Monuriki Island Weed Control

Feasibility Study Report

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EXECUTIVE SUMMARY

This Feasibility Study was undertaken by the National Trust of Fiji (NTF) with support and advice from the Pacific Invasives Initiative (PII). The study was conducted to determine the best way to manage invasive plants (weeds) on Monuriki Island, Fiji and how to proceed with such an operation.
The finding of the Feasibility Study is that invasive plant management on Monuriki is technically and socially feasible and can be achieved under several stages. It is clearly evident from numerous weed management programmes that removal of invasive plants from small (<1000ha) isolated islands such as Monuriki is highly achievable. The issue however is how best to go about doing so and what level of control or eradication of the invasive plant species present is required for native regeneration.

Invasive plant management has never previously occurred on the island so this effort is being done so without prior information of plant eradication, therefore lessons and methods have been acquired from literature on previous operations of a similar nature in addition to expert advice from area specialists. The local landowning community on the neighbouring island of Yanuya strongly support the total removal of the invasive plants on PKI in perpetuity. Local tourism operators who also use the island also support. The local landowners wish to see their island protected from invasive plant threats to the rare dry forest ecosystem and endemic and critically endangered crested iguanas found on Monuriki.

There are a number of risks and challenges that largely revolve around resource availability (skilled labour, island travel logistics, biosecurity, staff time, finances) and timeframe planning for completion, particularly surrounding the life of the project and timing of treatment. These however can and will be managed as explained further in the document.

1. INTRODUCTION

This document is to establish the feasibility of the effective eradication and control of a number of plant species from Monuriki. This study was conducted by the National Trust of Fiji and funded by the Critical Ecosystem Partnership Fund. Field visits to the island in relation to the formulation of this report were conducted between Sept 2012-Mar 2013.This invasive plant control project is part of the Monuriki Island Forest Restoration Project for the survival of the Crested Iguana population and other native species.

2. GOAL, OBJECTIVES and OUTCOMES

2.1 Goal

The goal of the proposed project is to eradicate and/or control invasive species present on Monuriki Island in low abundance at the early stages to ensure the successful regeneration of degraded tropical dry forest currently present on the island and functioning in a healthy state and secure from invasive plant impacts.

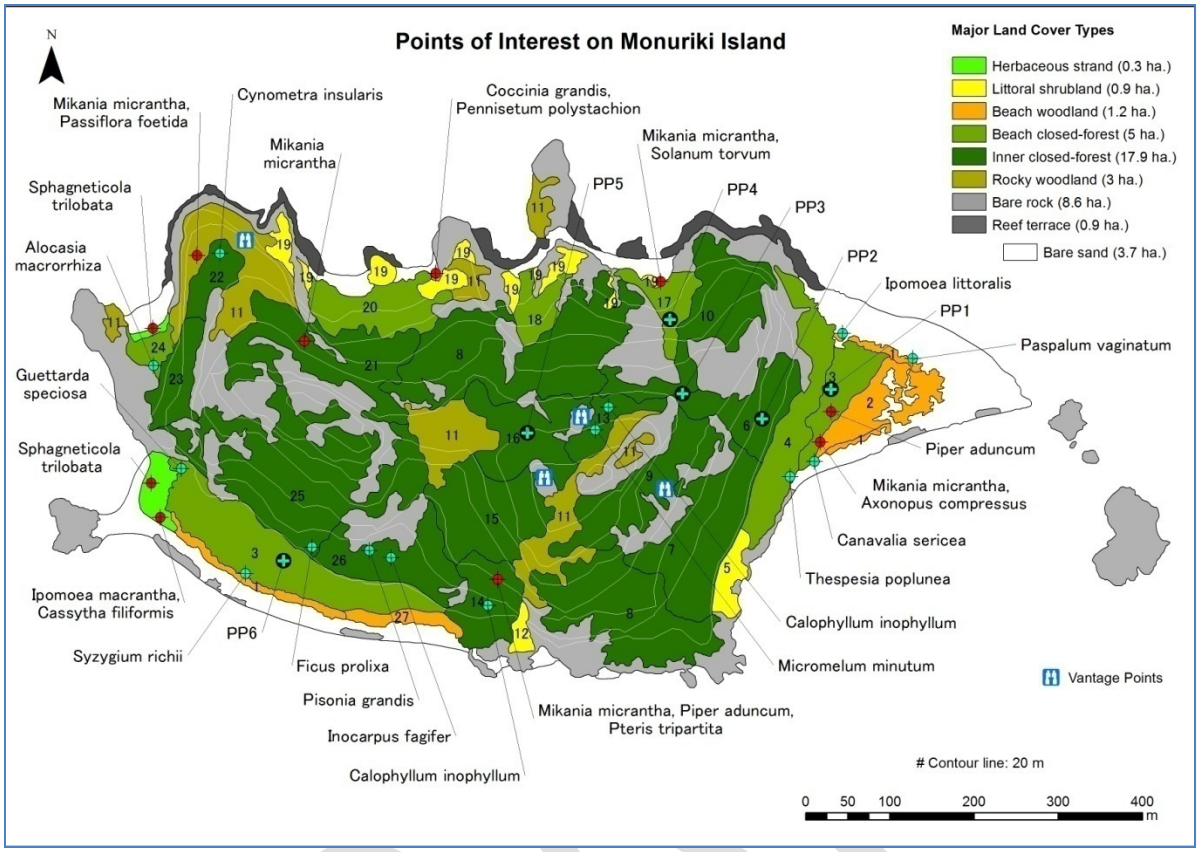
2.2 Objectives and Outcomes

Objectives	Outcomes
To eradicate • *Piper aduncum* • (Rogua & Savusavu Beaches) • *Sphagneticola trilobata* (Rogua & Launatovuto Beaches)	A tropical dry forest ecosystem free of invasive plant species and species that actively compete with important food plants. Habitat plants for crested iguanas.
To control: • *Cenchrus echinatus*(Savusavu Beach) • *Mikania micrantha* (Rogua & Launatovuto Beaches)	

The limited number of individuals currently observed on the island determines that a "species-led" approach be taken. It is believed some invasive plant species can feasibly be eradicated due to unlikely reinvasion, while others can at best be controlled to zero density over differing time scales due to either bird or wind borne reinvasion of seed.

3. THE SITE

SITE NAME: Monuriki
UNIQUE ID:
LONG: 177.033692°E
LAT: 17.609727°S
RADIUS (M):
PROVINCE: Nadroga
VILLAGE: Yanuya
LANDOWNER: Yanuya



4. THE TARGET SPECIES, IMPACTS AND BENEFITS OF MANAGEMENT

4.1 Target Species

PIPER ADUNCUM

TLA*	**PAD**
Local Name	yaqona ni Onolulu
Common Name	bamboo piper
Family	*Piperaceae*
Genus	*Piper*
Species	aduncum
Full scientific name	Piper aduncum
Synonyms	
Standard taxonomic abbreviation	
Distribution in Pacific	
Growth Habit	shrub/tree
PIER WRA	18
Invasiveness Category	4

Decision Tree Result	1E-Eradication is likely to be achieved cheaply and easily within 2-3 years
Height at Maturity (metres)	7m
Time to Maturity (years or months)	
Pollination method (wind, bat, etc.)	
Flowering period (month(s))	Throughout the year if sufficient moisture available
Time from flowering to seed-set (months)	
Seed Viability (years)	
Number of seeds/square metre	
Dispersal vectors	Tiny seeds dispersed by birds and flying foxes. Locally, it spreads by suckers, forming large clumps.
Dispersal distance (metres)	
Long Distance Dispersal vectors	
Long Distance Dispersal distance (metres)	
Vegetative reproduction	
Natural Inhibitors to growth	
Management Options	Specific control methods for this species are not available. Seedlings and saplings may be pulled or dug out. Larger shrub can be cut and the cut stumps treated with herbicide"
Origin	
website	

SPHAEGNETICOLA TRILOBATA

***TLA**	**STL**
Local Name	
Common Name	Trailing Daisy
Family	Asteraceae
Genus	*Sphagneticola*
Species	*trilobata*
Full scientific name	*Sphagneticola trilobata* (L.C. Rich.) Pruski
Synonyms	*Acmella brasiliensis* Spreng., *Acmella spilanthoides* Cass., *Buphthalmum repens* Lam., *Buphthalmum strigosum* Spreng., *Complaya trilobata* (L.) Strother, *Polymnia carnosa* Poir., *Polymnia carnosa* Poir. var. *aspera* (Rich.) Poir., *Polymnia carnosa* Poir. var. *glabella* (Rich.) Poir., *Polymnia carnosa* Poir. var. *triloba* (Rich.) Poir., *Seruneum paludosum* (DC.) Kuntze, *Seruneum trilobatum* (L.) Kuntze,

	Silphium trilobatum L., *Sphagneticola ulei* O.Hoffm., *Stemmodontia trilobata* (L.) Small, *Thelechitonia trilobata* (L.) H.Rob. & Cuatrec., *Verbesina carnosa* M.Gómez, *Verbesina carnosa* M.Gómez var. *aspera* (Rich.) M.Gómez, *Verbesina carnosa* M.Gómez var. *triloba* (Rich.) M.Gómez, *Wedelia brasiliensis* S.F.Blake, *Wedelia carnea* Rich., *Wedelia carnosa* Rich. ex Spreng., *Wedelia carnosa* Rich. var. *aspera* Rich., *Wedelia carnosa* Rich. var. *glabella* Rich., *Wedelia carnosa* Rich. var. *triloba* Rich., *Wedelia crenata* Rich., *Wedelia paludicola* Poepp. & Endl., *Wedelia paludosa* DC., *Wedelia triloba* (Rich.) Bello, *Wedelia trilobata* (L.) Hitchc.
Standard taxonomic abbreviation	
PIER WRA score	13
Invasiveness Category in your Country	1
Decision Tree Result for your plant	1E-Eradication is likely to be achieved cheaply and easily within 2-3 years
****Distribution in Pacific**	American Samoa, Cook Islands, Federated States of Micronesia, French Polynesia, Kiribati, Marshall Islands, Guam, Northern Mariana Islands, Nauru, New Caledonia, Niue, Palau, Samoa, Tonga, United States (Midway Atoll)
Growth habit	Herb
Height at Maturity (metres)	10in (Floridata, n.d.). 0.5 to 1 feet (Gilman, 2011). 45 - 60cm high (CAB International, 2012).
Time to Maturity (years or months)	
Pollination method (wind, bat, etc.)	
Flowering period (month(s))	All year round (Gilman, 2011; CAB International, 2012).
Time from flowering to seed-set (months)	
Seed Viability (years)	
Number of seeds/square metre	Few fertile seed produced. Spread is mainly vegetative (GISD, 2010).
Dispersal vectors	
Dispersal distance (metres)	
Long Distance Dispersal vectors	Humans (cultivation for ornamental purposes, or by accidental dumping of waste) (PIER, 2010). Grown as ornamental ground cover in Guam (Muniappan et al., 2002). Ground cover in many areas.
Long Distance Dispersal distance (metres)	
Vegetative	Stems form new plants where they come into contact with the ground. Pieces

reproduction	sprout roots (PIER, 2010). Stems take root when coming in contact with damp soil. Also, layering (Gilman, 2011).
Natural Inhibitors to growth	Frost (CAB International, 2012)
Management Options	Preventative measures: A risk assessment of *Sphagneticola trilobata* resulted in a high score of 13, indicating the species' potential to become a significant plant pest (PIER, 2005). It is recommended that planting of the species be restricted and existing plants within the landscape be eliminated, with extra caution taken when dumping vegetative material in order to prevent regeneration or accidental introduction to new areas (MacDonald et al., 2008). Early detection and prompt follow-up eradication is required to prevent establishment of the weed. Public awareness is crucial to reduce dumping of garden waste into native vegetation, which can facilitate introduction of weeds to new areas (Batianoff and Franks, 1998). Cultural control: According to CAB International (2012), importation and spread of the weed can be substantially reduced through disseminating public awareness on the identity, impacts to native ecosystems and control methods. *S. trilobata* can also be controlled through the management of nitrogen fertiliser usage and irrigation (CAB International, 2012). MacDonald et al. (2008) suggest planting native or non-invasive alternative species. Space and Flynn (2000) strongly advise an eradication campaign for the species. Manual control: Mowing and slashing should be undertaken with care in areas invaded by *S. trilobata* (DPI&F, 2007). Runners should be hand-pulled and dug up. It is critical that plant waste be disposed of carefully, as regeneration can take place from the smallest cuttings. Waste should either be burnt or put in a black plastic bag and be left to dry. Cleared areas should then be revegetated with mulching, to prevent further weed invasion (DPI&F, 2007). MacDonald et al (2008) discourage mowing and slashing in infested areas, and instead recommend uprooting of the weed followed by herbicide application. Seedlings and small plants can be hand-pulled, though entire roots and rhizomes should be removed (MacDonald et al., 2008). CAB International (2012) states that an effectual method of control would be to remove the top few centimetres of soil using an appropriate tool, with the intention of eliminating the soil seed bank of S. trilobata. While hand-pulling is effective, it is not a feasible control method for large-scale infestations. Repeated hand-pulling supplemented with herbicide administrations is usually required. Burning is also an option (CAB International, 2012). Chemical control: In Queensland, a registered herbicide for treating *S. trilobata* invaded areas is metsulfuron-methyl (600g/L), at a rate of 10g per 100L water plus wetting agent. It should be sprayed thoroughly to wet foliage but without resulting in runoff (DPI&F, 2007). Ensbey et al. (2011) recommends glyphosate (360g/L) at a rate of 200mL per 100L water to be used as a foliar spot spray, as well as a combination of 200mL glyphosate and 1.5g metsulfuron-methyl (600g/kg) per 10L water for spot spray application. Dense infestations of the weed may require 5% of Glyphosate along with follow-up treatments (MacDonald et al. 2008). Motooka et al. (2003) state

	that *S. trilobata* is sensitive to dicamba and 2,4-D (minimum of 2 Ib per acre) as well as to triclopyr in crop oil using a drizzle method at 2Ib per acre or more. Spencer (2010), however, found that Glyphosate was ineffectual in controlling *S. trilobat*a, and in addition, led to severe damage of native vegetation due to its properties as a broad spectrum herbicide. In place of Glyphosate, Spencer (2010) recommends metsulfuron-methyl (Brushkiller, Brushoff etc.), which was found to kill the weed efficiently, and with few impacts to native vegetation. In trials conducted to evaluate the effects of spraying on native species, 85% of 80 species of seedlings exposed to metsulfuron-methyl were largely unaffected, or recovered quickly. Certain chemical growth regulators have shown potential in the ability control the height of *S. trilobata* (CAB International, 2012).
Origin	Mexico, Central America, the Caribbean Islands (PIER,
Website/Reference	
* three-letter-abbreviation (for data recording purposes only – not the standard taxonomic abbreviation/symbol; e.g. http://plants.usda.gov/index.html)	

CENCHRUS ECHINATUS

TLA*	**CEN**
Local Name	se bulabula
Common Name	*Bur Grass*
Family	Asteraceae
Genus	*Cenchrus*
Species	*echinatus*
Full scientific name	*Cenchrus echinatus*
Synonyms	
Standard taxonomic abbreviation	
Distribution in Pacific	
Growth Habit	grass
PIER WRA	11
Invasiveness Category	3
Decision Tree Result	1E-Eradication is likely to be achieved cheaply and easily within 2-3 years
Height at Maturity	

(metres)	
Time to Maturity (years or months)	An annual **grass**
Pollination method (wind, bat, etc.)	
Flowering period (month(s))	
Time from flowering to seed-set (months)	
Seed Viability (years)	
Number of seeds/square metre	
Dispersal vectors	Seed. Burrs detach easily from the spike and attach to clothing or animals.
Dispersal distance (metres)	
Long Distance Dispersal vectors	
Long Distance Dispersal distance (metres)	
Vegetative reproduction	
Natural Inhibitors to growth	
Management Options	Physical: "The seeds are dispersed by clinging on to clothes or hair of animals. So strict checks are to be made for all clothing entering onto the island provided goats and rats remain off the island. Plants already present need to be physically pulled and destroyed.
Origin	New World, now weedy or invasive in most tropical and temperate countries.
website	

MIKANIA MIKRANTHA

TLA*	**MMK**
Local Name	wa bosucu
Common Name	*mile-a-minute*
Family	Asteraceae
Genus	Mikania
Species	*micrantha*
Full scientific name	Mikania micrantha
Synonyms	
Standard taxonomic abbreviation	
Distribution in Pacific	
Growth Habit	vine
PIER	25

WRA	
Invasiveness Category	2
Decision Tree Result	1C-Target density of plants can be achieved within 5 years cheaply and easily. Subsequent sustained control required to maintain target density is also cheap and easy
Height at Maturity (metres)	
Time to Maturity (years or months)	fast growing, perennial
Pollination method (wind, bat, etc.)	
Flowering period (month(s))	
Time from flowering to seed-set (months)	
Seed Viability (years)	
Number of seeds/square metre	
Dispersal vectors	Seed dispersed by wind or in clothing or hair of animals.
Dispersal distance (metres)	
Long Distance Dispersal vectors	
Long Distance Dispersal distance (metres)	
Vegetative reproduction	Vegetatively reproduces from broken stem fragments. Each node of the stem can produce roots.
Natural Inhibitors to growth	
Management Options	Physical: "The seeds are dispersed by air currents and germinate readily on moist bare soil. Seedlings and established plants are susceptible to chipping or cultivation in dry weather, but the vines root readily when left in contact with moist soil or plant debris.
Origin	
website	

MERREMIA Spp.

TLA*	**MEP**
Local Name	wa damu
Common Name	Merremia
Family	Convolvulaceae
Genus	*Merremia*
Species	*??*
Full scientific name	*Merremia ??* (L.) Merr.

Synonyms	*Convolvulus peltatus* L.*, Ipomoea nymphaeifolia* Blume*, Ipomoea peltata* (L.) *Choisy, Merremia nymphaeifolia* (Dietr.) Hall. fil., *Operculina peltata* (L.) Hall. fil.. *Convolvulus bufalina* Lour., *Convolvulus crispatulus* Wall., *Ipomoea bufalina* Choisy., *Ipomoea petaloidea* Choisy., *Merremia borneensis* Merr., *Merremia bufalina* Merr. and Rendle, *Merremia distillatoria* (Blanco) Merr., *Merremia elmeri* Merr., *Operculina bufalina* Hall. f., *Operculina petaloidea* Ooststr., and *Spiranthera peltata (L.) Bojer (Deroin, 2001 in Kirkham, 2005).*
Standard taxonomic abbreviation	
Distribution in Pacific	American Samoa, Cook Islands, French Polynesia, Marshall Islands, Federated States of Micronesia, New Caledonia, Wallis and Futuna
Growth Habit	Vine
PIER WRA	18
Invasiveness Category	1
Decision Tree Result	3C-Control to a specified density, or containment, is probably feasible with available resources
Height at Maturity (metres)	20 (stems can grow up to 20m long)
Time to Maturity (years or months)	
Pollination method (wind, bat, etc.)	Ants were observed on the corolla of flowers (Kirkham, 2005).
Flowering period (month(s))	
Time from flowering to seed-set (months)	
Seed Viability (years)	
Number of seeds/square metre	
Dispersal vectors	Stem fragments will resprout and root.
Dispersal distance (metres)	
Long Distance Dispersal vectors	Humans (Agriculture: It is sometimes promoted as a means of providing rapid ground cover thus reducing erosion and nutrient losses following disturbance of land). In Vanuatu, possibly introduced by the US Army for military (camouflage) purposes (Bakeo and Qarani, 2005 in Paynter et al., 2006). Humans (accidental transport of seeds in soil) (Kirkham, 2005).
Long Distance Dispersal distance (metres)	
Vegetative reproduction	Stem fragments will resprout and root. Stem fragments (Space, pers. comm., in Paynter et al., 2006). Adventitious rooting from stems (PIER, 2009).
Natural Inhibitors to growth	

Management Options	Preventative measures: Since it requires full sunlight, minimizing disturbance will inhibit growth. A Risk assessment of Merremia peltata for the Pacific region was prepared by Pacific Island Ecosystems at Risk (PIER) using the Australian risk assessment system (Pheloung, 1995). The result is a score of 18 and a recommendation of: reject the plant for import (Australia) or species likely to be a pest (Pacific). Integrated management: It is readily grazed by cattle, which can be used to control the weed. Non-grazed areas could be slashed, hand weeded or sprayed with 2,4 -D or Glyphosate at recommended rates (FAO Technical Bulletin: Vanuatu)." Physical: One option is to exploit its shade intolerance and plant trees to shade it out (Kirkham Undated). This technique , however, is labor intensive in that not only will trees need to be planted, but they must be tended to prevent the vines from growing into the canopy. Hand control is difficult due to resprouting and rooting of stem fragments. Since Merremia peltata requires full sunlight to grow, minimising disturbance will inhibit its growth. It is readily grazed by cattle, which can be used to control the weed. Non-grazed areas could be slashed, hand weeded or sprayed with 2,4 -D or Glyphosate at recommended rates (FAO Technical Bulletin: Vanuatu). Herbicides as 2,4-D, dicamba, triclopyr, picloram and Glyphosate are effective in controlling the weed. Trials have shown Glyphosate to be an effective herbicide for use against Merremia spp., a major weed in forestry plantation areas of the Solomon Islands. Results indicate that 1.5kg a.i./ha would be sufficient (Miller 1982).Chemical: Where they can be applied, such herbicides as 2,4-D, dicamba, triclopyr, picloram and Glyphosate are effective. ""Trials have shown Glyphosate to be an effective herbicide for use against Merremia spp., major weed problems in forestry plantation areas of the Solomon Islands. Results indicate that 1.5kg a.i./ha would be sufficient"" (Miller, 1982). Biological: In Samoa one option for management is simply to do nothing, and allow nature to take its course. As ground cover, M. peltata suppresses non-native weeds that would likely be present as ground cover in its absence (M. micrantha excepted). In the canopy, it helps to hand succession over from pioneer species to those more resembling climax species. Alternatively areas of M. peltata groundcover may be planted first with Macaranga harveyana and later with Cananga odorata, then following up with P. pinnata and other forest species. Scattering seeds, rather than establishing seedlings in nurseries, may be sufficient for this method. The low labor input and its self-maintaining strategy may make this a viable option.
Origin	Native range: In Africa it is native to Madagascar, Mauritius, La Réunion and Pemba Island in Tanzania. In tropical Asia, it is native to Indonesia, Malaysia, the Philippines and northern Queensland, Australia. In the Pacific it is thought to be native to Samoa, Cook Islands, Federated States of Micronesia, Fiji, French Polynesia, the Solomon Islands and Niue (PIER 2005).

website	http://www.issg.org/database/species/ecology.asp?si=163&fr=1&sts=sss&lang=EN http://www.hear.org/pier/species/merremia_peltata.htm

4.2 Impacts

The presence of invasive plant species on a small island such as Monuriki will have great impacts, not only on the composition of the Native dry forest ecosystem, but also on the low population of endemic crested iguanas.

Plants that should be particularly targeted for eradication and prevention from re-introduction due of the threats they pose (based on their behaviour elsewhere) to the health and regeneration of indigenous plants and to iguana and seabird habitat, and as a nuisance to ecotourism, include: mile-a-minute (*Mikania micrantha*), ivy gourd (*Coccinia grandis*), spiked pepper bush (*Piper aduncum*), prickly solanum (*Solanum torvum*), wedelia or trailing daisy (*Sphagneticola trilobata*), and burr grass (*Cenchrus echinatus*).

Consideration should also be given to the selective removal or stopping the spread of the native, thicket-forming shrub, beach privet, **aria** (*Clerodendrum inerme*). Weedy species that could be preserved, which don't seem to be invasive and/or because of their cultural value, often as medicinal plants, and potential value in ecocultural-tourism development include wood sorrel, **totowiwi** (*Oxalis corniculata*); goatweed, **botebotekoro** (*Ageratum conyzoides*); ironweed, **kaukamea** (*Cyanthillium cinereum*); wild daisy, **lusi** (*Tridax procumbens*); and stinking passion flower, **kutai** (*Passiflora foetida*), the seeds of which were probably dispersed in the past by rats, and the fruit of which is a favourite snack food for children and interesting to tourists.

Plants that should be particularly targeted for prevention from becoming established on Monuriki because of their threat to the health and regeneration of indigenous plants, the threat the pose to iguana and seabird habitat, and as a nuisance to ecotourism, include: Leucaena, **vaivai ni vavalagi** (*Leucaena leucocephala*), African tulip tree, **pispis** (*Spathodea campanulata*), giant sensitive plant, **cogadrogadro levu** (*Mimosa invisa*), raintree, **vaivai sirsa** (*Samanea saman)*, silver rain tree, **vaivai ni vavalagi** (*Albizia lebbek*), guava, **guava** (*Psidium guajava*) and redbead tree, **site** or **lera** (*Adenanthera pavonina*). Some priority might be given to the selective removal of two native plants, beach privet, **aria** (*Clerodendrum inerme*), which seems to be spreading out of control on some escarpment and lower coastal open slope locations, and, the potentially invasive thorny climbing vine, beach nicker, **qalausori** (*Caesalpinia major*).

4.3 Benefits of management

The benefits of the management of invasive plant species will be:

- Allow for the faster regeneration of degraded tropical dry forest vegetation, required for re-establishment of crested iguana populations.
- Increased food plants for iguanas.
- Maintenance of high biodiversity of flora.

5. CAN IT BE DONE?

5.1 Technical approach

Removal of a number of the target species is relatively easy due to the low numbers currently observed (*P. aduncum, S. trilobata, C. echinatus, M. micrantha*). Through rigid monitoring (frequent checks throughout the island), the target species can be successfully controlled to zero density. Treatment methods that will be used would be pulling as all target species are small shrubs and vines. Biosecurity and follow up monitoring will be done.

METHOD	***ADVANTAGE***	***DISADVANTGE***
Pulling	**Successful killing of individual plants to prevent resprouting.**	**Some roots and cuttings may be left within the soil allowing for regrowth.**

Past efforts – this is the first attempt to eradicate invasive plants from the island.

5.2 Sustainable

Re-invasion of the target species is not preventable due to the dispersal mechanisms involved (birds & bats, waves and wind), mainly. However, the feasibility of frequent monitoring will assist in controlling to zero density. pathways of major-risk invasives are shown below.

Table ?: Invasive Pathways

Invasive Species	**Source**	**Pathway**	**Risk**	**Prevention Strategy**
Species Name	*Where will be invasive species come from*	*How will it travel to the project site?*	*How severe is the risk: Critical(C)/High(H)/ Medium(M)/ Low(L)*	*How will you prevent the species using the pathway to re-invade*
PAD	Wind/birds/bats	Accidental/deliberate introductions / bat or bird-borne.	M	Biosecurity measures, Ranger patrols
STL	Neighbouring islands (floatation)	Unauthorised landings. Seeds clinging to clothing / equipment.	H	Biosecurity measures, Ranger patrols
CEN	Wind/birds/bats, Introduced animals.	Accidental/deliberate introductions. Seeds clinging to clothing / equipment.	L	Biosecurity measures, Ranger patrols
MMC	Neighbouring islands (floatation), Introduced animals.	Accidental/deliberate introductions. Seeds clinging to clothing / equipment.	M	Biosecurity measures, Ranger patrols
MEP	Wind/birds/bats, Neighbouring	Accidental/deliberate introductions	H	Biosecurity measures, Ranger

	islands (floatation)			patrols

5.3 Socially acceptable

The project is socially acceptable and is supported by all stakeholders. One of the major stakeholders, the local community will be greatly involved as the main Source of labour in physical invasive work. They will also be the main focus of any training workshops to be conducted.

Table ?: Key Stakeholders

Key stakeholders identified so far:

Name	**Affiliation** (e.g. agency, community, youth group etc)	**Contact details**	**Project interest**	**Notes/comments**
Landowners				
Tour operators				
PII				
NTF				

5.4 Politically and legally acceptable

There are no political or legal issues likely to affect this project. The NTF works on Monuriki under full approval from the traditional landowners. All aspects of this project are approved by the Director NTF in close consultation with the landowners. There are no external permits or approvals required. An MOU has been signed by the NTF and Landowners outlining ???

5.5 Environmentally acceptable

The project will have an anticipated net positive impact on the ecosystems and native biodiversity present on Monuriki. The least harmful and most environmentally acceptable treatment methods will be used. This includes the proper (minimal) application of any herbicide used with field staff undergoing specific training on herbicide use. Identify best-practice method for each treatment method in relation to the survival of surrounding native flora/fauna (as the island is a WILDLIFE sanctuary).

5.6 Capacity

All skills required are locally available. Project planners, managers, area expertise, field supervisors, assistants, GIS specialists are all available within the NTF network (includes local university and NGOs). General field workers will be sourced from NTF staff, volunteers and the local community.

There will be no shortage of people available for this field work due to the outstanding opportunity it provides for the local community to assist in conserving a valuable part of their natural heritage. Training requirements?? for such a field team are minimal with plant identification, data recording and biosecurity procedures being the basic skills required.

Table ?: Key Skills needed to complete the project

KEY SKILL	**PURPOSE**	**METHOD TO OBTAIN SKILLS**
Effective herbicide application	Effectively destroy target plants	Training, literature research

	with minimal off-target damage Learn about herbicide, target species	
Planning	Smooth project operation	Use available skills
Report writing	Document project work	Use available skills
GIS	Mapping of forested areas and location of invasives	Use available skills
Planting	Proper planting methods to ensure increased survival of new plants.	Use available skills
Invasive plant identification		Use available skills
Health and safety		

5.7 Affordability

Table ?: Indicative Costs

Item	Details	Cost (US$)
Project Design Stage		
Project Design Stage, Expected cost		
Operational Planning Stage:		
Operational plan compilation	32hrs labour (planning, consultation, liaison, etc for 4 staff x 2 days @57/day)	500
Operational Planning Stage, Sub-total		500
Operational Planning Stage, Contingency (10%)		50
Operational Planning Stage, Expected cost		**550**
Trip 1 logistics and Biosecurity		1500
Trip 2 logistics and Biosecurity		1500
3000		
Implementation Stage (yr 1-5):		
	Field equip	5000
	Transport	15,000
	Field supplies	5000
	Labour	5000
Pre-operational monitoring	Reconnaissance trip	1500
Implementation Stage, Sub-total		31,500
Implementation Stage, Contingency (20%)		6300
Implementation Stage, Expected cost		**37,800**
4 quarterly trips annually	April	25,000
25000		
Sustaining the Project Stage:		

Biosecurity – Set up		1000
Biosecurity – annual running costs		2500
Post-operational monitoring – annual costs		5000
Sustaining the Project Stage running costs for 5 years (A)		7500
Sustaining the Project Stage Set up costs (B)		1000
Sustaining the Project Stage sub-total(C=A+B)		**8500**
Sustaining the Project Stage Contingency (D=20% of C)		**1700**
Sustaining the Project Stage, Expected 5-year cost		**37,800**
PROJECT TOTAL, Expected cost		**$39,500**

6. CONCLUSION

The effective management of invasive plants on Monuriki is entirely feasible within 5 years and at relatively low cost. Keeping the islands free of invasive plant impacts in future is also feasible. It will require a concerted and systematic effort sustained for 5 years to achieve this. It will also require commitment from stakeholders to resource the activity. The environmental benefit of undertaking this project outweighs both the financial costs and the environmental losses from doing nothing.

Table ?: KEY ISSUES

Issue	Recommendation
Maintaining required cash resources	Ensure communication is maintained with stakeholders and reporting and feedback is provided. Sound financial management. Review to demonstrate success after 3 years.
Maintaining commitment over a long project life-cycle	Ensure communication is maintained with stakeholders and reporting and feedback provided. Review to demonstrate success after 3 years
Illegal landings could compromise biosecurity	Clear sign boarding/awareness on YT and in the surrounding area/province on the consequences of illegal landings.

7. REFERENCES

Thaman, R., Niukula, J., Takeda, S. 2012. *The Flora and Vegetation of Monuriki Island, Mamanuca Islands, Fiji, with Recommendations for Conservation and Enrichment-Technical Report.* National Trust of the Fiji, Suva.

Institute of Pacific Islands Forestry. 2013. *Pacific Island Ecosystems at Risk (PIER) Plant threats to Pacific ecosystems.* Online Database < PIER-website/pier/index.html>.

Pacific Invasives Initiative. 2012. *PII Resource Kit for Invasive Plant Management.* Pacific Invasives Initiative, Auckland.

8. APPENDICES

8.1 Biosecurity Checklist

Biosecurity Tasks	**Completed?**	
Have I given clear verbal biosecurity instructions to **all** trip members?	Yes	No
Have I checked they have understood these instructions?	Yes	No
Have any printed instructions been distributed to team members?	Yes	No
Are all supplies (food and equipment) packed in plastic air-tight and insect-proof containers?	Yes	No
List gear too bulky/awkward to fit into containers here: **(Check these items immediately prior to departure!)** • Gear 1 • Gear 2 • Gear 3 • Etc. *Add more as necessary* (Suggestion: treat equipment with insect spray and leave overnight to kill ants and any other invertebrates that could be hiding in gear)	 Yes Yes Yes	 No No No
Has everything been stored in an equipment room in sealed containers? If not, has it been re-checked immediately prior to departure? (Remember 'extras' like boats, radios, day-bags, last-minute items, etc).	Yes Yes	No No
Check with every member of trip: • All food packed in sealed bags? • All fresh food items checked for presence of ants, snails and other invertebrates? • Boots and other footwear clean and free of soil/seeds? • Packs kept in invasive-free areas or checked and re-packed since? • Packs, pockets, Velcro fasteners, socks, etc., clean of seeds? • Has anyone in party worked in area of known invasives infestation recently?	 Yes Yes Yes Yes Yes Yes	 No No No No No No
IF THE ANSWER TO *ANY* OF THE ABOVE IS "*NO*" – **THEN FURTHER ACTION IS REQUIRED!**		
What are the added risks on this trip? • Are any items being stored in areas that are not rodent- or insect-proof? • Are we taking fresh food which may contain ants, insects, soil etc.? • Are we leaving/ travelling at night? • Are there planned stops en-route where invasives could enter or exit? • Do we have bulky or non-invasive proof packages • Is the boat/vehicle we are travelling on invasive-free?	 Yes Yes Yes Yes Yes Yes	 No No No No No No
IF THE ANSWER TO *ANY* OF THE ABOVE IS "*YES*" – **BE AWARE YOUR TRIP HAS EXTRA RISKS!**		

Biosecurity Tasks	Completed?	
Have I addressed these concerns by identifying 'on-the-spot' solutions? (How do I deal with the added risk to minimise potential risk to the site?).	Yes	No
IF YOUR ANSWER TO THIS IS "*NO*", THEN YOUR TRIP SHOULD NOT PROCEED UNTIL YOU HAVE ADDRESSED THESE ISSUES!		
When travelling between sites where known invasives exist, or where invasive species management projects are underway: Are you travelling from the site with the least number of invasive species to the site with the most? If not, are you able to change the order of the visits so that the worst site is visited last?	 Yes Yes	 No No
1. Before leaving a site • Check that all personnel are free of the invasives at the site • Check that all equipment is free of the invasives at the site • Check that all vehicles/boats are free of the invasives at the site	 Yes Yes Yes	 No No No
2. In transit to the next site: If any sign of an invasive is detected while en-route to the new destination, **STOP**! Do not continue to any other site until the problem has been identified and remedial actions implemented. (NOTE: throwing an invasive out the window of a vehicle or overboard from a boat is not good practice. You do not know where it may end up).		
3. On Arrival at Destination: • Have I inspected all containers for rodent, ant or other invasive entry or damage which could allow such? • Has everything been unpacked or opened up and carefully inspected in an open area? • Have I instructed everyone on rules for disposal of organic and other rubbish? • If planning to go to another site from here, have I considered and established how to apply quarantine procedures before we leave? • If on a daytrip only, have I ensured only day-bags are being taken, and that they have been checked, cleaned and packed only on the day of departure?	Yes Yes Yes Yes Yes	No No No No No
IF YOU HAVEN'T DONE THESE TASKS, WHY NOT?! PLEASE DO IT! It is not possible to totally eliminate the risk of accidental introduction of invasive species - short of prohibiting all trips to the site. However risks can be minimised. Any non-compliance with the checklist above means that you are putting the flora and fauna of the site at an unnecessarily increased level of risk. Please do your bit to help preserve the conservation values of the site.		

Biosecurity Tasks	Completed?

8.2 Site Visit Reports

BIOSECURITY CONSULTATIONS 13TH-15TH SEPTEMBER 2012

Baravi Thaman
Jone Niukula

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1. INTRODUCTION

This field site visit was done with the objective to consult with landowners and tour operators regarding biosecurity planning for Monuriki in view of the current state of the island being free of Goats and rodents, and the imminent threat of invasive plants.

2. ACTIVITIES AND OUTCOMES

Activities completed and outcomes realised on this trip included:

- With landowners
    - Meeting with landowners for community consultations on their recommendations and concerns regarding biosecurity. Participants Included taukei Yanuya and two elders who were part of the biosecurity workshop that was facilitated by PII in Suva in 2010.
    - They expressed concern over illegal landings especially from yachties, requesting that they first present a sevusevu in the village before proceeding to Monuriki. The participants explained that the Sevusevu visit will be a good opportunity for them to warn the visitors the biosecurity measures of Monuriki.
    - The subject of biosecurity was well understood amongst the elders who then offered their support towards future planning of biosecurity for Monuriki, in view of the fact that the island has been rid of goats and rodents.

- With tour operators
    - The team met with South Sea Cruises hospitality manager *Elenoa Nimacere* regarding current and future biosecurity measures that would assist in the continual maintenance of the island in being invasive plant and animal free.
    - South Seas Cruises has an agreement with the landowners to take visitors to Monuriki Island.
    - They expressed concern over other unlicensed landings from other operators, as they are supposed to have an exclusive licence. In addition, other operators do not apply biosecurity or other environmental policies as South Sea Cruises do.

3. DISCUSSION

- Landowners request - biosecurity plan for the island is not to hinder tourists visits to Monuriki
- Other projects opportunities with South Sea Cruises
    - Yaqeta old village site assessment – South Sea Cruises will to cover expenses
    - Devuilau Iguana Survey – South Sea Cruises will to cover expenses

4. CONCLUSION AND NEXT STEPS

i. NTF is to draft biosecurity plan – end of October
ii. Biosecurity draft is to be circulated to South Sea Cruises then other tour operators for their perusal – early November
iii. NTF to discuss with Yachting Club on how yachtees can be notified about Monuriki
iv.
v.

MALOLO YOUTH WORKSHOP 8TH – 10TH NOVEMBER 2012

Jone Niukula
Sunia Vuniyayawa

1. INTRODUCTION

A visit was made to Yanuya Village This field site visit was done with the objective to consult with landowners and tour operators regarding biosecurity planning for Monuriki in view of the current state of the island being free of Goats and rodents, and the imminent threat of invasive plants.

2. ACTIVITIES AND OUTCOMES

Activities completed and outcomes realised on this trip included:

- With landowners
    - Meeting with landowners for community consultations on their recommendations and concerns regarding biosecurity. Participants Included taukei Yanuya and two elders who were part of the biosecurity workshop that was facilitated by PII in Suva in 2010.
    - They expressed concern over illegal landings especially from yachties, requesting that they first present a sevusevu in the village before proceeding to Monuriki. The participants explained that the Sevusevu visit will be a good opportunity for them to warn the visitors the biosecurity measures of Monuriki.
    - The subject of biosecurity was well understood amongst the elders who then offered their support towards future planning of biosecurity for Monuriki, in view of the fact that the island has been rid of goats and rodents.

- With tour operators
    - The team met with South Sea Cruises hospitality manager *Elenoa Nimacere* regarding current and future biosecurity measures that would assist in the continual maintenance of the island in being invasive plant and animal free.
    - South Seas Cruises has an agreement with the landowners to take visitors to Monuriki Island.
    - They expressed concern over other unlicensed landings from other operators, as they are supposed to have an exclusive licence. In addition, other operators do not apply biosecurity or other environmental policies as South Sea Cruises do.

3. DISCUSSION

- Landowners request - biosecurity plan for the island is not to hinder tourists visits to Monuriki
- Other projects opportunities with South Sea Cruises
    - Yaqeta old village site assessment – South Sea Cruises will to cover expenses
    - Devuilau Iguana Survey – South Sea Cruises will to cover expenses
    -

4. CONCLUSION AND NEXT STEPS

vi. NTF is to draft biosecurity plan – end of October

vii. Biosecurity draft is to be circulated to South Sea Cruises then other tour operators for their perusal – early November

viii. NTF to discuss with Yachting Club on how yachtees can be notified about Monuriki

Monuriki Visit Report 11th – 14th March, 2013

1 INTRODUCTION

A visit was conducted to Monuriki Island on 11th – 14th March, the first for the year involving a feasibility study for the removal of weeds from the island and community consultation regarding habitat rehabilitation and biosecurity.

The specific objectives of the field visit were:

- **I.** Discuss project updates with landowners and local community
  - **i.** Present results from 2012
    - **a)** Captive breeding
    - **b)** Vegetation Survey
  - **ii.** Plans for this year
  - **iii.** Introduce NFMV
- **II.** Conduct feasibility study for the removal of identified invasive weeds in Monuriki Island
  - **i.** Map weed distribution and size
  - **ii.** Prioritize weeds
  - **iii.** Confirm weed treatment dates
- **III.** Conduct a presence/absence observation of goats that may have survived the 2011 goat removal program
- **IV.** Take photos from photopoints to monitor re-growth of vegetation after goat and rodent removal

2 FIELD VISIT

The team left Suva on Monday, 11th March intending to board the 5pm South Sea Cruises ferry that leaves Denarau Marina. Upon arrival in Denarau, we were advised that the 5pm ferry was cancelled due to changing schedules surrounding the restoration of resorts in the Mamanuca Group that were devastated by Cyclone Evan in December, 2012.

The holdup provided us with a good opportunity to discuss the objectives of the visit and re-assess management options to be recommended to the landowners. We also discussed on sharing responsibilities for proposed activities on Monuriki on this trip to accommodate the limited time caused by the delay. The night was spent at the Travellers Holiday Apartments.

The team caught the 12pm ferry to Mana then hired a boat to transfer us to Yanuya Village. That afternoon was spent on discussions with the chief, other landowners, members who were trained in biosecurity and the local school head teacher.

On Wednesday, two teams were established for work on Monuriki. The first, which included the Jone Niukula, Baravi Thaman and Joeli Vadada visited all priority sites around the island conducting the feasibility study. The second group, which was headed by Momi Ranger, Sunia Vuniyayawa included two ladies and three men from the landowning unit. They experimented with hand-pulling of two identified invasive weeds; Sphagneticola/Wedelia trilobata and Cenchrus echinatus that occur on two beaches.

There was no further discussions in the evening with landowners due to exhaustion from the day's work. However, the Tatau was presented before the team departed on Thursday morning.

The visit was funded under the CEPF grant.

3 OUTCOMES

1. Crested iguana captive breeding programme update

Landowners were updated on the progress of the captive breeding programme at Kula Eco Park

- 20 original iguanas
- 21 juveniles bred in captivity
- 14 eggs incubating
    - 4 each from two iguanas laid on 19th February
    - 5 eggs laid on 1st March
- Kula and NTF exploring for further funding for extension of holding facility

The chief was overjoyed with this news of the successful breeding in captivity of their iguanas, which will eventually be translocated back to their original habitat on Monuriki. 2015 has been earmarked for this translocation to take place.

The Taukei Yanuya, chief landowner requested the Trust to accommodate a visit to Kula. His request was agreed to. The visit date can be planned to coincide with a trip to Monuriki by NTF.

2. Nursery Establishment

The native trees nursery will be constructed at the local school. The head teacher has agreed to this as it will be relevant to certain subjects where classes will be organized to participate in its management.

The nursery will be constructed in the next visit to the island. The chief requested for Yasi seedlings to be included.

3. Priority Reforestation Sites

Sites targeted for reforestation is Savusavu Beach, where tourists boats land. The landowners expect some planting to be conducted on Rogua Beach as the current vegetation is dominated by *Neisosperma oppositifolium*, which is not edible to iguanas.

The landowners were requested to select sites on Yanuya Island, where the reforestation program can be extended to. The Taukei Yanuya informed us that most of his Mataqali land on Yanuya were already been utilized for agriculture. However, the building of the nursery at the school will in itself extend its services to other landowning units.

4. Feasibility Study

It was apparent that the invasives highlighted by Randy and Shingo are behaving accordingly and should be taken care off immediately. Cyclone Evan that occurred in December, 2012 may have made matters worse for two reasons;

i. Assisting the dispersal of seeds
ii. Burying invasive plants roots deeper making it more difficult to uproot – especially those on sandy beaches

These are species and sites assessed during the trip;

Species	Location					Comments
	Rogua	Launatovuto	Savusavu	Nawai	Vabeagau	
Sphagneticola/ Wedelia trilobata	√	√	√			Outpost
Mikania micrantha			√	√		Both inland… east Nawai Beach
Piper aduncum	√		√			Both inland
Xanthium pungens	√					NW Rogua – inner beach
Axonopus compressus						
Caesalpinia major		√				Inland from Launatovuto
Coccinia grandis				√	√	Lower slopes
Solanum torvum	√			√		East Nawai
Cenchrus echinatus	√					Sandy inner parts of the north part of

						Rogua Beach
Clerodendrum inerme (Control only)		√		√	√	Open areas inland
Lantana camara	√					Disturbed inner beach at northwest Rogua

A proper feasibility report will be formulated and submitted to ensure proper actions are planned for control and eradication.

5. NatureFiji/MareqetiViti

It was discussed to the landowners that all projects where BirdLife International are involved in locally, including the Monuriki Project will now be run by NFMV. Monitoring of shearwater and rodents on Monuriki Island will be conducted by them in the near future.

In the discussions, we agreed to request to NFMV to erect a board on Monuriki Island illustrating biosecurity measures.

6. Goat Monitoring

There were no signs of goat presence on the island, showing that the eradication activity has been successful. Other evidence of its success is the high number of plant seedlings observed in all areas of the island, in addition to many other species starting to appear, not having been seen in the presence of goats.

4 DISCUSSIONS

Apart from the various project work and objectives set out for this field visit, a number of other issues were discussed.

7. Boat and Ranger

It is clear that the Taukei Yanuya, Mr. Sitiveni Drigi, is well aware of the conservation project and its goals. He has requested if the Trust can assist them in purchasing a patrol boat to police the island especially after 2015 when iguanas from Kula are translocated back to the island. He is concerned about yachtees who anchor beside the island and the threat they put to the island, in terms of smuggling of iguanas and introduction of unwanted plants and animals. He appreciates the involvement of Joeli Vadada stating that the boat can be utilized by him to check on yachtees and other visitors.

8. Visit to Kula

Hearing the successful breeding of Monuriki iguanas at Kula, the Taukei Yanuya has specifically requested for a visit to the captive breeding facility.

5 RECOMMENDATIONS

9. Next Visit

The following activities have been agreed to be conducted during the next visit;

i. Building of nursery
    a. Training in nursery running
    b. Seedling collection
ii. Control/eradication of prioritized species in prioritized sites
iii. Erection of biosecurity signboard on Monuriki Island
    a. Discuss with South Sea Cruises beforehand
    b. Request NFMV for funding
iv. Visit by the Taukei Yanuya to Kula

10. Biosecurity

- Meeting with Stakeholders planned for April
- Will be attended by Mataqali members who were trained in Biosecurity

6 CONCLUSION

In conclusion, apart from some drawbacks in transportation, this trip proved to be successful in that the majority of objectives initially set out were achieved. Most importantly, the assessment of invasive weeds, the relaying of the current project status to landowners, the agreement achieved in the construction and management of nursery, and the continued non-observation of goat presence.

The Flora and Vegetation of Monuriki Island

The Flora and Vegetation of Monuriki Island, Mamanuca Islands, Fiji, with Recommendations for Conservation and Enrichment

by

Randy Thaman, Jone Niukula and Shingo Takeda

National Trust of the Fiji Islands and funded by the Global Environment Facility Small Grants Program

Suva, Fiji

August 2012

Acknowledgements

The authors would like to acknowledge the hospitality, warmth and assistance of the people of Yanuya Village, the traditional owners of Monuriki Island. In particular, we would like to thank the Taukei Yanuya, Sitiveni Drigi, the high chief and traditional leader of Yanuya, and his family for their and hospitality and making us part of their extended family; Volunteer Ranger of Monuriki, Joeli Vadada, who acted as our guide and primary informant; two other informants, Mitieli Bale and Maciu Lete, who assisted as guides and informants on the flora and the local Yanuya names for plants; and boatsmen, ? and ? who looked after our sea transport and safety at sea. We also wish to thank Dr. Gunnar Keppel, Senior Lecturer in Environmental Biology at the University of South Australia, for supplying us with the manuscript of his 2004 Monuriki study; and Dr. Art Whistler, eminent Pacific botanist and ethnobotanist and Adjunct Professor at the University of Hawai'i, and Marika Tuiwawa, Curator of the South Pacific Regional herbarium, for their assistance in identifying some of the plants.

We would also wish to give thanks to the National Trust of Fiji, The University of the South Pacific and the Global Environment Facility (GEF) Small Grants Programme for their support and assistance.

To all of you, a big *vinadu riki* and apologies for any inaccuracies, particularly in relation to local Yanuya names, which we shall try to rectify with feedback.

Sincerely

Randy Thaman, Jone Niukula and Shingo Takeda

Suva, Fiji, August 2012

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Table 2. Rare or ecologically and culturally important trees or plants that should be gazetted, mapped, given some form of protection or planted because of their importance as iguana or bird habitat and food sources
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EXECUTIVE SUMMARY`

The report provides information on: the current status of the flora and vegetation of Monuriki Island in the Mamanuca Islands in northwestern Fiji; non-indigenous plants, many of which could become invasive species on the island; species that have returned or might return to abundance in the absence of goats and rats; species that should be made priority in vegetation and wildlife conservation and restoration efforts on the island; and recommended areas for action and suggested conservation and promotional activities. The analysis is based fieldwork conducted on the Monuriki from 9 to 11 July 2012, during which intensive reconnaissance and sampling surveys were conducted over most of the island and digital photos taken of almost all plant species and vegetation types. Reference is made to, and the results combined with, a previous study carried out by Gunnar Keppel on 8 June 2004, during which he was able to survey the northern portion of the island and identify some 40 indigenous species. At the time, he suggested that the grazing of goats on Monuriki "seems to be leading to an ecological disaster (Keppel 2004). In November, 2011 goats and Polynesian rats (*Rattus exulans*), both of which have certainly had long-term impacts of the vegetation and associated wildlife, had been successfully eradicated from the island.

The 2012 survey shows that the main vegetation types are tropical dry forest and woodland; *Casuarina* woodland and savanna; coastal lowland forest and woodland; coastal littoral forest

and shrubland; coastal littoral herbland; and, limited areas of disturbed ruderal vegetation; and that the total reported vascular flora of the island stands at about 121 species, of which 95 are assumed to be indigenous and 26 non-indigenous introductions. Of the 95 indigenous species, only 40 were listed by Keppel (2004) or Keppel or Tuiwawa (2007), and only 2 were not seen during the more extensive 2012 survey.

The main findings are that: 1) inland indigenous overstory vegetation of the island is relatively intact, but still lacking significant understory growth due to decades of goat grazing and browsing on the island and, almost certainly, the predation of fruits and seeds by rats; 2) there is now significant, often spectacular, regeneration of seedlings of many species, in both inland and coastal vegetation types; 3) there is some good remaining coastal littoral vegetation, but some economically and culturally valuable species are rare because they have either been removed over time or have always been rare; 4) there has been spectacular regeneration of coastal littoral herbaceous and small shrubby species and some evidence of the arrival of drift seedlings and saplings of common, ocean dispersed, coastal littoral species; 5) there are probably a number of coastal herbaceous and shrubby plants that were formerly present but which have been long absent because of goats, which should be put on alert for return; 6) there has been a very significant increase in the abundance and number of fern species, which are good indicators of the recovery of the pre-goat indigenous understory flora of the island; 7) there are many, previously unreported non-indigenous (introduced) weedy species, some of which are very invasive and should, if possible, be immediately eradicated because they pose threats to conservation; 8) there are some aggressive indigenous species, which in the absence of goats, could become excessively weedy and are spreading to form almost impenetrable thickets; 9) there are some potentially invasive plants, not currently seen on the island, but which should be prohibited from becoming established on the island.

Specific recommendations for action on Monuriki are made in terms of: 1) priority plants for protection and replanting; 2) invasive species that should receive priority for eradication and prevention of the spread; 3) the development of a number of scenic and educational nature and ecotourism or ecocultural trails or tracks; 4) considering Monuriki for nomination as a Ramsar Wetland site of international significance; and, 5) potential promotional and awareness raising activities

1 INTRODUCTION

The report includes information on: 1) the current status of the flora and vegetation of Monuriki Island in the Mamanuca Islands in western Fiji; 2) the nature of non-indigenous plants, many of which could become invasive species on the island; 3) species that have returned or might return to abundance in the absence of goats and rats; 4) species that should be made priority in vegetation and wildlife conservation and restoration efforts on the island; and, 5) and recommended areas for action and suggested activities. The analysis and findings are based fieldwork conducted on the Monuriki from 9 to 11 July 2012, during which intensive reconnaissance and sampling surveys were conducted over most of the island and digital photos taken of almost all plant species and vegetation types. Reference is also made to, and the results combined with, a previous study carried out by Gunnar Keppel on 8 June 2004, during which he was able to survey the northern portion of the island and identify 40 indigenous species. At the time, he suggested that the grazing of goats on Monuriki "seems to be leading to an ecological disaster (Keppel 2004). In November, 2011 goats and Polynesian rats (*Rattus exulans*), both of which have certainly had long-term impacts of the vegetation and associated wildlife, had been successfully eradicated from the island.

As was the case for Keppel's 2004 study, which was conducted about 7 years prior to the removal of goats and rats, special emphasis is placed establishing a baseline for future post-goat and -rat eradication assessments of floristic and vegetation changes and conservation outcomes, against which recommendations can be made to protect rare or threatened species, manage or eradicate invasive species and plant priority species in efforts to enrich the post-goat vegetation and fauna of Monuriki. In doing so, major differences, which have occurred over this period are highlighted. Some of these may be explained by either the continued presence of goats between the time of Keppel's 2004 survey and the eradication of goats in late 2011; the greater sampling and survey effort in 2012; or by rapid re-growth after goat and rat eradication, which has probably been aided by the very high rainfall during the first half of 2012:

Monuriki (known locally as Modriki) is a small, but spectacularly rugged, mountainous island surrounded by white-sand beaches and rocky headlands. It has an estimated total area of about 45 ha and is about 1.1 km long by 500 m wide at its widest point and oriented in an east-west direction. Much of the center of the island is composed of steeply sloping land and escarpments, vertical cliff faces and rocky outcrops. Along the coast there are two main beaches, Savusavu Beach on the far eastern end of the island and Rogua Beach on the southwestern part of the island, and a number of smaller beaches in coves bounded by rocky headlands on the north coast, beginning with Launatavuto Beach in the northwest and including, to the east, two beaches and associated headlands, both known as Vabeagau, and two beaches plus headlands known as Nawai. There are five offshore islets, two off of the

southwest coast and three off of the eastern tip of the island, the largest of which is known as Yanuyanu Sewa ('little island").

Monuriki is also one of the few islands where the endemic Fiji crested iguana, **vokai** (*Brachylophus vitiensis*), is still found naturally, although years of goat grazing and browsing and rats on the island have left the iguana population at a critically low level. The island also has among the largest breeding colonies of the threatened wedge-tailed shearwater, **manumanu ni Modriki** (elsewhere in Fiji: **gāgatitavea, gātuavekaveka** and **gū**) (*Puffinus pacificus*); and is one of the last remaining islands in the Pacific with breeding populations of the threatened peregrine falcon, **gānivatu** (*Falco peregrines*), which has active eyries (nests of falcons, eagles and other birds of prey) on the rocky peaks of the central part of the island. The long-resident Polynesian rat population has, as reported in other areas of the Pacific, undoubtedly had negative impacts on the wedge-tailed shearwater and other bird populations and on the regeneration of plants.

2 VEGETATION AND FLORA

2.1 Vegetation Types

The main vegetation types on Monuriki include: 1) tropical dry forest and woodland; 2) *Casuarina* woodland and savanna; 3) coastal lowland forest and woodland; 4) coastal littoral forest and shrubland; 5) coastal littoral herbland; and, 6) limited areas of disturbed ruderal vegetation. The vegetation types identified by Keppel (2004) were beach forest, coastal deciduous (dry) forest and *Casuarina equisetifolia* savanna, the latter two being roughly equivalent to tropical dry forest and woodland and *Casuarina* woodland and savanna. As stressed by (Keppel and Tuiwawa 2007), tropical dry forests constitute one of the most highly threatened ecosystems in the Pacific region. On Monuriki, the vegetation has, over decades been seriously impacted by resident goat populations, the most widespread impacts of which seem to have been the elimination of most palatable understory species (including most seeds, seedling and saplings) in all vegetation types, the elimination of edible coastal herbs, vines, shrubs and drift seedlings and saplings; and, if Keppel's study is correct, a great majority of all herbaceous introduced fast-growing herbaceous species, including ferns, grasses, sedges, vines and other small edible shrubs. These vegetation types will be discussed in detail after the discussion of the flora.

Where possible, common names, local Yanuya, Mamanuca or Fijian names, and the scientific names will be used throughout most of the discussion to make the report useful and understandable to as wide a range of people as possible, especially local scientists, students and community members.

2.2 Current Flora: The total reported vascular flora of Monuriki stands at about 121 species, of which 95 are assumed to be indigenous and 26 non-indigenous introductions (Table 1, Appendix A). Of the 95 indigenous species, only 40 were listed by Keppel (2004) or

Keppel or Tuiwawa (2007), and only 2 of which were not seen during the more extensive 2012 survey. None of the non-indigenous and many of the indigenous coastal littoral species, particularly herbaceous species, where recorded by Keppel, presumably due to the emphasis of his study on indigenous forests species and the apparent return to abundance of many indigenous and non-indigenous herbaceous species since goat and rat eradication in late 2011 and the very heavy rains during the first half of 2012. The nature of some these "new" species is discussed immediately below, whereas the discussion of most of the dominant woody species is included in the discussion of the main vegetation associations.

Table 1. The total number of indigenous and introduced vascular plant species reported present on Monuriki Island by Keppel in 2004 and Thaman *et al*. in 2012 (Note: the numbers in brackets indicate those species reported by Keppel, but not seen in 2012; the actual species by family and species are listed in Appendices I and II).

Taxa	Keppel -2004		Thaman *et al*. 2012		Grand Total		
	Indig.	Intro.	Indig.	Intro.	Indig.	Intro.	Total
Ferns	3		11		11		11
Monocotyledons	3		10	9	10	9	19
Dicotyledons	34 (2)		72	17	74 (2)	17	91
Total	40 (2)	0	93	26	95 (2)	26	121

2.2.1 Ferns: When Keppel visited the island, he reported only three ferns, all of which were reportedly rare and found only in deciduous forests near the highest points of the island. The current study found 10 ferns, all native, five of which are reportedly present in dry forest on other islands in Fiji by Keppel and Tuiwawa (2007). This seems to be clear evidence that ferns had been heavily predated by goats and may be returning to or increasing abundance on the island. (See Appendices I and II).

2.2.2 Monocotyledons: Whereas Keppel (2004) reported only three monocotyledons, the coconut palm, **niu** (*Cocos nucifera*) and pandanus, **vadra** (*Pandanus tectorius*), and an unidentified yam (*Disocorea* sp.)(now identified as the air yam (*Dioscorea bulbifera*), the July 2009 study indentified 16 additional species, bringing the total of monocotyledons to 19, 9 of which are recent introductions.

Coconut palm, **niu** is common to locally abundant in plantations on the coastal flats inland from the main beach ridges, such as behind Savusavu, Rogua, Launatavuto Beaches; and

pandanus, **vadra**, which is occasional to common in coastal littoral forests. The air or bulb yam, **vitua ni vikaikai** (*Dioscorea bulbifera*), which was detected by Keppel (2004), was seen to be a common seasonal component of the lower open slope forest and woodland, particularly on the southeastern part of the island.

Indigenous monocotyledons, not reported by Keppel, include: 1) the climbing taro vine, **yalu** (*Epipremnum pinnatum*), a common vine throughout inner coastal forests throughout Fiji, which was seen on a cliff face behind northwest Rogua Beach and on a lowland forest tree inland from southeast Rogua; 2) three sedges, *Eleocharis geniculata*, *Mariscus javanicus* and *Scleria lithosperma*, the latter two of which are reported present in tropical dry forest on other islands in Fiji; 3) four indigenous grasses, including the common coastal species, *Lepturus repens, Thuarea involuta* and *Paspalum distichum*, and *Digitaria setigera*, an apparently native grass that is found in disturbed open sites further inland.

Introduced species not reported by Keppel (2004), include burr grass (*Cenchrus echinatus*), citronella grass (*Cymbopogon refractus*), large crabgrass (*Digitaria* cf *ciliaris*), Natal grass or Natal redtop (*Melinus repens*), and mission grass (*Pennisetum polystachyon*), all of which were seen in more open disturbed sites; and basket grass (*Oplismenus compositus*), which is found in shadier sites in the understory of slope forest. All of these have probably become re-established or increased in abundance since goat and rat eradication.

Although not seen during either the 2004 or 2012 surveys, Polynesia arrowroot, **abia** (*Tacca leontopetaloides*), was reported by our two local informants to be present, and it is common in similar coastal lowland habitats on uninhabited offshore islands throughout Fiji. It is a seasonal herb that will probably increase in abundance in the future.

2.2.3 Dicotyledons: Indigenous dicotyledons not reported by Keppel include a range of common indigenous coastal herbaceous or shrubby species; a number of widespread coastal shrubs and trees; and a wide range of introduced herbaceous and small woody species, some of which are very invasive.

The indigenous herbs, many of which have probably re-established since the eradication of goats include: prickly chaff-flower, **sorisoritavē** (*Achyranthes aspera*); beach sunflower, **cikawa** (*Wollastonia biflora*), a common coastal littoral shrub and a very important medicinal plant; four indigenous morning-glories, the common beach morning-glory, **wa vulavula** (*Ipomoea pes-caprae*), coastal morning-glory, **wa ni sovivi** (*I. littoralis*), wild moonflower, **tovici** (*I. macrantha*), all coastal species, and blue morning-glory, **wa ni sovivi** (*I. indica*), which grows more commonly in inland coastal thickets; 4) beach spurge (*Chamaesyce atoto*), a common, often ephemeral, species in herbaceous beach vegetation; 5) the common coastal legumes, rosary bead, **lele** (*Abrus precatorius*), which was found just inland from Savusavu Beach, beach nicker, **qalau sori** (*Caesalpinia bonduc*), which was found as a single seedling inland from south Rogua Beach, silky seabean, **rautolu** (*Canavalia sericea*), found growing on the upper outer beach ridge on both Savusavu and Rogua

Beaches, fish poison plant, **samiti**? (*Tephrosia purpurea*), a woody herb or sub-shrub found growing in pocket of soil on open scree slopes; and the beach pea, **rau tolu** (*Vigna marina*), a common creeping and climbing vine in coastal littoral vegetation;

Shrubs and trees not reported by Keppel during his 2004 north coast surveys, but probably always present, include: beach mahogany or tomano, **dilo** (*Calophylllum inophyllum*), a rare tree seen as a very large individual in slope forest above the southeastern end of Rogua Beach and in the slope forest above the southcentral coast; scaevola or half-flower, **dredre** (*Scaevola taccada*), of which there were numerous seedlings and some mature shrubs along the main protected beaches; hernandia or Chinese lantern tree, **buevu** (*Hernandia nymphaeifolia*), mature individuals of which are found on Rogua, Launatavuto, Vabeagau and Nawai Beaches and a large stand along the southeast end of Rogua Beach; cannonball or puzzlenut tree, **leqileqi** (*Xylocarpus moluccana*), which was found on rocky outcrops in the outpost zone of a number of beaches; Portia or Thespians tree, **wiriwiri** (*Thespesia populnea*), which was seen as a mature tree in the outpost zone of southeastern Savusavu Beach and in the inner beach vegetation on northwestern Rogua Beach; a number of large banyan trees, **baka** or **baka ni Viti** (*Ficus obliqua* and *F. prolix*), which were occasional along the lower escarpment inland from south Rogua Beach and on some cliff faces, plus other member of the fig family, **masimasi** (a creeping vine, probably *Streblus pendulinus*), all three of which are mentioned as present by Keppel and Tuiwawa (2007) as components in dry forests elsewhere in Fiji; common inner coastal species, **qeniqoro** (*Eugenia reinwardtiana*) and **dakadaka** (*Syzygium richii*), both occasional in coastal or inland coastal vegetation near the base of the lower escarpment, mainly inland from the southwest coast, an area not surveyed by Keppel (2004); and the important bird rookery species, pisonia or bird-catcher tree, **touto** (*Pisonia grandis*), which is relative common on the lower escarpment and on rises behind the coastal plain of Rogua Beach, but also behind the east end of Launatavuto Beach; phaleria, **tokotoko ni vevewa** (*Phaleria disperma*), which was seen in lower slope forest some 15 m from the coast near the southeast end of Rogua Beach; beach burr (*Triumfetta procumbens*), a common littoral species on beaches, which was seen only on northwest Rogua Beach; two, normally secondary forest species, stinging tree nettle, **salato** (*Dendrocnide harveyana*), which was seen in inner coastal and opening in slope forest at a number of locations, and pipturus (*Pipturus argenteus*), the latter found as a shrub inland from north Savusavu Beach; and two Verbenaceae, beach elderberry, araro (*Premna serratifolia*) and blue vitex or beach vitex, **drala** (*Vitex trifolia*), the latter which is occasional in coastal littoral vegetation and dominant in the young regrowth on southwestern Rogua Beach. Many of these plants, especially the smaller shrubs, had probably been removed by goats and could be expected to increase in abundance with the eradication of goats.

Species seen as only small drift seedlings or saplings that could be part of replanting efforts include fish poison tree, **vutu** (*Barringtonia asiatica*), cordial, **nawanawa** (*Cordia subcordata*), and native soapbush or hoop withe, **vuso levu** (*Colubrina asiatica*).

One species that Keppel seems to have left out of his 2004 list and Keppel and Tuiwawa's 2007 list, is **tibuci** (*Tabernaemontana pandacaqui*), one of the most dominant shrubs throughout the more open woodlands and scrub on the island. Given his description this was probably mistaken for *Alyxia bracteolosa*.

Introduced dictoyledons not reported by Keppel, include: fast-growing introduced members of the daisy family (Asteraceae), goatweed, **botebotekoro** (*Ageratum conyzoides*), ironweed, **kaukamea** (*Cyanthillium cinereum*, formerly *Vernonia cinerea*), wild daisy or coast buttons, **lusi** (*Tridax procumbens*), Emilia or lilac tassel flower (*Emilia sonchifolia*), Noogoora burr, **dodobaigani** (*Xanthium pungens*), and two very invasive species, mile-a-minute (*Mikania micrantha*) and wedelia or trailing daisy (*Sphagneticola trilobata*), both of which should be eradicated immediately; the introduced ivy gourd (*Coccinia grandis*), which has escaped and is a very invasive woody vine (liana) in Sigatoka Sand Dunes National Park coastal forests; two spurges, *Chamaesyce hirta* and *C. prostrata*, the former which is quite common in disturbed open sites and on inner beaches; yellow wood sorrel, **totowiwi** (*Oxalis corniculata*), an edible herb, which is a very important medicinal plant for children; stinking passionflower, **kutai** (*Passiflora foetida*), a vine with an edible fruit seen present in a number of sites, such as just inland from the east end of East Nawai Beach; the very invasive; spiked pepper bush (*Piper aduncum*), single plants of which were seen inland from the main beaches at Rogua and Savusavu; prickly solanum, **soni ni vavalagi** (?) (*Solanum torvum*); waltheria or velvet leaf (*Waltheria indica*), which was found in on open rocky sites on a ridge between Launatavuto and Vabeagau and on the rocky crossing between West and East Nawai Beaches; and lantana, **lanitana** (*Lantana camara*), which was seen only as a single seedling on a disturbed inner beach at northwest Rogua.

The Tahitian chestnut, **ivi**, (*Inocarpus fagifer*), along with breadfruit, **kulu** (*Artocarpus altilis*), were found, apparently the result of deliberate planting, in a protected area of the coastal plain inland from southeast Rogua Beach.

2.3 Vegetation

As stressed above, the main vegetation types on Monuriki include: 1) tropical dry forest and woodland; 2) *Casuarina* woodland and savanna; 3) coastal lowland forest and woodland; 4) coastal littoral forest and shrubland; 5) coastal littoral herbland; and, 6) limited areas of disturbed ruderal vegetation. In this classification, forest refers to stands of trees with a closed canopy; woodland to areas of "open forest" where tree cover (cover abundance) is over 50%, with the area between tree cover consisting of herbaceous or shrubby species or bare substrate without vegetation cover; and savanna (in Keppel's classification) as areas where scattered trees make up less that 50% cover. In many sites these "cover abundance" classifications grade into one another and are difficult to differentiate as mapped entities.

2.3.1 Tropical Dry Forest and Woodland: In terms of structure and composition, tropical dry forest and woodland ranges from more species-rich closed forest on more protected sites

on, and near the base of, island slopes and escarpments, to almost mono-specific or less species-rich closed forest or woodland or, as Keppel suggests, *Casuarina* savanna on the more exposed drier slopes and upper ridges, terrace areas and some offshore islets.

By far the most extensive forests on the islands are the *Arytera brackgenridgei* (**marasa**), *Arytera – Diospyros* spp. (**kei lō**) and *Arytera – Casuarina equisetifolia* (**nokonoko**) closed forests. In more open and exposed woodland sites, dominant species include *Mallotus tiliifolius* (**yaqwata**), *Homalium vitiense* (**tura**), *Manikara dissecta* (**bausom**) and *Gyrocarpus americanus* (**madora**), the later forming impressive woodlands on upper ridges, such as to the northwest of the northwestern end of Savusavu Beach.

On the lower, more-protected slopes, such as on the lower slopes and inner portions of the coastal plain, *Burkella richii* (**bau**), *Pisonia grandis* (**touto**), *Ficus* spp. (**baka**) and *Hibiscus tiliaceus* (**vau**) dominate. Also common to occasional, in more protected areas is *Planchonella grayana* (**qalaka**). Other, less common, species found in this association include *Eugenia reinwardtiana* (**qeniqoro**), *Excoecaria acuminata* and *Drypetes vitiensis*.

Trees reported present by Keppel in 2004, but not seen in 2012 include *Vavaea amicorun* and beach walnut, **tosiga** (*Pongamia pinnata*), both important crested iguana trees and cultural plants, and plants that should be made priority for replanting efforts.

Common shrubby species, which according to Keppel are very dominant, possibly due to their unpalatability to goats, are **tavatava ri gwata** (*Maesa persicifolia*), **mudu**? (*Wikstroemia foetida*), and **tibuci** (*Tabernaemontana pandacaqui*), the latter which, although very common throughout open woodlands and open slope vegetation, seems to have been mistaken for *Alyxia bracteolosa* by Keppel during his 2004 study. A number of seedlings and saplings of stinging nettle tree, **salato** (*Dendrocnide harveyi*), a pioneer tree species not mentioned by Keppel in 2004, were also seen in a number of locations in 2012.

Common vines in the forest include the scrambling, arching and high climbing beach privet, **aria** (*Clerodendrum inerme*), which forms increasingly impenetrable thickets, mostly in rocky areas; derris vine, **tuva** (*Derris trifoliata*); *Parsonsia laevis*; *Tylophora brackenridgei*; the thorny creeping caper, **kadrukadru vatu** (*Capparis quiniflora*), which is seen climbing along the ground over rocks and on lower cliff faces; and the air yam, **vitua ni vikaikai** (*Dioscorea bulbifera*). An uncommon vine that will probably increase in abundance with the removal of goat browsing is the taro vine, **yalu** (*Epipremnum pinnatum*)

Understory species that are more common in more open woodland sites include the sedge, **o selesele** (*Scleria lithosperma*) and a range of ferns, mentioned above, which will undoubtedly all increase in abundance in the future. Weedy species seen in the more open rocky areas include Natal grass (*Melinus repens*), citronella grass, **o cagicagi** (*Cymbopogon refractus*) and mission grass, **volisi** (*Pennisetum polystachyon*); and fish poison plant (*Tephrosia purpurea*).

2.3.2 *Casuarina* Woodland and Savanna: The vegetation on the bare rock summits, cliff faces, rocky promontories, headlands, and smaller offshore islets, such as Yanuyanu Sewa, off of the eastern end of Savusavu Beach, is dominated almost entirely by casuarina trees, **yau** (*Casuarina equisetifolia*, although *Casuarina* is also scattered throughout many areas of slope forest and woodland, especially on the upper slopes. This is particularly true on the rocky offshore islets which are dominated by monospecific stands of *Casuarina* woodland or savanna. Although there seems to be little or no understory and an accumulation of casuarinas "needles" (leaves), this is a situation that might change with the eradication of goats.

2.3.3 Coastal Lowland Forest and Woodland

Coastal lowland forest and woodland is found in sandy sites inland from the more exposed coastal littoral vegetation and constitutes the main nesting sites for the wedge-tailed shearwater. It is dominated almost entirely by **vao** (*Neisosperma oppositifolium*) and by *Neisosperma* and coconut palms, **niu** (*Cocos nucifera*), in more extensive inland sites, such as the coastal plain areas inland from south Rogua Beach, Launatavuto Beach and Savusavu Beach, although most of the coconut palms were deliberately planted in the past as copra plantations. Other common to occasional species include tropical almond, **tivi** (*Terminalia catappa*), beach hibiscus, **vau** (*Hibiscus tiliaceus*) and pisonia, **touto** (*Pisonia grandis*) which are found along the inner margins the plain near the base of the lower escarpment, as are occasional banyan trees, **baka** (*Ficus* spp.). In more open sites, such as the areas behind Nawai Beaches, *Neisosperma-Casuarina* associations are dominant. On the inner margins the coastal lowland forest and woodland grades into, and has some of the same species as, the tropical dry forest and woodland, such as gyrocarpus or helicopter tree, **madora** (*Gyrocarpus americanus*) and **qalaka** (*Planchonella grayana*).

Keppel, who has studied coastal vegetation elsewhere, stated that he had "not observed the superabundance of *Neisosperma oppositifolium*, a member of the Apocynaceae with characteristic abundant white and poisonous latex, in other locations." And, as suggested by Harlow and Biciloa (1999), this is almost certainly due to this species being unpalatable to the relatively large goat population on the island. The resulting change in vegetation (caused by goats) was of concern not only because the composition of the vegetation is seemingly changing but also because this gives *Neisosperma oppositifolium* a competitive advantage over *Hibiscus tiliaceus*, a major food species of the rare crested iguana (*Brachylophus vitiensis*). As in the case of the tropical dry forest and woodland, understory species and seedlings and saplings of the upper canopy species, most notably seedlings and saplings of *Neisosperma,* coconut palms, are increasing in abundance.

Less common components include the shrubs or small trees, beach cherry, **qeniqoro** (*Eugenia reinwardtiana*) and **tokotoko ni vevewa** (*Phaleria disperma*), both common in coastal and slope forest inland from protected beaches and on rocky headlands elsewhere on islands off Western Viti Levu.

2.3.4 Coastal Littoral Forest and Shrubland

The coastal littoral forest and shrubland, which is composed of primarily salt-tolerant ocean dispersed trees and shrubs, is found along both more exposed and less-exposed sandy beaches and rocky shorelines of the island. Along more exposed sandy beaches and foredunes, such as along the southern shore of Rogua Beach and both northeast and southeast ends of Savusavu Beach the upper portions of steeply sloping beaches or dunes are covered with almost mono-specific stands of beach acacia, **tagia** (*Acacia simplex*) woodland, with the inner portions on Savusavu Beach dominated by a *Cocos-Pandanus* association. In some sites in southwestern Rogua there are stunted beach heliotrope trees, **evo** (*Tournefortia argentea*).

Other important components of coastal littoral on more protected beach sites forest include guettarda, **buatoka** (*Guettarda speciosa*), pandanus, **vadra** (*Pandanus tectorius*), coconut palms, **niu (***Cocos nucifera*) and occasionally beach hibiscus, **vau** (*Hibiscus tiliaceus*). *Neisosperma oppositifolium* is also found extending into the outer coastal littoral forest. In areas on the southeast end of Rogua Beach, which is dominated by broken up limestone beach-rock slab, and in the coastal forest of Launatavuto and Vabeagau Beaches, hernandia or lantern tree, **buevu** (*Hernandia nymphaeifolia*) is common**;** and puzzlenut, **leqileqi** (*Xylocarpus malaccensis*), is found on the rocky ends of southwest Savusavu and southeast Rogua beaches, as well as near the east end of Launatavuto Beach and in a number of other locations. Along the more protected bays of the northern beaches, Vabeagau and Nawai, less common components of coastal littoral forest include **vesi** (*Intsia bijuga*) and **tivi ava** (*Terminalia littoralis*). Another rare component, found only at the southeast end of Savusavu Beach is Portia tree, **wiriwiri** (*Thespesia populnea*). Occasional in the inner portions of coastal littoral forest in southeast Rogua are *Pandanus*, **dakadaka** (*Syzygium richii*), a very handsome tree with spectacular yellow powder-puff flowers. A very highly threatened tree, all of which were dead, but reportedly alive on Monuriki a few years back, is dadap or erythrina, **rara** (*Erythrina variegate* var. *orientalis*), which has been lethally attacked in many islands of the Pacific by the erythrina gall wasp (*Quadrastichus erythrinae*), which is native to East Africa. This has happened throughout Fiji, despite its great cultural importance. Only in Hawaii, where a parasitic predatory wasp has been introduced as a biological control, has the species been able to survive.

Shrubby components include some scaevola or half-flower, **dredre** (*Scaevola taccada*), beach vitex, **drala** (*Vitex trifolia*), in sandier sites; and beach privet, **aria** (*Clerodendrum inerme*).

Climbing vines found in the coastal forest and thickets include moonflower or night-blooming morning-glory, **tovici** (*Ipomoea macrantha*), sea pea, **routolu** (*Vigna marina*), fish-poison or derris vine, **duva** (*Derris trifoliata*) and *Parsonsia laevis* and *Tylophora brackenridgei*.

Common coastal species elsewhere in Fiji, which were seen only as drift seedlings on Monuriki, include beach cordia, **nawanawa** (*Cordia subcordata*) and fish-poison tree, **vutu** or **vuturakaraka** (*Barringtonia asiatica*).

2.3.5 Coastal Littoral Herbland: Along the outer edges and openings in the inner portions of the more protected sandy beaches, there is commonly an herbaceous "outpost zone" composed of grasses, creeping vines and drift seedlings of ocean-dispersed shrubs, trees and vines, often with shrubby, scrub vegetation on the inner edges, especially near the ends of beaches, were it merges with coastal littoral forest and shrubland. This is one of the vegetation types that seems to have suffered most to goat predation and has probably showed the most spectacular return to abundance. Areas where it is most abundant are the more protected beach areas, such as the east end of Rogua Beach, the northeast and northwest ends of Savusavu Beach, on Launatavuto Beach and, to a lesser extent, on Nawai and Vabeagau Beaches.

The most dominant species in the outermost seaward zone, especially along the beaches of the north coast is beach morning glory, **wa vulavula** (*Ipomoea pes-caprae*), which is seen creeping out towards the mean high-tide zone. Also common are the native grasses, beach bunchgrass (*Lepturus repens*), thuarea (*Thuarea involuta*) and, to a lesser extent, knotgrass (*Paspalum distichum*). Also seen in a couple locations on the inner beach and on rocky inner beach sites was the Javanese flat sedge (*Mariscus javanicus*). Less common, but probably returning to abundance are silky beach bean, **rautolu** (*Canavalia sericea*) and beach pea, **rautolu** (*Vigna marina*). Particularly common in the outer beach of southwestern Rogua Beach were dense populations of young blue vitex, **drala** (*Vitex trifolia*) and, on the inner margins, dense mats of beach dodder, **bualawawlawa** (*Cassytha filiformis*). All of these are particularly important sand-binding species that protect beaches from erosion during extreme tidal and weather events. Scattered throughout this herb zone are the seedlings and saplings of beach heliotrope, **evo** (*Tournefortia argentea*), beach half-flower, **dredre** (*Scaevola taccada*), coconut, **niu** (*Cocos nucifera*) and other coastal littoral plants.

Rare to occasional indigenous herbaceous species that could be expected to increase in abundance, and should probably be protected include beach burr (*Triumfetta procumbens*), prickly chaff-flower, **sorisori tavei** (*Achyranthes aspera*), and beach spurge (*Chamaesyce atoto*). Also found in this herbaceous zone are a number of introduced weeds, notably the very invasive creeping daisy or wedelia (*Sphagneticola/Wedelia trilobata*), which was found on Rogua, Launatavuto and Savusavu Beaches and apparently spreading in the herbaceous outpost zone.

These introduced species should be removed from this zone to facilitate the regeneration of the coastal littoral herbland and species that are the natural species commonly found in the sandy nesting areas of the wedge-tailed shearwaters (See sections on introduced monocotyledons and dicotyledons above).

Species not seen on Monuriki, but which could be expected to return to the island are beach sedge, **vuti sa** (*Cyperus stoloniferus*) and the indigenous grass *Stenotaphrum secundatum*, a common coastal species in more protected inner sandy sites. Both are species that were probably removed by goats.

2.3.6 Ruderal Vegetation: There limited areas of "ruderal" vegetation that are subject to almost continual human disturbance and arrivals. These areas, where there seems to be a large number of potentially invasive introduced plants, include the area where a structure is being built on the northwest end of Rogua Beach and the area inland from the main tourist destination on Savusavu Beach. Potentially invasive plants found in these areas include mile-a-minute (*Mikania micrantha*), spiked pepper bush (*Piper aduncum*), Noogoora burr (*Xanthium pungens*) and carpet grass (*Axonopus compressus*) (Appendix III). Both are areas are potential avenues for further introductions of potentially invasive plants. These is also an area inland from Launatavuto Beach where there is a large patch of giant taro, **via mila** (*Alocasia mocrorrhiza*) which seems to be spreading.

3 SUMMARY

The July 2012 study of the flora and vegetation of Monuriki Island was conducted some eight years after Keppel's June 2004 study; some eight months after the successful removal of goats and rats from the island in late 2011; and following a period of six months of uncharacteristically heavy rain, reportedly the result of prevailing La Niña conditions. When compared with the findings of Keppel's 2004 study and the study of tropical dry forest on other islands in Fiji by Keppel and Tuiwawa (2007), the 2012 shows that:

1. The main vegetation types are: tropical dry forest and woodland; *Casuarina* woodland and savanna; coastal lowland forest and woodland; coastal littoral forest and shrubland; coastal littoral herbland; and, limited areas of disturbed ruderal vegetation. The total reported vascular flora of the island stands at about 121 species, of which 95 are assumed to be indigenous and 26 non-indigenous introductions. Of the 95 indigenous species, only 40 were listed by Keppel (2004) or Keppel or Tuiwawa (2007), and only 2 of which were not seen during the more extensive 2012 survey.

2. The inland indigenous overstory vegetation of the island is relatively intact, but still lacking significant understory growth due to decades of goat grazing and browsing on the island and, almost certainly, the predation of fruits and seeds by rats.

3. There is now significant, often spectacular, regeneration of seedlings of many species, in both inland and coastal vegetation types. Some of the most common species includes the ebonies, **keilō** (*Disopyros* spp.), tura (*Homalium* spp.) and among coastal species, tropical almond (*Terminalia catappa*), guettarda, **buatoka**

(*Guettarda speciosa*) and, of course, neisosperma, **vao** (*Neisosperma oppositifolium*), which also regenerated rapidly during the periods of goat and rat infestations.

4. There is some good remaining coastal littoral vegetation, but some economically and culturally valuable species, such as **dilo** (*Calophyllum inophyllum*), **wiriwiri** (*Thespesia populnea*), **evo** (*Tournefortia argentea*), **vesi** (*Intsia bijuga*), **nawanawa** (*Cordia subcordata*), **tivi ava** (*Terminalia littoralis*), **tokatoka ni vevewa** (*Phaleria disperma*) and **qeniqoro** (*Eugenia reinwardtiana*) are rare because they have either been removed over time or have always been rare.

5. There has been spectacular regeneration of coastal littoral herbaceous and small shrubby species and some evidence of the arrival of drift seedlings and saplings of common, ocean dispersed, coastal littoral species.

6. There are probably a number of coastal herbaceous and shrubby plants that were formerly present but which have been long absent because of goats, which should be put on alert for return. These include the beach sedge (*Cyperus stoloniferus*), beach leucaena, **ravu** or **irubi ni sulua** (*Schleinitzia insularum***)**

7. There has been a very significant increase in the abundance and number of fern species, which are good indicators of the recovery of the pre-goat indigenous understory flora of the island.

8. There are many, previously unreported, non-indigenous (introduced) weedy species, some of which are very invasive and should, if possible, be immediately eradicated because they pose threats to the regeneration of iguana and bird habitat and food species. There are other introduced species that seem to be innocuous and may be of interest if ecocultural tourism is developed on the island.

9. There are some indigenous species, such as **aria** (*Clerodendrum inerme*), which in the absence of goats, are becoming excessively weedy and spreading to form almost impenetrable thickets. Also of potential concern is the potentially invasive thorny climbing vine, beach nicker, **qalausori** (*Caesalpinia major*), which currently was seen as a solitary seedling in the back-beach basin linland from Launatavuto Beach. If possible the spread of these should be controlled.

10. There are some potentially invasive plants, not currently seen on the island, but which should be prohibited from becoming established on the island by having an awareness campaign for both local people and visitors to the island, adopting strict biosecurity measures and conducting periodic patrols to insure they do not become established. Some of these species are listed below

4 SPECIFIC RECOMMENDATIONS FOR ACTION

The following are specific recommendations for action on Monuriki in terms of: 1) priority plants protection and replanting; 2) invasive species that should receive priority for eradication and prevention of the spread; 3) the development of a number of scenic and educational nature and ecotourism or ecocultural trails or tracks; 4) that Monuriki be considered for nomination as a Ramsar Wetland site of international significance; 5) potential promotional Activities

4.1 Priority Trees and Plants for Protection and Replanting

There are a number of rare or ecologically and culturally important trees or plants that should be located, mapped, gazetted, and giving some form of protection or replanted. These species are listed in Table 2. Included are a number of trees, not seen in 2012 that were either reported by Keppel in 2004 or known to be present on other islands off of Western Viti Levu that could be considered for planting and protection

Table 2. Rare or ecologically and culturally important trees or plants that should be gazette, mapped, given some form of protection or planted because of their importance as iguana or bird habitat and food source (In terms of estimated abundance, V = very abundant, A = abundant, C = common, O = Occasional, U = uncommon, R = rare, E = extirpated/locally extinct, not present on Monuriki or not seen in 2012).

Yanuya Name	**Common Name**	**Scientific Name**	**Abundance**
Araro	premna, beach elderberry	Premna serratifolia	R
Baka	Banyan trees	*Ficus* spp.	O
Bau		*Burkella richii*	C
Bausom		*Manilkara dissecta*	U
Buatoka	Guettarda, beach gardenia	*Guettarda speciosa*	O
Buevu	Hernandia, Chinese lantern tree	*Hernandia nymphaeifolia*	O
Cevua?	Wild sandalwood	*Vavaea amicorum*	E
Dakadaka		*Syzygium richii*	O
Dredre, vevedu	Half-flower, scaevola	*Scaevola taccada*	O
Drala	Beach vitex	*Vitex trifolia*	O

Evo	Beach heliotrope	*Tournefortia argentea*	U
Ivi	Tahitian chestnut	*Inocarpus fagifer*	R
Leqileqi	Cannonball tree, puzzlenut	*Xylocarpus moluccensis*	U
Kei lo, kai lo	ebony	*Diospyros* spp.	A
madora	gyrocarpus, helicopter tree,	*Gyrocarpus americanus*	C
Nawanawa	Beach trumpet, beach cordial	*Cordia subcordata*	R
nuqanuqa		*Decaspermum vitiensis*	R
qalaka		*Planchonella grayana*	C
Qeniqoro	beach cherry	*Eugenia reinwardtiana*	U
Tagia	Beach acacia	*Acacia simplex*	A
Rara, drala	Dadap tree, erythrina	*Erythrina variegate* var. *orientalis*	E?
Tivi	Tropical almond	*Terminalia catappa*	O
Tivi ava	Coastal or beach almond	*Terminalia littoralis*	U
Tokatoka ni vevewa	Phaleria	*Phaleria disperma*	R
Tosiga?, vesi wai	Beach walnut	*Pongamia pinnata*	E
Touto	Bird-catcher tree, lettuce tree	*Pisonia grandis*	O
Tura		*Homalium vitiense*	O
Vau	Beach hibiscus	*Hibiscus tiliaceus*	O
Wiriwiri	Thespian's tree, Portia tree, milo	*Thespesia populnea*	R
Toca, sinu gaga	Blinding tree	*Excoecaria agallocha*	O
Yaqwata		*Mallotus tiliifolius*	C
?		*Cynometra insularis*	R

?		*Drypetes vitiense*	R
?		*Excoecaria acuminata*	U
?	Silverbush	*Sophora tomentosa*	E?

4.2 Priority Plants for Eradication

Plants that should be particularly targeted for eradication and prevention from re-introduction due of the threats they pose (based on their behavior elsewhere) to the health and regeneration of indigenous plants and to iguana and seabird habitat, and as a nuisance to ecotourism, include: mile-a-minute (*Mikania micrantha*), ivy gourd (*Coccinia grandis*), spiked pepper bush (*Piper aduncum*), prickly solanum (*Solanum torvum*), wedelia or trailing daisy (*Sphagneticola/Wedelia trilobata*), Noorgoora burr (*Xanthium pungens*), and burr grass (*Cenchrus echinatus*). Consideration should also be given to the selective removal or stopping the spread of the native, thicket-forming shrub, beach privet, **aria** (*Clerodendrum inerme*).

Weedy species that could be preserved, which don't seem to be invasive and/or because of their cultural value, often as medicinal plants, and potential value in ecocultural-tourism development include wood sorrel, **totowiwi** (*Oxalis corniculata*); goatweed, **botebotekoro** (*Ageratum conyzoides*); ironweed, **kaukamea** (*Cyanthillium cinereum*); wild daisy, **lusi** (*Tridax procumbens*); and stinking passion flower, **kutai** (*Passiflora foetida*), the seeds of which were probably dispersed in the past by rats, and the fruit of which is a favorite snack food for children and interesting to tourists.

4.3 Priority Plants for Exclusion or Prevention from Establishment

Plants that should be particularly targeted for prevention from becoming established on Monuriki because of their threat to the health and regeneration of indigenous plants, the threat the pose to iguana and seabird habitat, and as a nuisance to ecotourism, include: leucaena, **vaivai ni vavalagi** (*Leucaena leucocephala*), African tulip tree, **pispis** (*Spathodea campanulata*), giant sensitive plant, **cogadrogadro levu** (*Mimosa invisa*), raintree, **vaivai sirsa** (*Samanea saman)*, silver rain tree, **vaivai ni vavalagi** (*Albizia lebbek*), guava, **quava** (*Psidium guajava*) and red-bead tree, **site** or **lera** (*Adenanthera pavonina*). Some priority might be given to the selective removal of two native plants, beach privet, **aria** (*Clerodendrum inerme*), which seems to be spreading out of control on some escarpment and lower coastal open slope locations, and, the potentially invasive thorny climbing vine, beach nicker, **qalausori** (*Caesalpinia major*).

4.4 Establishment of Nature and Ecotourism Trails

There are a number of extremely scenic nature trails or tracks though areas that would be attractive to nature and ecotourists. Attraction include good examples of dry forest and woodland, beautiful beaches and beach forest, scrub and herbland and beautiful, often spectacular, white-sand beaches, rocky headlands and wave terraces, ridges and cliff and vantage points with panoramic views (photo opportunities) of all these features, plus offshore islets, reefs, lagoons other surrounding islands. These trails also offer excellent opportunities for bird watching and, after restoration, crested iguana watching.

The main suggested tracks could begin at either Savusavu Beach, the main tourist Beach on the northeast of the island or from Rogua Beach in the southwest. The three main trails should initially be:

1. **Rogua-Savusavu Circum-coastal Track:** a walk, at low tide, between the two beaches, starting at either end, which would give hikers a chance to see all the main beaches, coastal littoral and coastal lowland forest and vegetation, and the interesting coastal cliff and wave-cut terrace and fringing reef formations as associated flora and fauna;

2. **Rogua-Launatavuto-Savusavu Northern Upland Track:** a trail beginning from Rogua Beach and the crossing the small divide between Rogua and Launatavuto Beaches, and then taking a route up along the escarpments and gradual cliff faces and upland areas above the beaches of the north coast, through the upland forests, woodlands and shrublands above Launatavuto, Vabeagau, Nawai and Savusavu Beaches. This could be done in either direction.

3. **Savusavu Southern Upland and Island Summit** Track: a trail beginning at the southwest end of Savusavu Beach and gradually ascending the escarpment to some spectacular outlooks over the southeast , south and southwest coasts of the island, with the option of making gradual ascents to the highest peaks and viewpoints on the island.

4. **Yanuya Village Ethnobotanical Trail:** This would consist of a walking tour through Yanuya Village to share, with the participants, knowledge and lore about culturally useful trees, plants and animals in the village and surrounding areas, with particular focus on plants, such as pandanus (**voivoi**), breadfruit (**kulu**), plantains and bananas (**vudi, bata** and **jaina**), taro (**taro**), yams (**uvi**), cassava (**tavioka**), sweet potato (**kumala**), noni (**kura**): animals, such as pigs (**vuaka**), chickens (**toa**), dogs (**koli**) that are central to the sustainability of Fijian subsistence living and which are not found on Monuriki. This will enrich the tourist experience and give them an enriched view of the ethnobotanical traditions of Fiji and the importance of the main island of Yanuya, the offshore resource islands of Monuriki and Monu and the tourist

destination of Tokoriki to the cultural, economic and environmental sustainability of the area .

5. **Monuriki Snorkel Tour:** Either as an independent activity or as an add-on to the hiking tours, participants could also be given time to have a snorkeling tours of designated reefs with particular focus on their ecology and the importance of dominant fishes, shellfishes, coral, sea weeds, seagrasses and other dominant organisms to the Fijian culture, economy and environment.

4.5 Consideration for Ramsar Listing

It is suggested that Monuriki be considered for nomination as a Ramsar Wetland site of international significance because of its unique biodiversity, as a world class nesting areas for threatened birds, such as the wedge-tailed shearwater and Fiji peregrine falcon, the focus of a captive breeding program for the restoration of crested iguana populations and as a very popular and well-known tourism site, due to its beauty, the quality of its reefs and its notoriety as the filming location for Tom Hanks movie, *Castaway*.

4.6 Other Promotional Activities

To maximize the potential of Monuriki as a conservation area for the unique dry forest and coastal forests, the threatened Fiji crested iguana, the wedge-tailed petrel, the Fiji peregrine falcon and other wildlife; and, as an ongoing source of income from nature and ecocultural tourism, the following activities are suggested:

1. Production of simple pamphlets, with appropriate photos, plant and animal lists highlighting important points about the geography, ecology, biodiversity, history, land and marine tenure, Fijian cultural and subsistence economy and the most important places, plants and animals that visitors to Monuriki and Yanuya will see, experience and learn about.
2. Highlight the ecological importance and uniqueness of dry forest and coastal and littoral vegetation, its endangered status and its unique floristic characteristics, including the massive banyan trees, the profusion of high-climbing vines or lianas, understory ferns and herbs, and other useful or ecologically important plants, many of which are critical habitat and food sources for the island's wildlife.
3. Highlight the almost complete absence on Monuriki of many invasive trees and other woody plants found on larger more disturbed islands and, most recently of goats and rats!– and the need to keep it this way.
4. Highlight the importance of the extensive nesting areas of the wedgetail shearwater (**manumanu ni Modriki**) and the peregrine falcon, **ganivatu** (*Falco peregrines*) and other birds, lizards and other animals, people will see as part of a nature or bird-watching trail.

5. Highlight the spectacular views and photographic opportunities, beautiful tree groves, beautiful beaches, reefs and snorkel opportunities, and the cultural and historical importance, as a resource island and the location for the filming of Tom Hank's movies, *Castaway*.

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