycle, to remove mature plants before they have an opportunity to set seed and start the whole process again. It is only by adopting a consistent and unrelenting attack on the weed population over the whole island every 12 months, that we can break the cycle of an ever-increasing weed population. As seeds can remain viable in the soil seed bank for up to 10 years (eg. bitou) this management regime would be required for at least a 10-year period. Graph 2 illustrates the fate of weed populations if treatment is sustained every year. This reflects the weed treatment program of Raoul Island, the only truly successful program witnessed from this tour.

Over the entire 30-year course of the LHI Board's weed control program, there has very rarely been consecutive annual treatment of any weed in any part of the Permanent Park Preserve or settlement, and our current weed population follows the pattern shown in Graph 1. The only way to make real change and ensure that the weed population begins a consistent decline in the future is to adopt the regime as described and illustrated in Graph 2.

Graph 1. Diagrammatic representation of the history of guava control at Lord Howe Island (arrows represent control effort)



Graph 2. Diagrammatic representation of the proposed future control of guava on Lord Howe island. (arrows represent control effort)



Individual *Psidium cattleianum* plants each produce thousands of seeds annually, and the seeds are believed to have a relatively short seed bank viability, but it appears that potential recruits may be concentrated in a “seedling bank”, rather than as dormant seeds in the soil (Huenneke & Vitousek, 1990).

Despite assiduous but uncoordinated efforts over many years at Lord Howe Island, the population of *Psidium cattleianum* (and other weeds) has increased, with concomitantly increased forecast costs of management into the future.

The only viable program for effective control is the removal of all reproductively mature plants in the population within the first few years, followed by removal of emergent seedlings before they reach fruiting age. In this way the “seed bank” can be exhausted in just over ten years. The effort required to complete this program is large in the first few years but significantly reduces with time as the seedbank is depleted without replenishment from mature trees.

Failure to remove the reproductively mature trees/plants from the population extends the timeframe for control indefinitely and leads to an exponential increase in the forecast costs of eventual control.

A detailed budget plan will be supplied to the LHI Board as a separate document, comparing the benefit:cost ratios of this new strategy, versus, continuing to fund the program at less than optimal levels.

Providing the LHI Board maintains a high level of commitment in the early phase of the program, after 10 years an adequate level of weed management using only local personnel without the need for outside (mainland) staff will result, with concomitant reduction in weed program costs. But this point can only be reached if a higher level of investment is made now. Adequate personnel are required to enable a search all of the Permanent Park Preserve and settlement areas every 12 months for at least the next 10 years. Funding a program which does not achieve this outcome is essentially wasted as we will never break the fruiting cycle, and so never effect a consistent downward trend in weed populations. The result - the LHI Board will be doomed to an open-ended future of “throwing” money at weeds, while at the same time, the weed problem will continue to worsen and the real cost of adequate management will rise exponentially and eventually be totally out of reach. Lord Howe Island will then share the fate Hawaii, Mauritius, Ile de la Reunion and most other sub-tropical islands of the Indo-Pacific - trying to defend small remnants of a previously widespread and spectacular island ecology.

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