

Operational Plan

Toloa Rainforest Restoration Project 2014-2020



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October 2014



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ACKNOWLEDGEMENTS

I would like to acknowledge the following people for their assistance with this project. Tupou College Principal, Reverend Feleti, CEO of the MEECCDMMIC, Paula Ma'u, staff of the MEECCDMMIC including the Assistant Director Lupe Matoto, Viliami Hakaumotu and Hoifua Aholahi, and the guidance of Sepuloni Folau, former Park Ranger.

I also acknowledge the technical advice and wisdom of David Moverley, the Invasive Species Adviser of the Secretariat of the Pacific Regional Environment Program (SPREP). Finally, I acknowledge the constructive feedback and guidance from all the people who participated in the debriefing meeting on August 1, 2014. Like most complex projects, the restoration of Toloa rainforest is a team effort and can only succeed through the coordinated and dedicated efforts of many. *Malo Aupito.*

EXECUTIVE SUMMARY

The Operational Plan for the Toloa Rainforest Restoration Project was prepared for the Ministry of Environment, Energy, Climate Change, Disaster Management, Meteorology, Information and Communication (MECCDMMIC), Tupou College and other partners under the Global Environment Facility Pacific Alliance for Sustainability (GEF-PAS) funded “Prevention, control and management of invasive alien species in the Pacific Islands” project.

Development of the Operational Plan was coordinated by consultant James Atherton in collaboration with MECCDMMIC staff in particular Viliami Hakaumotu, National Project Coordinator for the GEF-PAS Project and with the technical assistance of David Moverley, Invasive Species Adviser, of the Secretariat of the Pacific Regional Environment Program (SPREP).

The purpose of this Operational Plan is to outline the major elements of the restoration work planned in the Toloa rainforest in the period 2014 to 2020. Tupou College, as the stewards of the Toloa Rainforest Reserve, will have primary responsibility for implementing the plan with the support of project partners.

The plan includes a summary of the invasive plants in the reserve as well as a description of the implementation approach to be followed including invasive plant and mammal management techniques to be used, the budget and resources required, a seven year workplan, protocols for managing site biosecurity and staff safety as well as lists of equipment and staffing needed. Project objectives are guided by Tonga’s National Invasive Species Strategy and Action Plan (MLECCNR 2013). Detailed yearly work plans, planting plans and annual budgets will need to be prepared for the operational work but will be guided by this Operational Plan.

It is estimated that the restoration work over 7 years will cost approximately US\$ 60,000 of which about US\$ 40,000 has been assigned under the GEF funded “Prevention, control and management of invasive alien species in the Pacific Islands” project which ends in August 2016. The budget shown in this plan proposes how the GEF funds can best support this project, but also identifies the need for further funds to sustain activities over the full seven year period of this plan until 2020.

The restoration of the Toloa rainforest is an achievable goal and will have significant benefits for Tonga. Given the small area of the site, its accessibility and the commitment of partners to restore the forest, the Toloa forest could potentially become one of the most important sites in the Pacific region to raise awareness of the impacts of invasive species and to demonstrate the benefits of invasive species management and forest restoration.

1. INTRODUCTION

This Operational Plan was prepared for the Ministry of Environment, Energy, Climate Change, Disaster Management, Meteorology, Information and Communication (MECCDMMIC), Tupou College and other partners. Development of the Operational Plan was coordinated by consultant James Atherton in collaboration with MECCDMMIC and with the technical assistance of David Moverley of the Secretariat of the Pacific Regional Environment Program (SPREP). All project contributors are acknowledged in the acknowledgements section.

The purpose of this Operational Plan is to outline the major elements of the restoration work planned in the Toloa Rainforest Reserve in the period 2014 to 2020. The plan includes a summary of a recent forest survey in the reserve as well as a description of the implementation approach to be followed including invasive plant and mammal management techniques to be used, budget and resources required, workplan, protocols for managing site biosecurity and staff safety as well as lists of equipment and staffing needed. The plan outlines the proposed roles of project partners in the restoration, in particular of Tupou College and the MECCDMMIC. Separate detailed yearly work plans, planting plans and budgets will need to be prepared for the operational work but will be guided by this Operational Plan.

Approximately \$40,000 USD has been assigned for forest restoration in Toloa Rainforest Reserve under the GEF funded Regional Invasive Species Project and to be spent before August 2016. The budget shown in this plan proposes how the GEF funds can best support the establishment of this project, but also identifies the need for further funds to sustain project activities.

An Operational Team, led by a Restoration Project Manager, will need to be appointed to conduct the restoration work. It is recommended that a Toloa Rainforest Restoration Committee, composed of the key partners, will act as technical advisers to the Operational Team. It is hoped that over time other local community and school groups in Tongatapu in addition to Tupou College will become involved in the restoration work as the site is already heavily visited and is very accessible. Engaging such voluntary groups in restoration work such as invasive plant control and tree planting is cost effective and has major benefits in raising public awareness on Tonga's threatened environment, and on disseminating knowledge and skills on practical approaches to reverse forest degradation and build ecosystem resilience.

1.1. Methodology for plan preparation

This operational plan was prepared during July- September 2014 and involved the following elements and timelines (see Table 1). Please also refer to Annex 1 for details on the field survey methods used, Annex 2 for details of the survey results and to Annex 3 for the agenda and attendance of the project debriefing held on August 1. Annex 4 shows some site and plant photographs.

Table 1. Methodology for plan preparation

Action	Timeline	Outcomes	Methods Used
Research to inform restoration plan	July 2014	<ul style="list-style-type: none"> All relevant existing information to prepare restoration plan is compiled and reviewed 	<ul style="list-style-type: none"> Literature review Consultation with MLECCNR and partners
Site survey	July 28-30, 2014	<ul style="list-style-type: none"> Assessment of site characteristics Assessment of invasive species in the site Clarity on project deliverables Classify the rainforest into management areas Clarity on partner expectations and roles for this project 	<ul style="list-style-type: none"> Site visit and survey (see Annex 1 for methods and Annex 2 for results) <ul style="list-style-type: none"> Interviews with partners/stakeholders
Project Debriefing for stakeholders	Aug 1, 2014	<ul style="list-style-type: none"> Feedback on draft operational plan 	<ul style="list-style-type: none"> Presentations and Discussion (See Annex 3)
Draft restoration plan	August 31 2014	<ul style="list-style-type: none"> First draft of restoration plan submitted to MLECCNR and other partners for review by August 31 	<ul style="list-style-type: none"> Collation and analysis of results of site survey and interviews
Final restoration plan	Sept 30, 2014	<ul style="list-style-type: none"> Final draft of operational plan submitted to MLECCNR for review by Sept 30, 2014 	<ul style="list-style-type: none"> Revision of draft plan based on feedback received

2.SUMMARY OF THE PROJECT SITE

The Toloa Rainforest Reserve is located approximately 11 km southeast of central Nukualofa, immediately to the north of the Fua’amotu International Airport. The total area of the forest reserve is approximately 20 ha (49 acres) (Ball 2001). The key features of the forest are shown in Table 2, while a location map of the project site is shown in Figure 1.

Table 2. Key features of the Toloa Rainforest Reserve

Site name	Toloa Rainforest Reserve
Land Tenure	99 year lease by Free Wesleyan Church for Tupou College (recently renewed)
Longitude Centre Point	-175° 9' 31.626"
Latitude Centre Point	-21° 13' 53.76"
Area	Approximately 21 ha (52 acres)
Natural Vegetation of Area	Lowland rainforest, but now invasive plants spreading into forest
Geology	Coral limestone rock (Pliocene/Pleistocene)
Topography	Flat. Elevation ranges from 30m in N to 35m in S
Main threats	Invasive species, Tree Cutting, Cyclones, Conversion to other land use

2.1 Vegetation and flora of the project site

The original or “primary” vegetation of the Toloa rainforest was lowland forest of an inland type (growing 2 to 4km from the sea) (Ball 2001). The entire centre of Tongatapu would have originally been covered with tropical lowland rainforest, but now only small patches remain of which the Toloa forest is the largest and most intact (Palmer 1988).

According to the published literature, the Toloa forest is dominated by tavahi (*Rhus taitensis*), ngatata (*Elatostachys falcata*) and fekika vao (*Syzygium clusiifolium*) trees in the canopy, fekika vao and ahi vao (*Vavaea amicorum*) trees in the sub canopy and ahi vao, fekika vao and maamalava (*Elaeocarpus floridanus*) and motou (*Cryptocarya hornei*) in the small saplings and seedlings layer (Palmer 1988). Lianas are particularly abundant in the forest and include hoi (*Dioscorea bulbifera*), tutuuli (*Jasminum* species), *Melodinus vitiense* (no Tongan name) and sipi (*Entada phaseoloides*) as well many invasive vines such as pula vaine (*Ipomoea indica*), and vaine kai (*Passiflora edulis*).

Over 200 plant species have been recorded in the reserve (Ball 2001). A combined checklist of 77 plant species recorded in the reserve by Palmer (1988), Whistler in 2010 and 2013 and/or by our survey team in 2014 is shown in Table 3 and includes 42 native species and 35 introduced plants.

Table 3. Checklist of plants recorded in the Toloa Forest by Palmer (1988), Whistler (2010 and 2013) and survey team (2014) showing current dominance

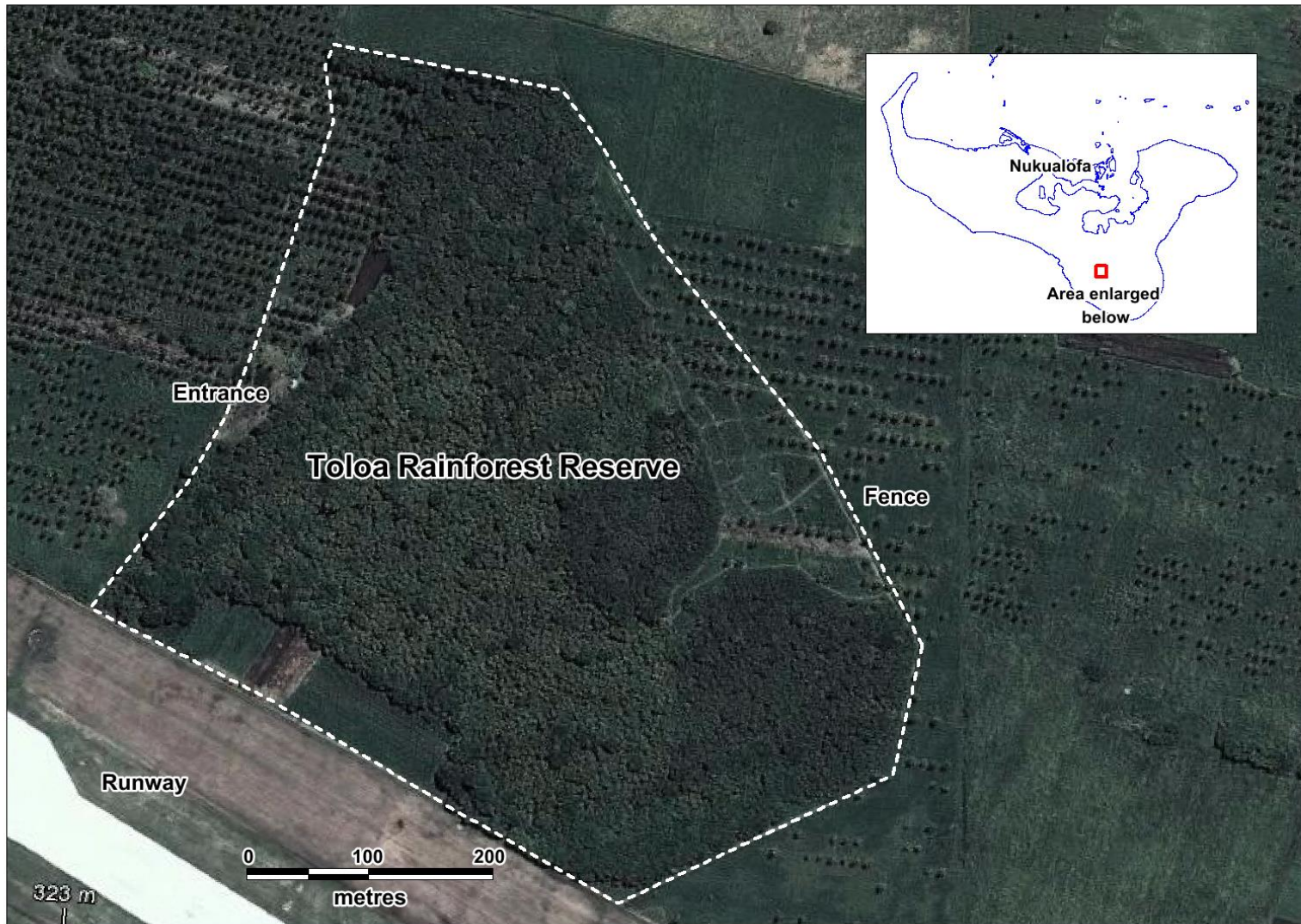
Species	Habit	Tongan Name	Status	2014 Dominance in Survey Blocks
DICOTYLEDONAE				
ANACARDIACEAE				
<i>Mangifera indica</i>	Tree	Mago	Introduced	Uncommon
<i>Rhus taitensis</i>	Tree	Tavahi	Native	Dominant
ANNONACEAE				
<i>Cananga odorata</i>	Tree	Mosooi	Introduced	Uncommon
APOCYNACEAE				
<i>Alyxia stellata</i>	Vine	Maile	Native	Common
<i>Melodinus vitiensi</i>	Vine		Native	
<i>Neisosperma oppositifolia</i>	Tree	Fao	Native	Uncommon
<i>Tabernaemontana pandacaqui</i>	Tree	Te’ete’emanu	Native	Common
ARALIACEAE				
<i>Polyscias multijuga</i>	Shrub	Tanetane vao	Native	Common
ASTERACEAE				
<i>Ageratum conyzoides</i>	Herb		Introduced	
<i>Elephantopus molli</i>	Herb		Introduced	
<i>Eleutheranthera ruderalis</i>	Herb	Pakaka	Introduced	
<i>Pseudelephantopus spicatus</i>	Herb		Introduced	
<i>Synedrella nodiflora</i>	Herb		Introduced	

Species	Habit	Tongan Name	Status	2014 Dominance in Survey Blocks
BORAGINACEAE				
<i>Cordia alliodora</i>	Tree	Kotia	Introduced	Common
CARICACEAE				
<i>Carica papaya</i>	Tree	Lesi	Introduced	Common
CONVOLVULACEAE				
<i>Ipomoea indica</i>	Vine	Pula vaine	Native?	Common
EBENACEAE				
<i>Diospyros elliptica</i>	Tree	Kanume	Native	Uncommon
ELAEOCARPACEAE				
<i>Elaeocarpus floridanus</i>	Tree	Ma'ama'alava	Native	Common
EUPHORBIACEAE				
<i>Aleurites moluccana</i>	Tree	Tuitui	Introduced	Common
<i>Bischofia javanica</i>	Tree	Koka	Native	Uncommon
<i>Macaranga harveyana</i>	Tree	Loupata	Native	Common
FABACEAE				
<i>Adenantha pavonina</i>	Tree	Lopa	Introduced	Uncommon
<i>Entada phaseoloides</i>	Vine	Valai	Native	Common
<i>Glycine wightii</i>	Herb		Introduced	
<i>Inocarpus fagifer</i>	Tree	Ifi	Introduced	Common
FLACOURTIACEAE				
<i>Xylosma smithiana</i>	Tree	Filimoto	Native	Common
LAURACEAE				
<i>Cryptocarya hornei</i>	Tree	Motou	Native	Common
<i>Cryptocarya turbinata</i>	Tree	Motou	Native	
LILIACEAE				
<i>Asparagus species</i>	Herb	Asparagus fern	Introduced	Uncommon
MALVACEAE				
<i>Sida rhombifolia</i>	Herb		Introduced	Common
MELIACEAE				
<i>Dysoxylum forsteri</i>	Tree	Mo'ota	Native	Common
<i>Vavaea amicorum</i>	Tree	Ahi vao	Native	Common
MORACEAE				
<i>Castilla elastica</i>	Tree		Introduced	Uncommon
<i>Ficus tinctoria</i>	Tree	Masi mole	Native	Common
<i>Ficus obliqua</i>	Tree	Ovava	Native	Uncommon
<i>Ficus scabra</i>	Tree	Masi ata	Native	Common
MYRISTICACEAE				
<i>Myristica hypargyrea</i>	Tree	Kotone	Native	Common
MYRTACEAE				
<i>Eucalyptus spp</i>	Tree		Introduced	Uncommon

Species	Habit	Tongan Name	Status	2014 Dominance in Survey Blocks
<i>Eugenia reinwardtiana</i>	Tree	Unuoi	Native	Common
<i>Psidium guava</i>	Tree	Kuava	Native	Uncommon
<i>Syzygium clusiifolium</i>	Tree	Fekika vao	Native	Common
OLEACEAE				
<i>Jasminum didymum</i>	Vine	Tutu uli	Native	Common
<i>Jasminum simplicifolium</i>	Vine	Tutu uli	Native	Common
OXALIDACEAE				
<i>Oxalis corniculata</i>	Herb	Kihikihi	Introduced	
PASSIFLORACEAE				
<i>Passiflora edulis</i>	Vine	Vaine kai	Introduced	Common
<i>Passiflora laurifolia</i>	Vine	Vaine tintina	Introduced	Common
<i>Passiflora maliformis</i>	Vine	Vaine Tonga	Introduced	Common
PIPERACEAE				
<i>Macropiper puberulum</i>	Shrub	Kavakavaulie	Native	Uncommon
RHAMNACEAE				
<i>Alphitonia zizyphoides</i>	Tree	Toi	Native	Uncommon
RUBIACEAE				
<i>Coffea arabica</i>	Tree	Kofe	Introduced	Common
<i>Cyclophyllum barbatum</i>	Tree	Olamata	Native	Uncommon
<i>Gynochtodes epiphytica</i>	Tree		Native	
<i>Morinda citrifolia</i>	Tree	Nonu	Native	Common
<i>Tarrena sambucina</i>	Tree	Manonu	Native	Uncommon
RUTACEAE				
<i>Citrus maxima</i>	Tree	Moli Tonga	Introduced	Uncommon
<i>Micromelum minutum</i>		Takafalu	Native	Uncommon
SAPINDACEAE				
<i>Elattostachys apetela</i>	Tree	Ngatata	Native	Uncommon
<i>Pometia pinnata</i>	Tree	Tava	Native	Uncommon
SAPOTACEAE				
<i>Planchonella grayana</i>	Tree	Kalaka	Native	Uncommon
SOLANACEAE				
<i>Capsicum frutescens</i>	Shrub	Polo fifisi	Introduced	Uncommon
<i>Cestrum nocturnum</i>	Shrub	Lakau po'uli	Introduced	Common
SOLANACEAE				
<i>Solanum americanum</i>	Shrub	Polo kai	Introduced	
<i>Solanum mauritianum</i>	Shrub	Pula tree	Introduced	Common
<i>Solanum torvum</i>	Shrub	Tisaipale	Introduced	Uncommon
TILIACEAE				
<i>Grewia crenata</i>	Tree	Fo'ui	Native	Common
VERBENACEAE				

Species	Habit	Tongan Name	Status	2014 Dominance in Survey Blocks
<i>Lantana camara</i>	Shrub	Talatala	Introduced	Common
<i>Stachytarpheta cayennensis</i>	Herb	Hiku ' kuma	Introduced	Common
<i>Cordyline fruticosa</i>	Shrub	Si	Native	Common
ARECACEAE				
<i>Roystonea regia</i>	Tree	(Royal palm)	Introduced	Uncommon
DIOSCOREACEAE				
<i>Dioscorea bulbifer</i>	Vine	Hoi	Introduced	Common
ORCHIDACEAE				
<i>Corymborchis veratrifolia</i>	Herb	Oketi vao?	Native	
<i>Dendrobium sp.</i>	Herb		Native	
PANDANACEAE				
<i>Pandanus tectorius</i>	Tree	Fa	Native	Uncommon
POACEAE				
<i>Cyrtococcum oxyphyllum</i>	Grass	Mohuku 'apopoa?	Native	
<i>Eleusine indica</i>	Grass	Takataka a le ala	Introduced	
<i>Oplismenus compositus</i>	Grass	Mohuku 'apopoa?	Native	
<i>Panicum maximum</i>	Grass	Saafa	Introduced	
<i>Paspalum conjugatum</i>	Grass	Vailima	Introduced	

Figure 1. Location Map of the Toloa Rainforest Reserve



2.2 Main threats to the Toloa Rainforest

The four main threats to the Toloa rainforest are from invasive species, tree cutting, cyclones and clearance for other land use, in particular for agriculture and development (the airstrip).

Invasive Species

Introduced invasive plant species are spreading into the forest. In every hectare block visited in the July 2014 survey invasive plants were recorded. This is perhaps not surprising given the small size of the forest, the fact that it is surrounded by farmland containing many invasive plants and the heavy disturbance to the forest for firewood, timber and medicinal plants.

The dominance of invasive plants is highest in the ground and liana layers, and lowest in the canopy layer, and highest along the western and northern sides of the forest. At least 36 invasive plants are found in the forest including 3 grasses, 10 herbs, 5 shrubs, 13 trees and 5 vines. Dominant invasive plants in parts of the forest include the trees, Kotia (*Cordia alliodora*) and pula tree (*Solanum mauritianum*), the shrubs lakaupouli, (*Cestrum nocturnum*) and talatala (*Lantana camara*) and the lianas pula vaine (*Ipomoea indica*), vaine kai (*Passiflora edulis*), vaine tinetina (*Passiflora laurifolia*) and vaine Tonga (*Passiflora maliformis*). The list of invasive plants in the forest, maps of their distribution and notes on their management is covered in section 3.1. Photos of some of these invasive plants are shown in Annex 4.

In addition to invasive plants there are also many invasive animal species in the forest including mammals such as rats and pigs, birds such as wild chickens and the red-vented bulbul as well as numerous invasive ants (including the Yellow Crazy Ant), molluscs and insects. Although no cats were seen in the forest they are believed to be in the forest. In a few places cattle have also entered the forest and cause damage by trampling on seedlings, eating the leaves of plants and damaging the soil.

It is not known how many of Tonga's 4 rodent species are found in the reserve but most likely *Rattus rattus* (ship rat) and *R. exulans* (Pacific rat) as these tend to be the most common rats in forested areas. The impact of invasive animals on native biodiversity and ecosystem functioning within the reserve has not been assessed but experience from elsewhere indicates it is likely to be significant, including predation on native plants and animals, the spread of diseases to native birds, and ecosystem disturbance such as the spread of seeds of invasive plants. Included in this plan are some basic invasive mammal management activities, such as rat, cat and pig management and exclusion of cattle from the forest.

Tree cutting and harvesting

The Toloa rainforest is heavily utilised by students of the Tupou College for firewood and fence posts and by students and the general public for medicinal plants. The timber in the forest is the main source of firewood for cooking for the 900 students of Tupou College and every day students enter the forest to collect firewood. In most cases the students use dead trees and branches but removing these from the forest removes important habitat for native biodiversity such as nesting sites for birds and food and habitat for insects and organic matter for the soil. Students and the general public also remove live wood for fence posts and harvest medicinal plants, or remove bark from certain trees for cultural purposes (eg to stain tapa cloth). If not managed carefully, the high level of human disturbance can be harmful for a

number of reasons, in addition to the removal of many native plants, such as the trampling damage done to native seedlings underfoot, the accidental destruction of native plants when removing firewood or cutting down trees, and the promotion of the spread of invasive plants in the numerous canopy openings and trails created through the forest.

Cyclones

Cyclones are a major threat to the integrity and condition of the Toloa forest. Past cyclones that caused significant damage in the forest including Cyclone Isaac in February 1982 and Cyclone Cora in December 1998 (Ball 2001). Cyclone damage opens up gaps in the forest which are then invaded by introduced weeds, grasses and vines which slow down the regrowth of native plants. In the past large ngatata (*Elatostachys falcata*) trees have been particularly badly impacted by cyclones, especially Cyclone Isaac in 1982 and the canopy in some areas has not recovered (op cit).

Conversion to other land use

Most of the land area on Tongatapu was cleared for agriculture long ago. Currently, only 3.3% of the island is still covered in native forest (Ball 2001). The Toloa Forest has been under the custodianship of the Free Wesleyan Church since 1948 and since then much of the original forest has been cleared for cattle pasture and crops. More recently, in the 1970's more forest in the south, including some of the highest canopy forest, was compulsorily cleared for the expansion of the runway by the airport authority (op cit). Although according to local contacts, there are currently no plans for further expansion of the runway into the Toloa forest, this threat cannot be discounted in the future, should the Tonga Airports Ltd decide to widen the runway, or build a new runway. This gives further emphasis on the need to expand the forest area outwards especially to the north and east to increase the resilience of the forest to future forest loss or other impacts.

3. SUMMARY AND MAPPING OF FIELD SURVEY RESULTS

The full results of the field survey conducted from July 28-30 are shown in Annex 2. In the following section the distribution and abundance of invasive plants in the reserve is presented, followed by some comments on biodiversity values in the reserve.

3.1 Invasive Plant Abundance and Distribution

Field observations were made in each of the following four forest layers (see Annex 1 for the data sheet):

- Canopy Trees (>15m height)
- Sub-canopy trees and shrubs (>1m<15m)
- Ground cover (<1m)
- Vines

The following figures (Figures 2 to 5) show the results of the field survey in each of the 24 survey blocks for each of the four forest layers in terms of survey blocks where invasive plants were abundant, observed, or not observed. Figure 6 is a composite map showing the overall level of invasion of each hectare block by invasive plants in all three forest layers combined (canopy, sub canopy and ground cover).

Figure 2. Distribution of Invasive Canopy Trees in the Toloa Rainforest



Figure 3. Distribution of Invasive Sub-Canopy Trees in the Toloa Rainforest

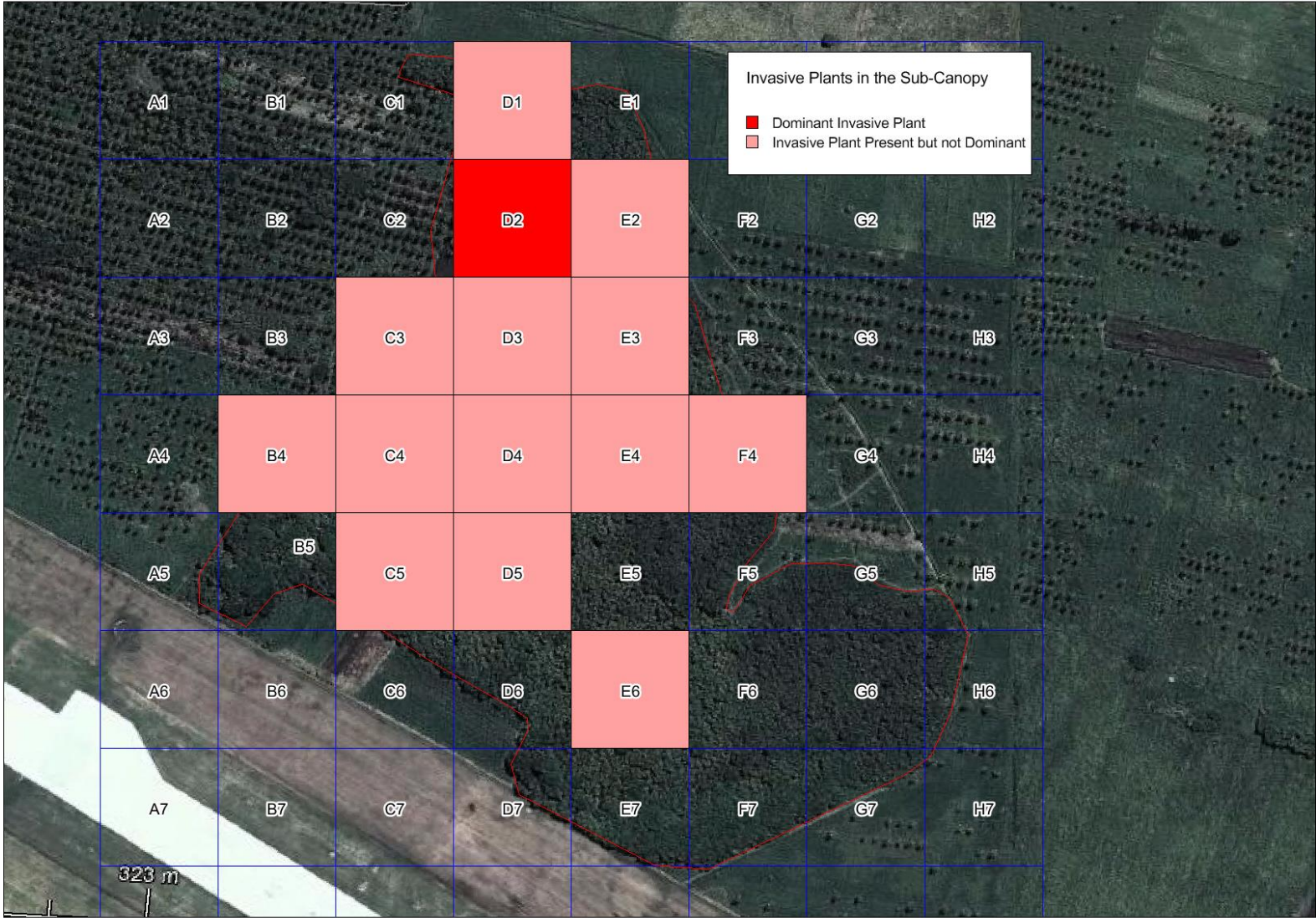


Figure 4. Distribution of Invasive Ground Cover in the Toloa Rainforest



Figure 5. Distribution of Invasive Vines in the Toloa Rainforest

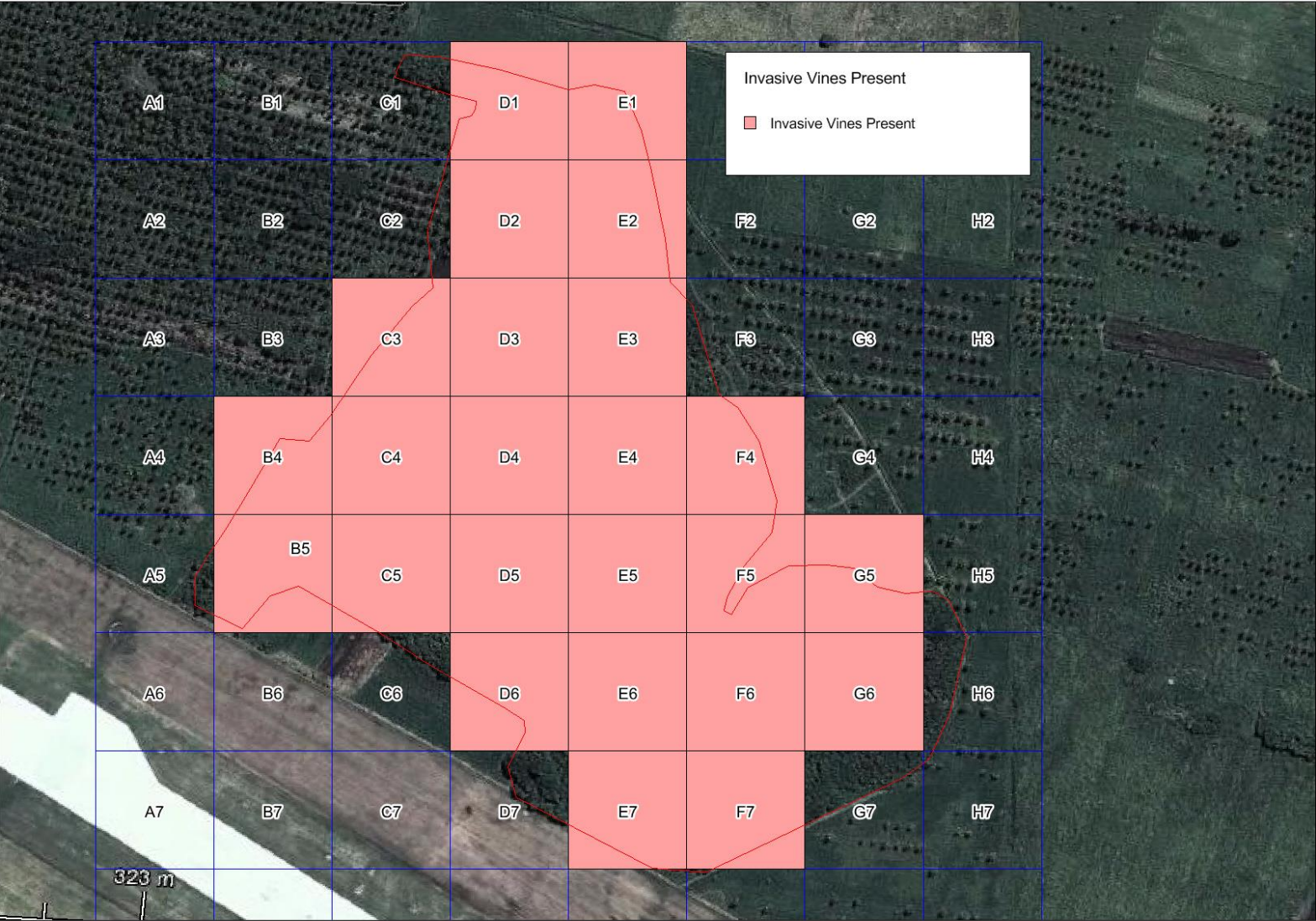
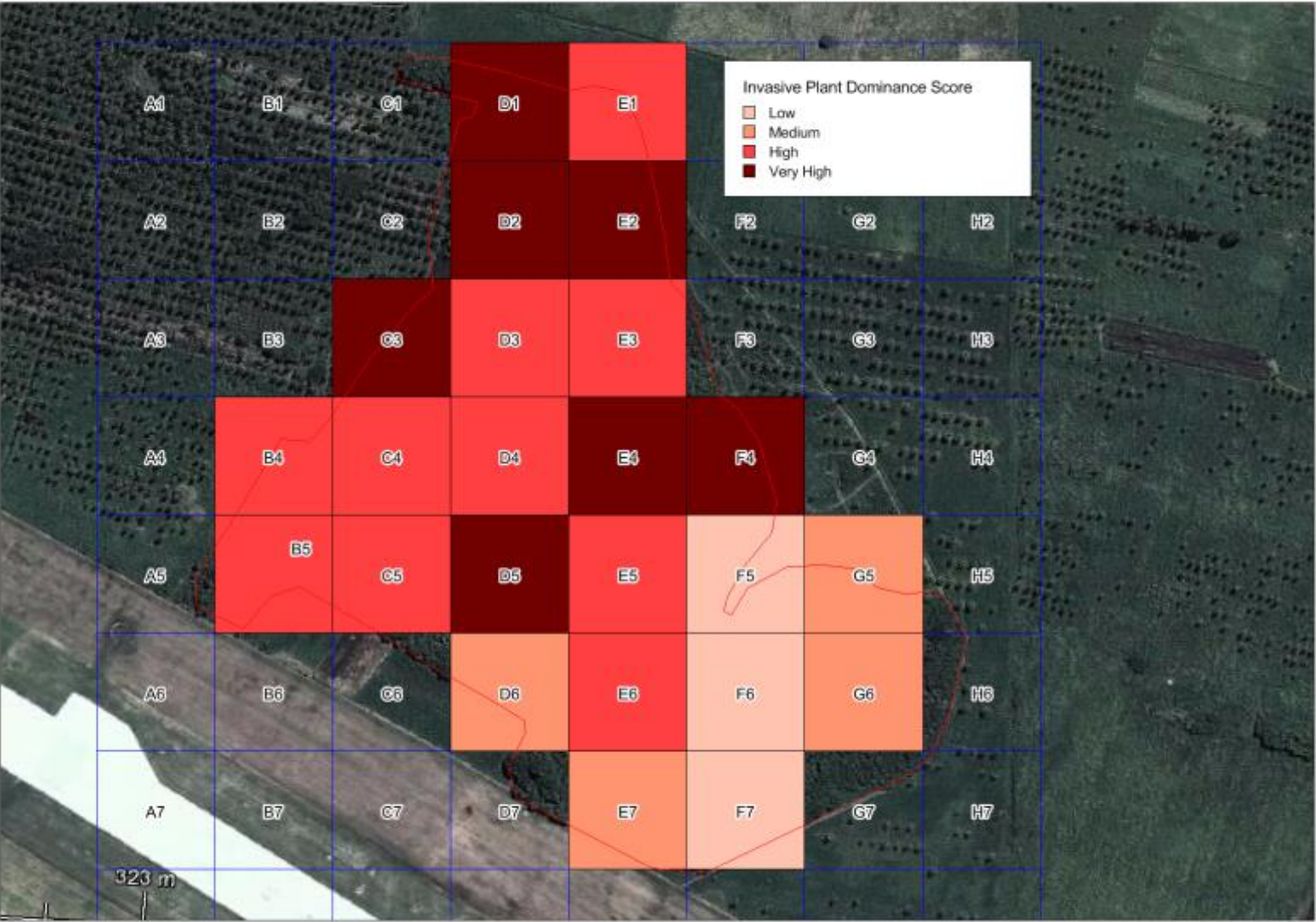


Figure 6. Overall Level of Invasion by Invasive Plants in the Toloa Rainforest



Key: Low = Invasive dominance is low in all 3 forest layers (canopy, sub canopy and ground cover), Medium = High in 1 layer, High = High in 2 layers, Very High = High in all 3 layers

The following is a summary of the key findings of the field survey:

- The degree of invasion by invasive canopy trees is generally low, except in the north and the west of the forest. The main invasive canopy tree is kotia (*Cordia alliodora*), but there are also a few specimens of lopa (*Adenanthera pavonina*).
- The degree of invasion by invasive sub canopy trees and shrubs is more significant, once again especially in the north and west of the forest. The main invasive sub canopy trees are kotia (*Cordia alliodora*), the pula tree (*Solanum mauritianum*) and shrubs are lakaupouli (*Cestrum nocturnum*), talatala (*Lantana camara*).
- The degree of invasion by invasive ground cover plants is significant, once again especially in the north and west of the forest and in gap areas. The main invasive ground cover plants are lakaupouli (*Cestrum nocturnum*), talatala (*Lantana camara*), polo kai (*Solanum americanum*) and tisaipale (*Solanum torvum*).
- The degree of invasion of the forest by invasive vines is high and widespread throughout the whole forest area, but especially around the margins and in forest gaps. The main invasive vines are pula vaine (*Ipomoea indica*), vaine kai (*Passiflora edulis*), vaine tinetina (*Passiflora laurifolia*) and vaine Tonga (*Passiflora maliformis*).
- The overall level of invasion of invasive plants in all layers is highest in the north and west of the forest, and lowest in the east and south of the forest reserve.

3.2 Native biodiversity observations

Incidental observations were made of native biodiversity during the field survey, including birds, reptiles and flying foxes.

Birds

Ten bird species were seen and/or heard during the field surveys (Table 4), although more birds have been recorded in the forest (Ball 2001). The Fuiva (Red-vented bulbul, *Pycnonotus cafer*) was seen outside the forest, but not in the forest during the field surveys.

Table 4. Birds recorded during the field survey

Local Name	English Name	Scientific name	Status in the Toloa forest
Fulehehu	Wattled Honeyeater	<i>Foulehaio carunculata</i>	Very common
Kaka	Red shining parrot	<i>Prosopie tabuensis</i>	Very rare (1 individual?)
Kulukulu	Purple-crowned fruit dove	<i>Ptilinopus porphyraceus</i>	Rare?
Lulu	Barn owl	<i>Tyto alba</i>	Common
Lupe	Pacific pigeon	<i>Ducula pacifica</i>	Rare?
Misi Tonga	Polynesian starling	<i>Aplonis tabuensis</i>	Common
Moakaiavo	Red-jungle fowl	<i>Gallus gallus</i>	Common
Pekapeka	White-rumped swiftlet	<i>Aerodramus spodiopygius</i>	Common
Sigota	White-collared kingfisher	<i>Halycon chloris</i>	Common
Veka	Banded rail	<i>Gallirallus philippensis</i>	Common

Reptiles

We recorded a few moko, or Oceanic Gecko (*Gehyra oceanica*) in leaf litter and under tree bark in the forest, but at least 7 other reptile species are known from the forest (Ball 2001).

Flying foxes

Four peka or flying fox (*Pteropus tonganus*) roosts were observed in the forest. Two of the roosts were in large ovava or banyan trees (*Ficus obliqua*), while the other two roosts were in a kotone (*Myristica hypagyraea*) and a ngatata (*Elatostachys falcata*) tree. We estimate that collectively there are at least 120 peka in the reserve. According to former reserve ranger Sepuloni Folau, these roosts move a lot from tree to tree. The location of the 4 roosts at the time of the field survey is shown in Figure 7.

Figure 7. Location of Peka Roosts and approximate number of Peka in each roost



4.PROJECT GOALS, OBJECTIVES and OUTCOMES

Given its easy accessibility, its small size, its popularity for recreation, and the commitment of the Tupou College and the Government of Tonga for its restoration, the Toloa rainforest is an excellent site to demonstrate forest restoration approaches that are applicable throughout Tonga and elsewhere in the Pacific region. The following are the main benefits of the restoration:

- Ecological benefits: improved ecological functioning and resilience of the site, safeguarding biodiversity, potentially allowing for species translocations in future, to conserve soil and water resources
- Social and aesthetic benefits: improved aesthetic and recreational value, to provide a source for medicinal plants, to provide for education and scientific study
- Demonstration benefits: to demonstrate restoration techniques and to research cost and approaches for forest restoration, as well as raising public awareness on invasive species threats and on their management

Considering the high level of disturbance of the reserve, restoring the reserve to its original, unaltered state is not achievable. However, moving it towards its more original state may be achievable. Therefore, it is proposed that the overall goal of the Toloa Forest Restoration Project is to: *“Improve the ecological functioning and resilience of the Toloa Forest Reserve through forest restoration”*.

It is proposed that the Toloa restoration project has 5 main objectives related to: weed management, forest expansion, forest enrichment, invasive mammal management and public awareness raising. These objectives, along with 2020 targets and outcomes, are explained in Table 5.

Table5. Objectives,2020 targets and outcomes of the Toloa Rainforest Restoration Project

Objectives	Target by 2020	Expected Outcomes
1. Reduce the abundance and distribution of invasive plant species in the Toloa Rainforest	<ul style="list-style-type: none"> • No mature invasive plants of priority species are alive in the forest 	<ul style="list-style-type: none"> • Mature individuals of the priority invasive plants are removed and managed thereafter to zero density
2. Expand the forest area outwards with native trees	<ul style="list-style-type: none"> • The forest area will have been expanded by 5.6 hectares (25%) 	<ul style="list-style-type: none"> • The resilience of the forest to future threats, especially invasive species is increased. • The buffer area around the forest will have a reduced number and density of invasive plants
3. Enrich the rainforest by planting native tree species currently under-represented in the forest	<ul style="list-style-type: none"> • Native trees will have been planted to fill all forest gaps within the rainforest reserve and species considered under-represented will have been planted to a density more closely mimicking that of untouched Tongan lowland rainforest 	<ul style="list-style-type: none"> • The resilience of the forest to future threats, especially invasive species is increased. • Open areas are recolonized with native tree species rather than invasive species • The plant diversity of the forest is increased to more closely

Objectives	Target by 2020	Expected Outcomes
		match the historical state including uncommon or rare native plants
4. Reduce invasive mammal threats in the forest	<ul style="list-style-type: none"> • Reduce the impact of invasive rats, pigs and cats in the reserve via trapping, removal and hunting programs • Eliminate the threat from cattle to the forest by removing cattle from the reserve area and fixing the fence around the reserve 	<ul style="list-style-type: none"> • The threat from invasive mammals, especially to native birds and reptiles, is reduced. • Native bird and reptile populations increase • Native plants regenerate more vigorously
5. Raise public and student awareness on weed management and forest restoration approaches	<ul style="list-style-type: none"> • The awareness of the general public and Tupou college students in particular will have been increased to ensure a longer term and sustainable commitment for Toloa forest restoration and management 	<ul style="list-style-type: none"> • Knowledge of successful approaches to restore the Tongan rainforest is increased • Awareness levels in the local community on the importance of the reserve, on the threat from invasive species and on weed management and restoration approaches is increased • Local voluntary groups are active in assisting with project activities

5. IMPLEMENTATION APPROACH

All restoration effort in the Toloa rainforest reserve will attempt to get the greatest benefit for the effort and cost expended, with an emphasis on the most cost effective and simplest options that help nature heal itself with minimal human intervention.

The implementation approach includes the following five main phases: a) conduct weed management throughout the forest; b) expand the forest area by planting outside to the fence line with appropriate tree species; c) enrich the existing forest by planting native trees currently under-represented in the forest; d) conduct invasive mammal management and e) maintain the gains by conducting follow-up weed and mammal control and replacing dead seedlings.

5.1 Operational Principles and Implementation Approach

There are few examples of ecological restoration work in the tropical Pacific to learn from and base this restoration project on. However, based on experiences in Australia and New Zealand in particular, there are three operational principles that should be considered for restoration to succeed (Bradley 2002).

1. **Work from areas of native plants (core areas) towards weed infested areas (bad areas).** The principle here is that native plants will take back the ground that exotic plants have taken from them, if given the chance. This is the principle behind first improving the condition of the core areas of good native forest and working outwards from these areas. The small size of the Toloa rainforest and the large workforce of the school deem that this principle will not be as relevant

as it would be for larger forest areas. It is likely that the whole forest will be completed for each weed type in a relatively short period of time.

- 2. Make minimal disturbance to the area. The principle here is that undisturbed bush soil is resistant** to weed invasion. Disturbing an area by weeding or killing trees causes gaps and disturbs the soil allowing further weed invasion. Where weeding has to be done, the soil should be returned to its original location. In the Toloa rainforest this principle is paramount to the removal of the canopy species. Tree species should only be removed once an established native sub-canopy is formed.
- 3. Let native plant regeneration dictate to rate of removal.** Experience has shown that over clearing can hamper restoration by encouraging further weed invasion, especially in open areas. The better the condition of the forest, the greater the area that can be weeded, and vice versa. As the weeds get thicker, the slower the rate of native plant regeneration and also the lower the weeding rate should be. In the Toloa rainforest it is anticipated that re-planting with suitable native plants to form a quick sub-canopy will subdue light-dependent vines and make the restoration of the weedier areas both easier and faster. As mentioned in principle two, removal of weeds beneath canopy weed species should occur first before the canopy is treated. This should only happen either once native plants have established or immediately prior to planting of natives.

5.2 Phasing of weed management

Experience from New Zealand and elsewhere has shown that successful site-led weed management can follow a process called the “Forest Restoration Framework” which has four distinct primary phases that sites should go through for effective and efficient restoration (Moverley 2012). These phases relate to the target weeds lifestyles and provide a structured approach for planning, operational implementation, monitoring success and reporting. Table 6 explains the key features, including the timing, of each phase.

The phases are:

1. Initial control. This phase targets seedlings, shrubs and trees by either cutting stems and applying herbicide to the stump (cut stump application) or manual removal of those that are able to be hand-pulled. Vines are cut to release the canopy and other plants from the vines. These actions provide an immediate positive effect on the ecosystem, improves access for further works and defines and minimises targets for foliar spraying if required.

In the case of Toloa the initial control phase could be split into two or three actions to reflect the different methodologies and most likely separate implementation stages to complete the initial control.

Suggested sub-classifications could be:

- Initial control-vines manual
- Initial control- shrubs manual
- Initial control- cut stump herbicide application

2. *Follow-up foliar control.* This phase targets herbaceous vines with foliar spraying which have been previously cut during the Initial control phase, and other plants which are more suited to foliar spraying. In Toloa this phase would target the vines on the edge of the forest and any areas which continued to grow due to a slow close of the canopy following release of the native vegetation from the vines.

3. *Seedbank control.* Following the successful control of all target species within an area the area enters the seedbank phase where germinating seeds are treated on a regular pre-determined basis until the seedbank is exhausted. It is vital that this regular operation is implemented before the target plants set seed.

4. *Forest protection.* Once the seedbank of all target weeds is exhausted or are inhibited from germination (for example due to light requirements) the forest needs to be regularly searched for new weed arrivals. This process is required most likely well into the future unless propagules from surrounding areas can be restricted from entering the area.

An additional complementary phase, “Long Term Control” allows for sites where large scale removal of target species would result in loss of ecosystem function or environmental benefits. Examples of this could be long term canopy management to ensure natives are established before killing or removing weed canopy trees, or the slow removal of weeds and replacement with natives in areas that are prone to erosion.

Table 6. Proposed phasing of weed management work (Source: Moverley 2012)

Phase	Definition	Methodology	Phase Duration	Outcome to be monitored	Proposed timing in Toloa
Initial Control	Weeds that transform the function of the ecosystem are present within the designated area.	Cut stump application of all woody weed species and releasing of vines etc. from desirable plants in preparation for the next phase. Provides immediate positive effects on the ecosystem, improves access, eliminates mature woody plants, and subdues vines.	Dependent on resources. Commonly a total area is worked through in stages	All target weeds are dead. Vines released from native plants and placed on ground for foliar (leaf) spraying.	2014-2015
Follow-up control	Weeds that transform the function of the ecosystem requiring foliar (leaf) spraying are present within the designated area.	Foliar spraying of vines and weeds. Implemented twice to eliminate all weeds that have germinated.	Within one year of the initial control.	All initial target weeds are dead.	2015
Seedbank control	All original weeds that transform the function of the ecosystem are dead. Seedbanks	Foliar spraying or hand pulling of all plants that have germinated from the seedbank.	Generally three to four years, depending on seed	No target weedsreaching maturation	2016-2020

Phase	Definition	Methodology	Phase Duration	Outcome to be monitored	Proposed timing in Toloa
	remain in the soil resulting in germination events within the designated area		viability of the species concerned.		
Forest protection	All target weeds eliminated and the seedbank exhausted. Weeds re-enter the designated area from neighbouring locations.	Cut stump, foliar spray, or hand pull recently arrived plants. Sites prone to invasion (edges, streams, tracks, disturbance sites, and beneath fruiting or perch trees) are checked.	Ongoing	New individual incursions only, no communities of target weed plants evident. No target weeds reaching maturity.	2020-ongoing
Long Term Control	Target weeds are slowly removed to allow ongoing ecosystem function or benefits.	Target weeds are removed in stages to allow for regeneration or increased growth of existing natives to fulfil ecological function.	Ongoing	Slow replacement of weeds with native plants performing ecosystem function.	2015-2020

In the Toloa rainforest the long-term control phase would relate to the kotia (*Cordia alliodora*) trees where established native vegetation should be evident before controlling the canopy trees. Alternatively if saplings are available to plant in the newly created light well this could accelerate the process.

5.3 Management Units

To implement the forest restoration framework the forest or target area should be split into discrete manageable areas or management units. This provides a finer scale for which to plan, implement and analyse with each unit capable of being in a different phase of control. It also breaks down each of the tasks into smaller manageable units which allows for a strategic implementation approach and an opportunity to increase both motivation and recordable success. The units should be based on existing tracks which can be displayed geo-spatially on a map within the GPS unit and on hard copy maps. The boundaries of the units should be clearly marked and labelled with marker tape at regular intervals to ensure easy identification while on the ground. The five proposed management units (MU) are shown in Figure 8 along with their areas in hectares.

The proposed management units are all of approximately equal size between 4- 5 ha each. Currently vine management effort has commenced near the entrance to the reserve on the western edge. Consequently, it is proposed that the work commences in a broad west to southeast movement across the reserve as indicated by the numbering of the management units from MU1 to MU5.

Figure 8. Proposed Management Units in the Toloa Forest



5.4 Target Invasive Plant Species

Target Weed Species

Thirty six invasive plants have been recorded in the reserve, including 3 grasses, 10 herbs, 5 shrubs, 13 trees and 5 vines (Table 7). All of these are introduced plants, except for one, the pula vaine (*Ipomoea indica*) which although native is highly invasive in degraded areas and causes environmental impacts by smothering native vegetation and inhibiting forest regeneration.

Table 7. Prioritisation of invasive plants for management in the Toloa reserve

Species	Habit	Tongan Name	Status	2014 Dominance in Survey Blocks	Invasive Risk in Toloa
<i>Eleusine indica</i> (L.) Gaertn.	Grass	takataka a le ala	Introduced	?	High
<i>Panicum maximum</i> L.	Grass	saafa	Introduced	Common	High
<i>Paspalum conjugatum</i> Berg.	Grass	Vailima	Introduced	?	High
<i>Ageratum conyzoides</i> L.	Herb		Introduced	?	?
<i>Asparagus species</i>	Herb		Introduced	?	High
<i>Elephantopus mollis</i> H. B. K.	Herb		Introduced	?	?
<i>Eleutheranthera ruderalis</i>	Herb	Pakaka	Introduced	?	?
<i>Glycine wightii</i> (Wight & Arn.) Verdc.	Herb		Introduced	Common	High?
<i>Oxalis corniculata</i> L.	Herb	kihikihi	Introduced	?	?
<i>Pseudelephantopus spicatus</i>	Herb		Introduced	?	?
<i>Sida rhombifolia</i> L.	Herb		Introduced	Common	High
<i>Stachytarpheta cayennensis</i> (L.C. Rich.) M. Vahl	Herb	hiku ' kuma	Introduced	Common	High
<i>Synedrella nodiflora</i> (L.) Gaertner	Herb		Introduced	?	?
<i>Capsicum frutescens</i> L.	Shrub	polo fifisi	Introduced	Uncommon	Low?
<i>Cestrum nocturnum</i> L.	Shrub	lakau po'uli	Introduced	Common	High
<i>Lantana camara</i> L.	Shrub	talatala	Introduced	Common	High
<i>Solanum americanum</i> Mill.	Shrub	polo kai	Introduced	Uncommon	High
<i>Solanum torvum</i>	Shrub	tisaipale	Introduced	Uncommon	High
<i>Adenantha pavonina</i> L.	Tree	lopa	Introduced	Uncommon	Low?
<i>Aleurites moluccana</i> (L.) Willd.	Tree	tuitui	Introduced	Common	Low?
<i>Cananga odorata</i>	Tree	mosooi	Introduced	Uncommon	Low
<i>Carica papaya</i> L.	Tree	Lesi	Introduced	Common	Low
<i>Castilla elastica</i>	Tree		Introduced	Uncommon	High
<i>Citrus maxima</i> (Burm.) Merr.	Tree	moli Tonga	Introduced	Uncommon	Low?
<i>Coffea arabica</i> L.	Tree	kofe	Introduced	Common	Low?
<i>Cordia alliodora</i> (Ruiz & Pavon) Oken	Tree	kotia	Introduced	Common	High
<i>Eucalyptus spp</i>	Tree		Introduced	Uncommon	Low
<i>Inocarpus fagifer</i> (Park.) Fosb.	Tree	ifi	Introduced	Common	Low
<i>Mangifera indica</i> L.	Tree	mago	Introduced	Uncommon	Low
<i>Roystonea regia</i> (Kunth) O.F. Cook	Tree	(royal palm)	Introduced	Uncommon	Low
<i>Solanum mauritianum</i> Scop.	Tree	pula tree	Introduced	Common	High
<i>Dioscorea bulbifera</i> L.	Vine	hoi	Introduced	Common	Low
<i>Ipomoea indica</i>	Vine	pula vaine	Native?	Common	High
<i>Passiflora edulis</i> L.	Vine	vaine kai	Introduced	Common	High
<i>Passiflora laurifolia</i> L.	Vine	vaine tintina	Introduced	Common	High
<i>Passiflora maliformis</i> L.	Vine	vaine Tonga	Introduced	Common	High

Twelve of the 36 plant species are considered to have a high actual or potential invasive risk in the reserve and are therefore higher priorities for management (see section 6.1). Invasive risk is based on information held in the Pacific Island Ecosystems at Risk database (<http://www.hear.org/pier/>).

6. OPERATIONAL DETAILS

6.1 Weed management

The recommended approach for managing different weeds depends on a range of factors including (National Trust of Australia 1999):

- the growth habit of the plant
- the time in the plant's life cycle
- the tools available
- the weather conditions
- the surrounding plants
- whether herbicides can be used on the site
- physical attributes of the site
- accessibility of the weed

There are eight main weed control methods: shading, hand weeding, ring barking, mechanical weeding, controlled grazing, biocontrol, use of herbicides or use of fire (DOC 2001). However, most weeds in the Toloa reserve will be removed by hand or by applying herbicides. If the weeds are small or non woody they can usually be hand pulled. However, if they are larger or have deep tap or lateral roots they may need to be cut and treated with herbicide.

Weed management techniques

Of the 36 invasive plants recorded in the reserve, 12 are considered priorities based on their high invasive risk in the forest and their actual and potential impact on the forest (Table 8). The most appropriate management technique to be used for the twelve priority invasive plant species depends on whether the plants are herbs, shrubs, woody trees or vines and is shown in Table 8. The skills levels and knowledge needed to manage invasive plants increases as the size of the plant increases as shown in Figure 9, while management techniques for different types of plants are shown in Figure 10-13 (National Trust of Australia 1999).

In all cases the cut material should be placed in tidy piles to ensure easy access for follow up operations. Refer to the National Trust of Australia (1999) for more information.

Table 8. Summary of recommended management techniques for 12 priority invasive plants

Species	Habit	Recommended management technique	Figure
<i>Asparagus species</i>	Herb	Hand pulling. The growing points must be removed below the surface which may involve using a knife	Refer to Figure 10
<i>Ipomoea indica</i> <i>Passiflora edulis</i> <i>Passiflora laurifolia</i> <i>Passiflora maliformis</i>	Vines	Hand pulling and/or cutting at ground level and at head level. It is important that broken portions are stacked off the ground as they will regrow if they are left in contact with the ground and environmental conditions are conducive to growth.	Refer to Figure 11
<i>Cestrum nocturnum</i> <i>Lantana camara</i> <i>Solanum americanum</i> <i>Solanum torvum</i>	Shrub	Hand pulling for small seedlings For larger shrubs - cut stumps near the ground and apply 25% glyphosate immediately to the cut stump	Refer to Figures 10 and 12
<i>Castilla elastica</i> <i>Cordia alliodora</i> <i>Solanum mauritianum</i>	Woody trees	Hand pulling for small seedlings For saplings- - cut stump near the ground and apply 25% glyphosate immediately to the exposed cambium, phloem and collar root to the ground, for saplings <10cm DBH apply to whole cut stump area. For larger trees- use stem injection or ring chopping. This involves cutting into cambium layer in a downward direction every 6-10cm around the trunk and applying herbicide immediately.	Refer to Figures 10, 12 and 13

Figure 9. Illustration showing the increasing skill level, knowledge and equipment required for managing invasive plants as they increase in size

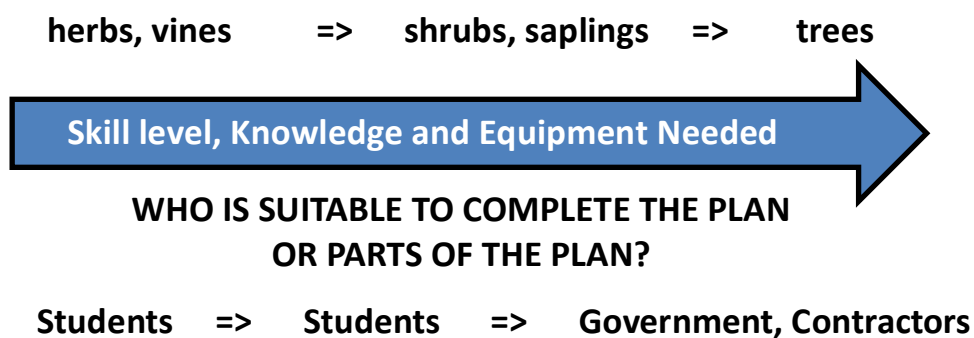


Figure 10. Methods for hand pulling herbs and seedlings

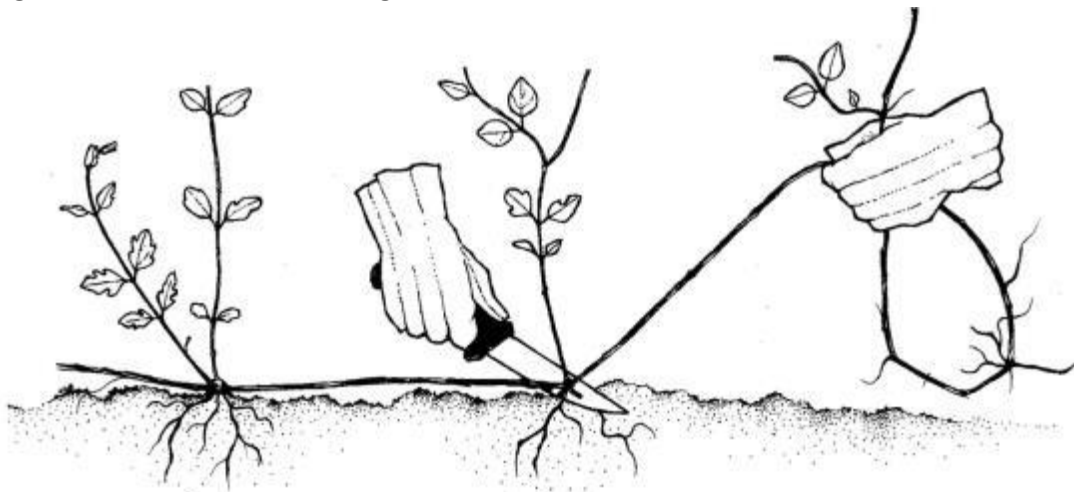


Hand pull herbs and seedlings from ground level to avoid breakage. If the plant has lateral roots pull them horizontally through the soil towards the stem of the plant to avoid breakage.



Removal of Asparagus fern using a knife. The growing points must be removed from the ground, it has been noted that water tubers can be left in the ground as they won't grow back, however if control of this plant was needed at a larger scale, a reliable method is to release the fern from desirable plants and foliar spray the target with 1% glyphosate .

Figure 11. Methods for removing vines



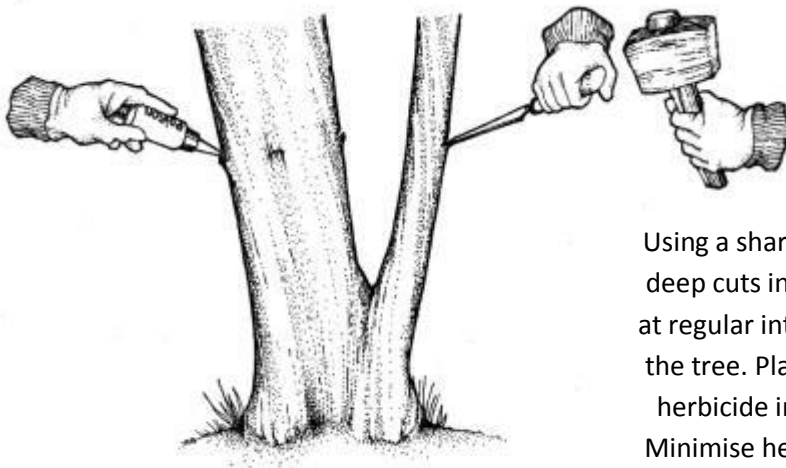
Cut the vines at head height. Remove vines along the ground by pulling them up towards you. Use a knife to cut off fibrous roots and try and remove all broken pieces of stem or roots as they will grow back. Follow the runners until the main root system is located and remove it manually. Follow up regularly. If shading out from native canopy is not effective over time, the procedure can be repeated with the application of 25% glyphosate to the stump. For vines on the perimeter of the reserve or large areas within, the vines should be cut at head height and placed on the ground so a 2% glyphosate mix can be applied to the remaining leaf and stems on the ground.

Figure 12. Methods for cut stump of small saplings



Cut the plant as close to ground level as possible and horizontally. Herbicide should immediately be painted on the whole surface of the cut stump if the stump is less than 10cm diameter, otherwise around the rim only. Minimise herbicide dripping onto the soil.

Figure 13. Methods for killing larger trees



Using a sharp chisel, axe or drill make deep cuts in the sapwood (cambium) at regular intervals around the base of the tree. Place the correct amount of herbicide into each hole as it is cut. Minimise herbicide dripping onto the soil.

Timing of weed control operations

It is important to structure and time the removal of weeds correctly and in accordance with plant lifestyles and in a spatially coordinated manner if any weed control operation is to be successful. This is important to ensure further weed propagules are not added to the existing seedbank and over time the seedbank within the soil is reduced until it is exhausted. It is also important to have a targeted approach over an area that is not too large to manage by using management areas as discussed earlier. A suitable timeframe is represented in Table 12 below which is classified by categories and sub-categories and the time of year, including the timing of infill planting once weeds are at a level which will not threaten the survival rate of the newly establishing plants.

6.2 Tree planting

Selection and source of trees to plant

In this restoration project trees will be planted to: a) enrich the existing forest to a more natural species mix and b) expand the forest outwards into the surrounding grassland thereby increasing the resilience of the forest to threats.

Only native plants will be planted in the reserve and only in the appropriate locations. The selection of which native species to plant is site and condition specific and requires an understanding of a range of factors including climate (eg light, temperature and rainfall) and soil requirements of the species, the former and current distribution of the plant, as well as its position in forest succession processes, subjects which are not well understood in Tonga. Another factor to consider is the forest layer to which the plant belong, be it the shrub layer, sub canopy, canopy or emergent tree layer. The healthiest forests have a range of layers evident.

Table 9 shows 17 candidate tree species for planting in the Toloa rainforest. The information recorded includes for each species the assumed successional stage, based on observation, along with current abundance in the reserve and proposed propagation method, where known.

Table 9. List of trees for the Toloa Forest restoration planting programs

Tongan Name	English Name	Tree Layer	Species Name	Successional stage	Abundance in the Toloa Forest	Proposed Propagation Method
Toi	?	Canopy	<i>Alphitonia zizyphoides</i>	Early secondary?	Uncommon	Grow from seed or transplant wildings
Koka	?	Canopy	<i>Bischofia javanica</i>	Late secondary?	Uncommon	Grow from seed or transplant wildings
Tamanu	?	Canopy	<i>Callophyllum neo-ebudicum</i>	Primary?	Not found	Grow from seed or transplant wildings
Motou	?	Canopy	<i>Cryptocarya hornei</i>	Primary?	Common	Grow from seed or transplant wildings
Kanume	?	Sub canopy	<i>Diospyros elliptica</i>	Primary?	Uncommon	Grow from seed or transplant wildings
Mo'ota	?	Canopy	<i>Dysoxylum forsteri</i>	Late secondary?	Common	Grow from seed or transplant wildings
Ma'amalava	?	Sub canopy	<i>Elaeocarpus floridanus</i>	Late secondary?	Common	Grow from seed or transplant wildings
Ngatata	?	Canopy	<i>Elattoscahys falcata</i>	Late secondary?	Uncommon	Grow from seed or transplant wildings
Ovava	Banyan	Emergent	<i>Ficus obliqua</i>	Primary?	Uncommon	Transplant wildings
Foui		Canopy	<i>Grewia crenata</i>	Late secondary?	Common	Grow from seed or transplant wildings
Lou pata	?	Sub	<i>Macaranga</i>	Early	Common	Transplant wildings

Tongan Name	English Name	Tree Layer	Species Name	Successional stage	Abundance in the Toloa Forest	Proposed Propagation Method
		canopy	<i>harveyana</i>	secondary		
Kotone	Wild Nutmeg	Sub canopy	<i>Myristica hypargyrea</i>	Primary?	Common	Grow from seed or transplant wildings
Kalaka	?	Canopy	<i>Planchonella grayana</i>	Primary?	Uncommon	Grow from seed or transplant wildings
Tavahi	?	Canopy	<i>Rhus taitensis</i>	Early secondary?	Common	Grow from seed or transplant wildings
Kafika vao	?	Sub canopy	<i>Syzygium clusiifolium</i>	Primary?	Common	Grow from seed or transplant wildings
Ahi vao	?	Sub canopy	<i>Vavaea amicornum</i>	Primary?	Common	Grow from seed or transplant wildings
Filimoto	?	Canopy	<i>Xylosma smithiana</i>	Primary?	Common	Grow from seed or transplant wildings

For a few tree species, such as *kafika vao* and *kotone* there are abundant seedlings in places in the Toloa forest that can be transplanted to other sites within the forest. However, in most other cases seedlings must either be grown from seed in the nursery, or transplanted from other sources on the island of Tongatapu.

Plant Nursery

A 30m by 40m (approximately) plant nursery is currently being constructed near the entrance to the reserve inside the fence (see Figure 14 for the location). The nursery is supplied with water by a long pipe from the school.

Planting Plan

A draft planting plan has been prepared for the reserve which is appropriate to local site conditions and tree species already present and the plant species to be planted (Figure 14). The plan shows the approximate locations, densities and species of each clump of plants to be planted in the two main planting zones- the forest expansion zone around the reserve and the enrichment planting zone within the reserve. Table 10 shows the approximate number of trees to be planted in each planting zone.

Forest Expansion Zone

There are three areas around the reserve that will be planted with trees to expand the forest area (Figure 14), totalling 5.6 ha. The trees most common to the reserve area will form the framework (eg Tavahi) but with a range of species planted to get maximum biodiversity benefits, such as food (nectar or fruits) and habitat for birds. Spacing of plants is dependent on the site conditions and the species to be planted. Large canopy trees obviously need further spacing (eg 3-5m apart) than small trees or shrubs which might be 1-2m apart in between canopy trees. In all cases trees will be planted randomly and not in straight lines, so as to better mimic nature.

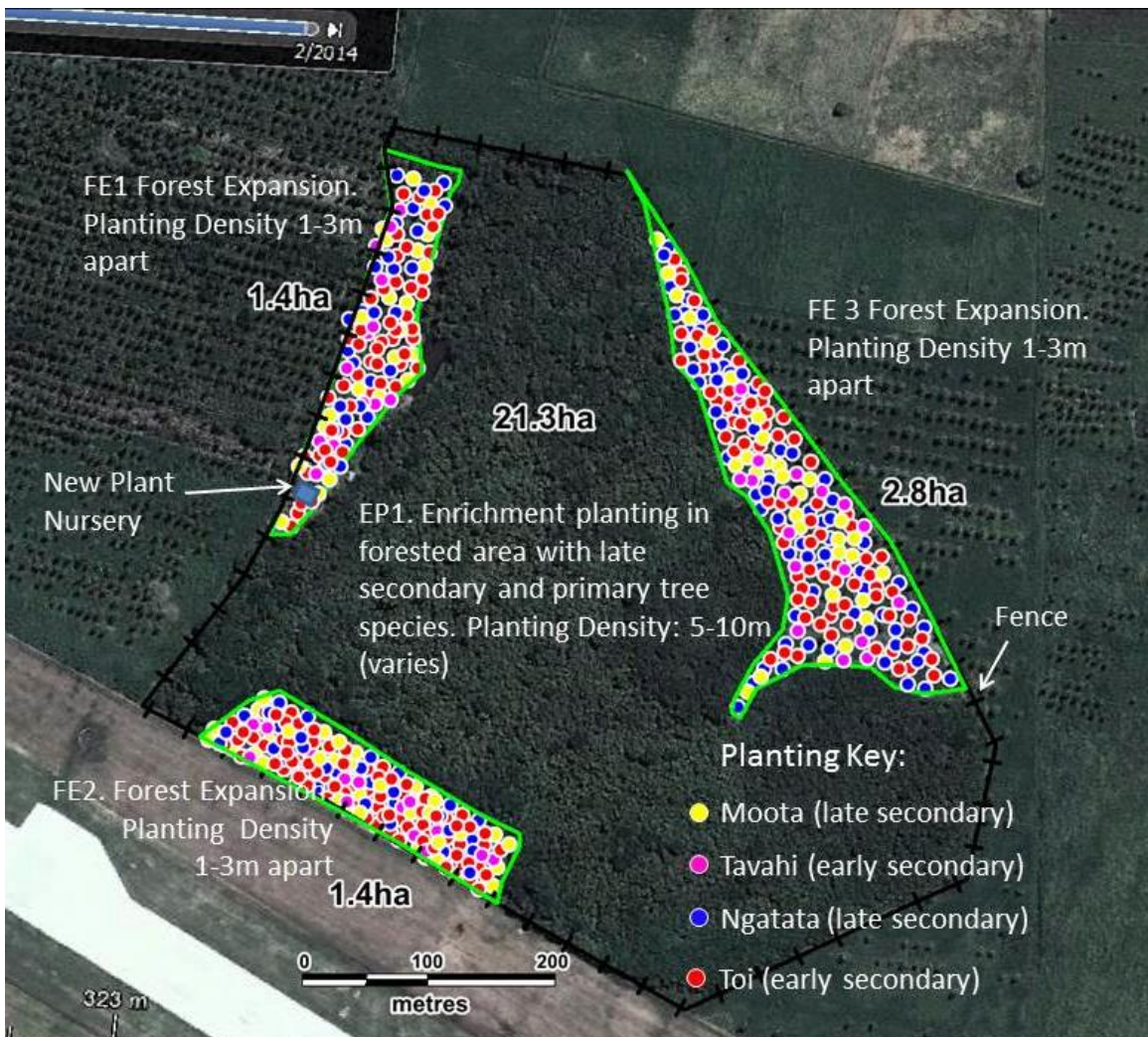
In general, the forest expansion areas as well as gaps in the forest should be planted with early secondary (or pioneer) species such as Lou pata, Toi or Tavahi or later secondary trees such as Ngatata, Moota or Maamalava, in order to establish a canopy under which primary forest trees such as Ovava, Motou and Kanume, can later grow. In these open areas trees will be planted quite densely (eg 1-4m apart) than in shaded areas (eg 5-10m apart).

Enrichment Planting Zone

Within the existing forest trees will be planted to fill gaps and to add species currently under-represented in the forest. Areas where there is already lots of shade can be planted with more shade tolerant late secondary or primary forest trees such as Tamanu, Motou, Kanume, Kotone and Ahi vao at a spacing of approximately 5-10m apart.

Given the critical role of *Ovava (Ficus obliqua)* as a flying fox roost, as food source for native bird and bats and as a habitat for plants, insects and other native biota coupled with the fact that there are only 3 *Ovava* trees in the reserve, it is recommended that 10 or more *Ovava* trees are planted throughout the reserve.

Figure 14. Planting Plan for the Toloa reserve



Site preparation

Before planting, sites must be prepared in order to ensure that weed competition with the planted trees for light, soil moisture and nutrients is minimised and hole digging is easier. Ground preparation includes mowing or slashing grassy areas first or hand removing weeds from the areas where trees will be planted or spraying, but not over-clearing or damaging the roots of any adjacent native plants. The exposed ground should be mulched with the removed vegetation (DOC 2001).

Number of trees to be planted

Table 10 shows the approximate tree density and number of trees to be planted in each of the two main planting zones in the reserve- the forest expansion zone (3 areas) and the forest enrichment zone in the existing forest. The total number of trees that will be planted is approximately 16,000-20,000 of which approximately 3,000 would be toi, and 2,400 each of mootaa, ngatata and tavahi, and about 100-500 each of the 13 other target tree species (see Table 10).

Table 10. Planting density and number of trees to be planting in the Toloa Forest

Planting Unit	Approximate Unit Area (ha)	Tree Species to plant	Approximate Composition (%)	Average density of trees to plant	Number of trees needed/ha	Approx. total number of trees planted
Forest Expansion (FE) Zone						
FE1	1.4	Toi	20	2mx2m	500	700
		Tavahi	15	2mx2m	375	525
		Ngatata	15	2mx2m	375	525
		Mootaa	15	2mx2m	375	525
		13 other trees (in between above fast growing trees)	35	2mx2m	875	1225
		Unit Total			2500	3500
FE2	1.4	Toi	20	2mx2m	500	700
		Tavahi	15	2mx2m	375	525
		Ngatata	15	2mx2m	375	525
		Mootaa	15	2mx2m	375	525
		13 other trees (in between above fast growing trees)	35	2mx2m	875	1225
		Unit Total			2500	3500
FE3	2.8	Toi	20	2mx2m	500	1400
		Tavahi	15	2mx2m	375	1050
		Ngatata	15	2mx2m	375	1050
		Mootaa	15	2mx2m	375	1050
		13 other trees (in between above fast growing trees)	35	2mx2m	875	2450
		Unit Total			2500	7000
Enrichment Planting (EP) Zone						
EP1	21.3	All 17 species but focus on late secondary and	100	10x10m (varies)	100	2130

Planting Unit	Approximate Unit Area (ha)	Tree Species to plant	Approximate Composition (%)	Average density of trees to plant	Number of trees needed/ha	Approx. total number of trees planted
		primary forest species				
Total number of trees planted						16130

Planting approach

Planting will follow best practise guidelines (eg see DOC 2001) and will be done on wet or overcast days and will be avoided on dry or windy days for obvious reasons. Most planting will be done during the wet season months of October to March.

Mulching and Maintenance

Around planted trees mulch from dried plant waste will be used to keep down weeds and build soil moisture and fertility. Weeding will be needed at 2-3 monthly intervals for the first year, then at 4 monthly intervals for the 2nd year, then at 6 monthly intervals from years 3 to 6.

6.3 Invasive Mammal Management

As noted invasive mammals have detrimental impacts on the biodiversity and integrity of the forest reserve: rats have a large impact on native birds, reptiles and plants; cats impact native birds, cattle wander through holes in the fence into the forest trampling on native plants and damaging the soil and pigs also eat native plants and damage the soil, as well as creating wallows where water accumulates and mosquitoes breed.

It is therefore proposed to conduct mammal management to reduce the negative impacts. Mammal management needs to be conducted in a phased approach so as to minimise non-target risks and the possibility of secondary poisoning from rat baiting. Thus cattle and pigs should be removed and the fence repaired before any rat baiting is conducted so that no cattle and pigs can enter the forest and be at risk from secondary poisoning. Note that secondary poisoning can also be eliminated by using first generation rat poisons.

It is also important that there is good monitoring to show the benefits of any mammal management. For example, tracking tunnels or wax tags should be used to demonstrate rat reduction and bird counts or nesting studies of pigeons and doves to show benefits to birds, as well as seedling plots to show benefits for plant recruitment. Monitoring could be pre-treatment and post treatment or within treatment areas and outside treatment areas.

Table 11 outlines the proposed mammal management actions and the expected outcomes of the management.

Table 11. Proposed mammal management actions in the Toloa reserve

Invasive mammal	Proposed Actions to manage the invasive mammal	Expected Outcomes of the management
Cattle	<ul style="list-style-type: none"> Remove cattle from within the fence Fix holes in the fence to stop cattle entry into the forest and maintain the fence thereafter 	<ul style="list-style-type: none"> Cattle incursion into the reserve stopped with concomitant biodiversity benefits
Pigs	<ul style="list-style-type: none"> Pig hunting throughout the year or removal of pigs and exclusion through suitable fencing 	<ul style="list-style-type: none"> Reduced pig population with concomitant biodiversity benefits Once pigs removed the risk of secondary poisoning of pigs from rat bait will be zero
Rats	<ul style="list-style-type: none"> Comprehensive rat management plan and implementation focused on baiting a regular grid with a focus on the bird reproduction season 	<ul style="list-style-type: none"> Reduced rat population with concomitant biodiversity benefits
Cats	<ul style="list-style-type: none"> Cat trapping throughout the year 	<ul style="list-style-type: none"> Reduced cat population with concomitant biodiversity benefits

6.4 Seasonality of Work

In general the follow-up control spraying of weeds with herbicides and application of rat bait is best done during the dry season when the weather conditions are dry and the toxins are less likely to be washed away quickly. Conversely, tree planting is best done in the wet season when the ground is wet and the trees are less likely to get water stressed. Other activities are less seasonally influenced. The ideal timing for each phase of work is shown in Table 12.

Table 12. Timing of restoration work

ACTIVITY	Oct-Dec 2014	Jan-March 2015	Apr-Jun 2015	Jul-Sep 2015	Oct-Dec 2015	Jan-Mar 2016-2020	Apr-Jun 2016-2020	Jul-Sep 2016-2020	Annually
Initial Control-vines manual, all mgmt units	Y	Y	Y						
Manual vine control boundaries and problem areas				Y			Y		Y
Initial Control-shrubs manual, all mgmt units		Y		Y					
Initial control-cut stump herbicide application, all mgmt units			Y	Y					
Follow up foliar control, boundaries and problem areas				Y	Y				
Seedbank Control, all mgmt units						Y		Y	
Forest protection									Y
Long Term control of kotia (<i>Cordia alliodora</i>)	Y	Y	Y	Y	Y	Y	Y	Y	Y
Planting area preparation				Y					
Tree maintenance					Y	Y	Y		
Tree planting					Y	Y			

The scheduling is a guide only, and common sense should prevail with appropriate activities selected according to the current weather on the day.

6.5 Seven Year Work Plan (2014-2020)

A phased 7 year work plan for the restoration of the Toloa rainforest reserve has been prepared based on commencing with the simplest tasks, such as weed management of vines and shrubs first before moving to more to complex tasks (See Table 13). The workplan also shows the estimated costs per year.

Table 13. Draft 7 year Workplan for the Toloa Rainforest Restoration Project (2014-2020)

Year	Main Activities	Expected Outcomes	Estimated Costs (USD)	
2014	<ul style="list-style-type: none"> • Fundraising • Design and establish long-term monitoring plots and procedures • Purchase equipment and materials • Recruitment of Project Manager • Identification of Restoration Team (students, volunteers etc) • Conduct training of team in restoration, biosecurity and health and safety • Prepare weeding and tree planting plans • Build nursery and scale up propagation of native trees • Conduct initial weed control • Conduct follow up control in target areas 	<ul style="list-style-type: none"> • Sufficient funding secured for project commencement. • All materials and equipment purchased • Nursery built • Staff hired and trained • Weed management underway • Tree planting underway 	Chemicals 1224 Equipment 7760 Materials 2500 Nursery establishment 15732 Personnel 480 Total 27,696	
2015	<ul style="list-style-type: none"> • Fundraising • Purchase of equipment and materials • Remove cattle and pigs and fix fence around forest • Commence tree planting around reserve and enrichment planting in reserve (in wet season) • Continued training as required • Continue restoration activities incl weed management and tree planting • Commence invasive mammal management • Continue monitoring activities • Engage local community groups in restoration work 	<ul style="list-style-type: none"> • Restoration activities continue • Community groups engaged • Results of restoration are monitored • Annual report written 	Awareness Raising 4383 Chemicals 804 Equipment 130 Materials 1466 Total 6,783	
2016	<ul style="list-style-type: none"> • Fundraising • Purchase of equipment and materials • Continued training as required • Continue restoration activities incl weed management, tree planting and mammal management 	<ul style="list-style-type: none"> • Restoration activities continue • Community groups engaged • Results of 	Awareness Raising 3383 Chemicals 804 Equipment 130 Materials 1466 Total 5,783	

Year	Main Activities	Expected Outcomes	Estimated Costs (USD)
	<ul style="list-style-type: none"> Continue monitoring activities Engage local community groups in restoration work 	<ul style="list-style-type: none"> restoration are monitored Annual report written 	
2017	<ul style="list-style-type: none"> Fundraising Purchase of equipment and materials Continued training as required Continue restoration activities incl weed management, tree planting and mammal management Continue monitoring activities Engage local community groups in restoration work 	<ul style="list-style-type: none"> Restoration activities continue Community groups engaged Results of restoration are monitored Annual report written 	Awareness Raising 3383 Chemicals 804 Equipment 130 Materials 1466 Total 5,783
2018	<ul style="list-style-type: none"> Fundraising Purchase of equipment and materials Continued training as required Continue restoration activities incl weed management, tree planting and mammal management Continue monitoring activities Engage local community groups in restoration work 	<ul style="list-style-type: none"> Restoration activities continue Community groups engaged Results of restoration are monitored Annual report written 	Awareness Raising 3384 Chemicals 804 Equipment 130 Materials 1466 Total 5,784
2019	<ul style="list-style-type: none"> Fundraising Purchase of equipment and materials Continued training as required Continue restoration activities incl weed management, tree planting and mammal management Continue monitoring activities Engage local community groups in restoration work 	<ul style="list-style-type: none"> Restoration activities continue Community groups engaged Results of restoration are monitored Annual report written 	Awareness Raising 3384 Chemicals 804 Equipment 130 Materials 1466 Total 5,784
2020	<ul style="list-style-type: none"> Fundraising Purchase of equipment and materials Continued training as required Continue restoration activities incl weed management, tree planting and mammal management Continue monitoring activities Engage local community groups in restoration work 	<ul style="list-style-type: none"> Restoration activities continue Community groups engaged Results of restoration are monitored Annual report written 	Awareness Raising 3384 Chemicals 804 Equipment 130 Materials 1466 Total 5,784
		ESTIMATED TOTAL	USD \$63,397

6.6 Detailed Implementation Plan for 2014-2015

A detailed implementation plan outlining key tasks and completion dates has been prepared for 2014-2015 and is shown in Table 14. The Restoration Project Manager will prepare similar implementation plans for subsequent years.

Table 14. Key tasks, responsibilities and timing for 2014-2015

TASK	BY WHEN	RESPONSIBLE
Review of Operational Plan, (including Monitoring Plan and Biosecurity Plan)	2014 October	MEECCDMMIC Tupou College
Endorsement of Operational Plan	2014 October	MEECCDMMIC
Recruitment of Restoration Project Manager and formation of core restoration team	2014 October	Tupou College
Design and build the plant nursery	2014 October	MEECCDMMIC Tupou College MAFFF (Forestry)
Establishment of monitoring sites including photo points etc	2014 October	MEECCDMMIC Tupou College
Training of students in biosecurity, safety and respect for nature	2014 October	MEECCDMMIC Tupou College
Training of restoration team in plant identification focusing on vines	2014 October	MEECCDMMIC Tupou College
Training of restoration team in Initial Control- manual Vine control	2014 October	MEECCDMMIC Tupou College
Training of restoration team in growing plants in the nursery from cuttings, transplanting and seed- plan what, how and many plants are required to be grown on.	2014 October-November	MEECCDMMIC Tupou College MAFFF (Forestry)
Remove large kotia from forest boundary only and stack for firewood	2014 coordinate with nursery building and fence repair	MEECCDMMIC MAFFF (Forestry)
Complete initial manual vine control in all 5 management units Restoration Team members leading teams of students	2014 October-November	Tupou College
Training of restoration team in Initial manual shrub control and identification	2014 November-December	MEECCDMMIC Tupou College
Order equipment for predator control	2014 November-December	MEECCDMMIC SPREP
Collect cuttings and grow in the nursery	2014 December-January 2015	Tupou College MAFFF (Forestry)
Assess fence and get quotes for fixing, check with Tupou College and Airport about replacing missing gate adjacent to runway	2014 Before end of year	MEECCDMMIC
Complete initial manual shrub control	2015 January-February	Tupou College
Transplant existing excess seedlings to the nursery for growing	2015 January	Tupou College
Collect seed as it becomes available and grow in the nursery	2015 When available	Tupou College
Complete maintenance of boundary fence	2015 February-March	MEECCDMMIC
Training of herbicide use and safety and management	2015 February	SPREP MEECCDMMIC Tupou College
Training of restoration team in Initial control cut stump herbicide application	2015 February	SPREP MEECCDMMIC Tupou College
Training in data collection	2015 February	SPREP MEECCDMMIC

TASK	BY WHEN	RESPONSIBLE
		Tupou College
Training for predator control	2015 February	SPREP MEECCDMMIC Tupou College
Complete second round of manual vine control and manual shrub control in all 5 management units Restoration Team members leading teams of students	2015 February-March	Tupou College
Complete Initial control-cut stump herbicide application	2015 April-May	MEECCDMMIC Tupou College MAFFF (Forestry)
Complete third round of manual vine control and manual shrub control in all 5 management units Restoration Team members leading teams of students	2015 June-July	Tupou College
Complete second control-cut stump herbicide application	2015 August	MEECCDMMIC Tupou College MAFFF (Forestry)
Complete manual vine control around boundaries and problem areas within forest	2015 August-September	Tupou College
Foliar spray vines around perimeter and problem areas within the forest following manual vine control	2015 August-September	MEECCDMMIC Tupou College MAFFF (Forestry)
Prepare forest expansion zones for planting	2015 September	MEECCDMMIC Tupou College MAFFF (Forestry)
Prepare a detailed workplan for 2016	2015 September	Tolea Forest Restoration Technical Committee
Planting training and planning	2015 September	MEECCDMMIC Tupou College MAFFF (Forestry)
Plant forest expansion zones with plants from nursery	2015 October- November-December	MEECCDMMIC Tupou College MAFFF (Forestry)
Plant enrichment planting areas	2015 December and into 2016	MEECCDMMIC Tupou College MAFFF (Forestry)

Note: Predator control activities to be added following detailed plan establishment of priorities.

6.7 Site Biosecurity

In order to ensure that the project does not inadvertently promote the spread of new invasive weeds into the reserve or from weed infested to non-infested areas within the reserve a few simple biosecurity protocols will be followed for all project staff, students and volunteers as follows:

Quarantining process

1. All equipment and supplies will go through a thorough cleaning processes before they are used.
2. A basic quarantine inspection will be undertaken before each trip into the reserve and any seeds removed and destroyed. This includes clearing velcros, pockets, dusting each other and clearing the dirt out of boots and equipment.
3. Weeders will clean themselves off when they finish weeding a site and before moving to the next site.

Public awareness

Members of the operational team will promote the application of the above biosecurity protocols amongst students and members of the public assisting with project activities as volunteers.

7. PROJECT BUDGET

An outline project budget is shown in Table 15. The gives approximate costs for all major project expenses over the 7 years of the plan (2014-2020). The budget also shows a proposed breakdown of GEF-PAS costs until August 2016, versus unsecured costs beyond that date which will need to be sought.

7.1 Budget Assumptions

The following are the main assumptions used in the budget:

1. Exchange rates: 1USD = 1.9 TOP; 1 USD = 1.15 NZD;
2. Core restoration team consists of 6 members: Project Manager and 5 Core Team members;
3. GEF-PAS costs are until August 2016 only;
4. Weed management is for 8 months a year while remainder of year focusses on tree planting;
5. Imports include freight and duty;
6. Project Manager (Ranger) salary is covered by the Tupou College from 2015 onwards;
7. All restoration team members other than the Ranger are volunteers;
8. Training costs are not included in this budget as they will be calculated separately by SPREP.

Table 15. Outline Toloa Forest Restoration Project Budget (2014-2020)

Item/Expenditure	Number of units Needed	Approximate Price/Unit (USD)	Assumptions and comments	Total (USD)	Year of purchase	Purchased locally or from overseas, or in kind support	GEF-PAS component (USD)	Unsecured Component (USD)
Equipment								
Chainsaws short bar	2	394.00	2 already purchased- 1500 TOP for both	788	1	L	788	
Ear muffs	2	60.00	Cost from NZ	120	1	O	120	
Safety Boots	6	109.57	Assumes 1 pair boots for each member of restoration team	657	1	L	657	
Garmin GPSMAP 62 CSx	1	550.00	Needed for mapping of management areas	550	1	O	550	
Laptop	1	2000.00	For Ranger to record info	2,000	1	O	2,000	
Work Gloves	42	7.30	Assumes 1 pair gloves/year for each member of restoration team	307	1	L	307	
Protective Gloves	2	20.00	Nitrile gloves for handling herbicides (in boxes of 100). Assumes 2 boxes needed	40	1	L	40	
Files	36	10.96	Assumes that 12 files need replacing every 2 years	394	1	L	394	
Day back-pack	1	91	For Ranger	91	1	L	91	
Long handle Axe	4	36.52	4 ordered at 68 TOP	146	1	L	146	
Rolls of flagging tape	70	7.00	Assumes 10 rolls/year	490	1	O	490	
First Aid Kit	1	152.17		152	1	L	152	

Item/Expenditure	Number of units Needed	Approximate Price/Unit (USD)	Assumptions and comments	Total (USD)	Year of purchase	Purchased locally or from overseas, or in kind support	GEF-PAS component (USD)	Unsecured Component (USD)
Replenishment of first aid kit	6	130.00	Assumes first aid kit replenished every year from year 2 onwards	780	Yearly	L	260	520
12 l Knapsack Sprayers	2	170.43	Assumes 2 needed	341	1	L	341	
Spray bottles (1litre)	20	9.13	Assumes 20 needed	183	1	L	183	
Rat bait stations	60	16.67	Assumes 60 needed	1,000	1	O	1,000	
Cat traps	10	50.00	Assumes 10 needed	500	1	O	500	
Subtotal Equipment				8,540			8,020	520
Chemicals (Herbicides & Adjuvants)								
20l of Roundup (Glyphosate)	9	190.00	60l (2015) 20 l/year afterwards	1,710	Yearly	O	570	1,140
5l Adjuvants (organo silicone)	3	140.00	Assumes 2 litres/year for 7 years	420	Yearly	O	120	300
20l Blue Dye	1	420.00	Assumes 20l	420	1	O	420	
Rat bait	7	300.00	Yearly costs for rat bait	2,100	Yearly		600	1,500
Insecticides/pesticides	7	200.00	Yearly costs to control pests in nursery	1,400	Yearly	O	400	1,000
Subtotal Chemicals				6,050			2,110	3,940
Nursery establishment								
Establish plant nursery		13100.00	Cost = 25,000 TOP	13,100	1	L	13,100	-
Materials to complete nursery		2632.00	Cost= 5,000 TOP	2,632	1	L	2,632	-

Item/Expenditure	Number of units Needed	Approximate Price/Unit (USD)	Assumptions and comments	Total (USD)	Year of purchase	Purchased locally or from overseas, or in kind support	GEF-PAS component (USD)	Unsecured Component (USD)
Subtotal Nursery Establishment				15,732			15,732	-
Materials								
Repair fence	1	2500.00	Approx cost incl adding new gate adjacent to runway	2,500	1	L	2,500	
Nursery bags	10,000	0.30	Assumes approx 10,000 trees to be potted (others transplanted)	3,043	Yearly	L	869	2,174
Yearly Fuel	7	200.00	Needed for chainsaw	1,400	Yearly	L	400	1,000
Stationary	7	121.74	Write in the rain notebooks, pens etc	852	Yearly	L	242	610
Miscellaneous Materials	7	500.00	Includes yearly costs for sacks, ropes, baskets etc	3,500	Yearly	L	1,000	2,500
Subtotal Materials				11,296			5,011	6,284
Personnel								
Annual salary of Restoration Project Manager	24	20.00	Part time salary provided by project til end of 2014, then by Tupou College	480	1		480	-
Subtotal Personnel				480			480	-
Staff Training								
First Aid Training	1		Assumes one 2 day training for key project staff	0	2		0	0
Training in safe use of herbicides and in biosecurity	1		Assumes one 2 day training for key project staff	0	2		0	-
Training in GPS/GIS	1		Assumes one 2 day training for key project staff	0	2		0	-

Item/Expenditure	Number of units Needed	Approximate Price/Unit (USD)	Assumptions and comments	Total (USD)	Year of purchase	Purchased locally or from overseas, or in kind support	GEF-PAS component (USD)	Unsecured Component (USD)
Training in recording and monitoring data	1		Assumes one 2 day training for key project staff	0	2		0	-
Training in safe use of chainsaws and other equipment	1		Assumes one 2 day training for key project staff	0	2		0	-
Training in nursery husbandry and tree planting techniques	1		Assumes one 2 day training for key project staff	0	2		0	-
Subtotal Staff Training				-			-	
Awareness Raising Activities								
T shirts	50	10.00		500	2		500	
Baseball caps	50	10.00		500	2		500	
Public Open days	21	200.00	Assumes 3 events/year for 7 years	4,200	Yearly		1,200	3,000
Media outreach	7	300.00	Yearly cost of eg newspaper articles, TV ads, press releases etc	2,100	Yearly		600	1,500
Public Awareness Materials	7	2000.00	Includes signs, brochures, posters etc	14,000	Yearly		4,000	10,000
Subtotal Awareness/Reporting				21,300			6,800	14,500
TOTAL PROJECT BUDGET 2014-2020				63,397				
GEF-PAS Total (USD)							38,152	
Unsecured Total (USD)								25,244

8. MANAGEMENT OF PROJECT IMPACTS

8.1 Non Target Impacts

Non-target impacts arise from the accidental weeding or death of native plants during herbicide application, or via trampling of native plants during operations. Such impacts will be minimised by:

- Training all operational staff, students and volunteers in plant identification to minimise the accidental removal or damage to native species.
- Emphasising hand-weeding techniques over herbicide use where feasible.
- Using the lowest toxicity herbicide that is available.
- Carefully applying herbicides only to the target invasive weeds
- Following the correct rat baiting approach

While some native plants may accidentally be killed during the project, in the long term the native plant population will be increased significantly through habitat enhancement and native plant recruitment rates vastly exceeding mortality rates.

8.2 Management of impacts on people

The management of adverse impacts on people includes both the health and safety of operational staff and also visitors to the reserve. Key safety considerations revolve around the following risks:

Use of herbicides

Only trained people should be allowed access to herbicides. Agrichemical management and use should be in compliance with the NZS:8409:2004, New Zealand Standard “Management of Agrichemicals”. This includes storage, use, protective clothing and emergency response. Training for all relevant people in the management and use of agrichemicals will be conducted in year one of the project and at regular intervals throughout the project term.

When herbicide application is occurring a sign will be placed at the entrance to the reserve to inform the public and to reassure them that they are not at risk from the operation.

Use of rat bait

Only trained people should be allowed access to rodent bait. Only first generation baits are to be used to reduce secondary poisoning to other animals. A comprehensive plan is to be produced for animal control and this will detail further aspects of managing the impacts on people.

Use of chainsaws, sharp knives and other dangerous equipment

Risks from injury from equipment, especially chain saws, sharp knives and other equipment will be minimised through proper training and the use of the appropriate personal protective equipment such

as overalls, gloves and boots. Only trained people will be allowed to use the more dangerous equipment, such as chain saws and this will be strictly enforced.

Extreme weather conditions

Risks from injury to the operational team during bad weather will be minimised by proper training, use of suitable protective equipment and avoiding working in extreme weather conditions, such as heavy rain or strong winds.

Risk from falling trees

Within operational areas where trees have been treated, the risk from falling trees will be reduced by clearly marking such areas with flagging tape, and training of staff in being cautious and observant in these areas. It can also be minimised by not working when there are strong winds. Trees to be killed within close proximity to tracks and other public use areas should be carefully felled so as not to have falling limbs in these areas.

First Aid Training and First Aid Kit

A first aid kit will be carried by the operational team in the field and another should be available at the Tupou College. Furthermore, key members of the Operational Team will be required to undergo First Aid Training (see also section 9.2).

9. OPERATIONAL TEAM AND PROJECT GOVERNANCE

9.1 Operational Team

The proposed composition and responsibilities of the Toloa Restoration Operational Team is shown in Table 16.

Table 16. Responsibilities of Toloa Restoration Operational Team

Title	Responsibilities
Forest Restoration Project Manager (Ranger)	<ul style="list-style-type: none"> • Project planning and oversight. • Restoration Team selection. • Budgeting, reporting, analysing database information. • Manages field team performance • Logistical management. • Procurement.
Field Assistants (5-20)- Tupou college teachers and senior students	<ul style="list-style-type: none"> • Assist ranger to supervise work of students and other volunteers • All restoration work as required
Volunteers- Tupou college students principally	<ul style="list-style-type: none"> • Weeding • Tree planting • Nursery work
SPREP, MEECCDMMIC, MAFFF staff and contractors	<ul style="list-style-type: none"> • Technical advise • Training • Herbicide application

Title	Responsibilities
	<ul style="list-style-type: none"> • Tree removal • Invasive mammal management (rat baiting, cat trapping, pig hunting)

9.2 Training

Appropriate training will be conducted for members of the Restoration Team, including the Project Manager (Ranger) so that they can perform their work professionally and safely. Table 17 shows the proposed training for different members of the restoration operational team.

Table 17. Proposed training courses and skills required

TRAINING REQUIRED	WHEN	BY WHO	FOR WHO
Training in monitoring sites including photo points etc	2014 October	MEECCDMMIC Tupou College Ranger SPREP Assist	Tupou College Ranger Viliani Hakaumotu
Training of students in biosecurity, safety and respect for nature	2014 October	MEECCDMMIC Tupou College Ranger	Field Assistants (5-20) Volunteers (Tupou college students principally)
Training of restoration team in plant identification focusing on vines	2014 October	MEECCDMMIC Tupou College Ranger	Field Assistants (5-20) Volunteers (Tupou college students principally)
Training of restoration team in Initial Control- manual Vine control	2014 October	MEECCDMMIC Tupou College Ranger	Field Assistants (5-20) Volunteers (Tupou college students principally)
Training in First Aid	2014 October	Red Cross	Tupou College Ranger Field Assistants (5-20)
Training of restoration team in growing plants in the nursery from cuttings, transplanting and seed- plan what, how and many plants are required to be grown on.	2014 October- November	MEECCDMMIC Forestry	Tupou College Ranger Field Assistants (5-20)
Training of restoration team in Initial manual shrub control and identification	2014 November- December	MEECCDMMIC Tupou College Ranger	Tupou College Ranger Field Assistants (5-20)
Training of herbicide use and safety and management	2015 February	SPREP MEECCDMMIC Tupou College	Tupou College Ranger Field Assistants (5-20)
Training of restoration team in Initial control cut stump herbicide application	2015 February	SPREP MEECCDMMIC Tupou College Ranger	Tupou College Ranger Field Assistants (5-20)
Training in data collection	2015 February	SPREP MEECCDMMIC Tupou College	Tupou College Ranger
Training for predator control	2015 February	SPREP MEECCDMMIC	Tupou College Ranger Field Assistants (5-20)
Planting training and planning	2015 September	MEECCDMMIC Forestry	Tupou College Ranger Field Assistants (5-20)
Refresher and volunteer training	AS required	Tupou College Ranger Field Assistants (5-20)	Volunteers (Tupou college students principally)

Note: It is intended that generally the Ranger and Field Assistants will train their groups of volunteers prior to operations.

9.3 Toloa Forest Restoration Technical Committee

It is proposed that a small technical committee be formed to oversee the implementation of the operational plan including acting as a technical adviser to the Operational Team. The proposed membership and responsibilities of this committee are shown in Table 18.

Table 18. Membership and Responsibilities of the Toloa Forest Restoration Technical Committee

No	Name	Job Title	Organization	Role/responsibility
1	Viliami Hakaumotu	National Project Coordinator for the GEF-PAS	MEECCDMMIC	- Project Oversight - Budgeting - Reporting - Procurement - Fundraising
2	David Moverley	Invasive Species Adviser	SPREP	- Technical advice - Fundraising
3	Sepuloni Folau (to be confirmed)	Forest Restoration Project Manager (Ranger)	Tupou College?	- Project planning and oversight. - Budgeting, reporting, analysing database information. - Manages field team performance - Logistical management. - Procurement
4	Rev Feleti	Principal	Tupou College	- Coordinates role of Tupou College in the project
5	Pelenatita Kara		Civil Society Forum of Tonga (CSFT)	- Coordinates role and involvement of civil society in the project - Fundraising
6	Lupe Matoto	Head of Environment	MEECCDMMIC	- Project Oversight - Technical advice - Liaison with MEC - Fundraising
7	Maloni Havea	Deputy Head of Forestry	MAFFF	- Technical advice - Liaison with MAFFF - Training in nursery management and tree planting - Training in herbicide usage

10. MONITORING AND RESEARCH

10.1 Monitoring

Monitoring is needed to measure the success of the project against the stated goals and objectives and must be kept as simple as possible (DOC 2001). As noted it is particularly important that good baseline data are collected before major restoration activities, such as rat management, are conducted. Comprehensive data presented in this report can contribute to the baseline, but more data need to be collected. It is recommended that monitoring focusses on the following simple methods:

- Six monthly photopoints in 2 or 3 specific places in the reserve to record qualitative changes in forest structure and native plant regeneration, as well as changes in abundance of weeds

- Standardised six monthly observations of birds (eg five minute bird counts) and observations before and after any rat management operations

Considerable progress has been made over the past ten years in the use of proxy measures to indicate the success of weed control objectives. When the process is aligned with the Forest Restoration Framework, simple observations from the site may be used as provided in Table 8. Hectares that successfully move through the phases of the framework will indicate success.

When measured against a constantly defined area (such as management units), proxy measures of efforted hours, herbicide use, number of stems and age class can be used as indicators of success (Moverley & Floyd, 2012). For the Toloa rainforest, recommended proxy measures per management area or total forest area are control effort per method/application.

All of these measures can be captured within a database so results can be discussed and analysed. It also provides a record of herbicide use and proxy measures. An example database that relates collected data to the site or management unit is provided in Figure 15. This database could be simplified to allow for the large workforce of the school, recording only hours rather than actual people. This database should be managed by the Project Manager (Ranger).

Figure 15. Example database for monitoring management effort

The screenshot displays the 'ECOLOGICAL RESTORATION DAILY DIARY' software interface. At the top, it shows site information: '6466 NSEC Birkenhead/northcote'. Below this, there are input fields for 'Diary Entered By: Jay', 'Date: Tuesday, 30 June 2009', 'JOB #: 6466', and 'Reserve or MU Name: CH5-Chelsea Park'. A central map shows an aerial view of a forested area with a yellow boundary and a label 'CH5'. To the right of the map, there are 'Primary Restoration Phases July 2009' (IC, FU, SB) and 'Complementary Restoration Phases for 2009-2010' (Long Term Control, Tradescantia Control). The bottom section is divided into three main panels: 'Diary Information' (Team Leader: Jay, Vehicle Kms: 0, Staff list with start/finish times and hours), 'Agrichemical Use Record' (Phase: JCC-INITIAL CONTROL, Method: CUT STUMP, Total Volume Used: 3.00 litres, Herbicides: Metasulfuron, Glyphosate, Markers/Dye, Adjuvants, Organosilicone), and 'Diary Information' (Target Species list: Elaeagnus, Privet, Chinese, Privet, Tree, Monkey Apple, Woolly Nightshade, Phoenix Palm, Bangalow Palm, Ginger, Kahili). The interface also shows navigation buttons for diary records and a total staff hours summary of 19.5.

10.2 Research

Given the accessibility of the Toloa forest and the demonstration value of this project, the forest is a good site for targeted research on restoration approaches such as rat management and weed control. Table 19 shows some possible research projects in the Toloa forest.

Table 19. Possible research projects in the Toloa forest reserve

Research theme	Details of research projects	Comments
Propagation techniques for native trees	<ul style="list-style-type: none"> ▪ Seed germination trials ▪ Trials of plant propagation via cuttings ▪ Costs of propagation methods 	<ul style="list-style-type: none"> ▪ See section 6.2
Impacts of invasive mammal management on forest species diversity	<ul style="list-style-type: none"> ▪ Impacts of rat, cat, and pig control on native birds and other native biodiversity (eg plants) 	<ul style="list-style-type: none"> ▪ See section 6.3
Viability of native seeds in the soil	<ul style="list-style-type: none"> ▪ Viability of native seeds of different tree species in the soil over time ▪ Enclosures to study germination rates of native plants when rats and pigs are excluded 	<ul style="list-style-type: none"> ▪ So that the appropriate mix between letting native seeds germinate in situ versus tree planting can be determined
Growth rates of native tree species in different sites	<ul style="list-style-type: none"> ▪ Research on growth rates of native species in different areas with eg different planting densities and levels of light/canopy density and different species mixes 	<ul style="list-style-type: none"> ▪ So that better estimates can be made of growth rates under different scenarios for future restoration work
Weed management approaches	<ul style="list-style-type: none"> ▪ Optimal approaches to remove weedy shrubs and vines (eg hand removal versus use of herbicides) ▪ Optimal approaches to defoliate and kill different invasive trees ▪ Minimal volumes of herbicide to use on different plants/areas 	<ul style="list-style-type: none"> ▪ See section 6.1
Costs of forest restoration	<ul style="list-style-type: none"> ▪ Costs of conducting all forest restoration activities/ha (incl labour and materials for weed management, plant propagation, tree planting and maintenance) 	<ul style="list-style-type: none"> ▪ So that more accurate budgeting of forest restoration can be done in future

11. PUBLIC AWARENESS AND COMMUNITY ENGAGEMENT

A key objective of the project is to engage with the local community on restoration activities in order to raise public awareness of the threat posed by invasive species and to foster support for, and participation in, restoration activities such as weed management and tree planting. The key local group that will be engaged in the project is the Tupou College which has about 1000 students, but it is hoped that other schools and local community groups will also become actively involved in the project.

A public awareness budget has been included in the project budget to cover such items as the production of awareness material and the purchase of light refreshments for public open days. A project brochure will be prepared and disseminated and public open days will be conducted regularly to raise awareness and to show people the restoration work being conducted and to encourage the public to participate in restoration activities. In addition, a series of simple instructional brochures will be prepared in English and Tongan on management approaches for different weeds and for tree planting and forest restoration.

The following community groups will be targeted by the public awareness program in particular: the adjacent communities of Toloa and Pelehake, farmers, schools, local charities such as the Rotary, staff of the MEECCDMMIC and other Government ministries, the Civil Society Forum of Tonga (CSFT), the Tonga Community Development Trust and other local NGOs and interested individuals. It is hoped that

a “Friends of the Toloa Forest” group will eventually be formed and will be active in providing volunteers for restoration activities.

In the long run it is hoped that nature trails, benches, signage and other facilities for environmental interpretation will be constructed in the reserve to improve the visitor experience and to raise awareness of the environmental values of the site. For example, Tupou College would like to put in a bird viewing platform above the canopy to allow better birdwatching opportunities and for viewing the surrounding countryside.

Given the location of the Toloa forest adjacent to Tonga’s main airport, there may be good opportunities to develop and register the forest as a certified “Carbon Forest” and to secure carbon offset funds from visitors to Tonga who wish to offset the carbon produced from their international travel. There is huge interest and impetus internationally in establishing certified forests using C offset funds which are used for tree planting or other restoration activities that lock up carbon. Tonga has the potential to take a leading role in the Pacific in this regard as there are currently no certified C- offset forests in the region yet.

12. CONCLUSION

The restoration of the Toloa rainforest is an achievable goal and will have significant benefits for Tonga. Given the small area of the site, its accessibility and the commitment of partners to restore the forest, the Toloa forest could potentially become of the most important sites in the Pacific region to raise awareness of the impacts of invasive species and to demonstrate the benefits of invasive species management and forest restoration.

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Annex 1: 2014 Survey Methodology; July 28-30, 2014

METHODOLOGY

- Toloa Forest (approx. 20ha) was subdivided into 1 ha working blocks (100m X 100m)- see map overleaf
- Field crew walked in a zigzag fashion through the forest from the NW corner to the SE corner visiting all 1 ha blocks covered with more than about 50% forest cover. This involved a walk of approximately 2700m long and notes were taken in 24 separate blocks.
- A visual assessment of the vegetation in the centre of each hectare block was made to cover tree canopy, sub canopy and shrub layer/ground cover. GPS locations were noted and photos taken of the site and any species that could not be identified.
- Trails through the site were also walked as well as the perimeter (2400m) with a similar assessment of vegetation and invasive plants.
- Incidental records of native species (eg birds, flying foxes, reptiles) were also be made on the walks

FIELD CREW: Sepuloni Folau (former Ranger), Dave Moverley (SPREP), Hoifua Aholahi (MEECCDMMIC), Viliami Hakaumotu (MEECCDMMIC), James Atherton (consultant).

DATA COLLECTION: Data was collected on each hectare block and recorded on a record sheet (see below). Notes focussed on listing the plants present (checklist of native and invasive plants present) including their dominance and density of invasive plants at each observation point.

OUTCOMES:

- Map of the vegetation of the site including areas dominated by invasive plants and areas with large native trees
- Map of other key biota in the site (eg flying foxes, rare birds etc)
- Checklist of plants present in the forest including invasive plants, along with notes on their dominance in the forest

See Annex 2 for the completed data sheets.

Map of survey walked (white line) on 1ha Grid.

NB. Green dots are waypoints of observation points and other features



2014 Survey Data Sheet

Surveyor's names:		
Date:	Time:	Weather:
Block Number:	Start Lat:	Finish Lat:
Slope:	Start Long:	Finish Long:
Elevation (m):	WP #:	WP #:
Canopy cover (trees >15m height) – species and dominance		
Sub canopy and shrubs (trees >1m < 15m height)- species and dominance		
Ground cover (<1m, <5cm dbh)- species and dominance		
Level of disturbance by cyclones or humans (H, M, L) and nature of disturbance		
Degree of invasion by invasive plants (H,M,L) and dominant invasive plants noted:		
Invasive animals noted (eg rats, cats, pigs, YCA, snails etc):		
Birds seen/heard:		
Other Indigenous biota	#species seen	Comment/spp./dominance etc
Insects (eg butterflies)		
Reptiles		
Flying foxes		
Other Comments		

Annex 2: 2014 Survey Results

Block_Number	Date_Visited	Observers	Time_Start	Weather	Slope_Degrees	Elevation_M	WP_Number	Canopy_Description	Canopy_Invasive	Sub_canopy_description	Sub_canopy_invasive	Ground_cover	Ground_Cover_Invasive	Disturbance_Openness	Degreee_Invasion	Dom_Invasive_Plants	Invasive_Vines	Invasive_Animals	Birds	Other Biota	Other comments
D1	28-Jul	James, Hoifua, Viliami, Sepulona, David	2.54pm	Fine	0	37	463	Dominated by Kotia, Tavahi, Eucalyptus. Also Foui, Tuitui, Masi ata	D	Dom by Fekika vao, Fau. Also Ahi vao, Tanetane vao, Nonu, Gatata, Laukaupouli, Panama rubber (1)	r	Dom by Kotia, Fekika vao, Moota, Takafalu, Kanume	D	L	H	Kotia, Vaine kai, Panama rubber	r	Y (pig and cow hoof prints)	Moa kaivao, Fuleheu	N	Many wild yams. Panama rubber
E1	28-Jul	James, Hoifua, Viliami, Sepulona, David	3.26pm	Fine	0	35	464	Dominated by Tavahi, Lau pata, Kotia. Also Gatata, Pula tree	D	Dom by Fau, Tavahi. Also Kalaka, Fekika vao, Tuitui, Ahi vao, Motou, Masi tala, Olamaka		Dom by Kotia, Laukaupouli. Also Polo, Fekika vao, Moota	D	M	H	Laukaupouli, Pula vine, Kotia, Tisaipale, Tutuuli	r	Y (cattle and rat dung)	Fuleheu, Lupe	N	Dead Koka from debarking, Filimoto chopped down. High disturbance along east side
E2	28-Jul	James, Hoifua, Viliami, Sepulona, David	4.07pm	Fine	0	38	467	Dominated by Tavahi, Filimoto. Also Foui, Loupata, Fekika vao, Ifi, Toi, Teeteemanu, Fao, Gatata	r	Dom by Fekika vao, Fau. Also Kotia, Tavahi, Kotone, Laukaupouli, Kalaka, Takafalu, Manonu, Ahi vao, Kavakavaulie	r	Dom by Fekika vao. Also Lopa, Filimoto, Koka, Tuitui, Moli Tonga, Spicy, Moota	r	L	M	Kotia, Laukaupouli, Kofi, Panama Rubber (1)	r	N	Fuleheu	N	Many Fekika vao seedlings (WP 465). Panama rubber plant (WP 466). Asparagus plant (WP 468). Good native forest
D2	28-Jul	James, Hoifua, Viliami, Sepulona, David	4.52pm	Fine	0	43	469	Dominated by Foui, Tavahi, Loupata. Also Kotia, Ifi, Tuitui	r	Dom by Kotia, Fau. Also Fekika vao, Nonu, Ifi, Teeteemanu, Motou, Olamaka	D	Dom by Fekika vao, Kotia. Also Gatata, Takafalu, Ifi, Tavahi, Masi ata, Vaine kai and ferns	D	L	M	Kotia, Kofi, Laukaupouli	r	Y (signs of rata eating vaine kai)	Faleheu, Moakaivao	N	Large ifi trees and seedlings in area; very large sipi (>27 DBH). Also Kotone seedlings
C3	28-Jul	James, Hoifua, Viliami, Sepulona, David	5.20pm	Fine	0	39	471	Dominated by Fekika vao. Also Masi ata, Tuitui, Kotia, Tavahi	r	Sparse but dom by Gatata, Kotia, Ahi vao, Filimoto, Fau, Kofi	r	Dom by Fekika vao. Also Unuoi, Laukaupouli, Nonu, Kotone,	r	M	M	Kotia, Laukaupouli, Lesi	r	N	Fuleheu	N	Major tree cutting of sub canopy, ground orchids seen (but not

Block_Number	Date_Visited	Observers	Time_Start	Weather	Slope_Degrees	Elevation_M	WP_Number	Canopy_Description	Canopy_Invasive	Sub_canopy_description	Sub_canopy_invasive	Ground_cover	Ground_Cover_Invasive	Disturbance_Openness	Degreeee_Invasion	Dom_Invasive_Plants	Invasive_Vines	Invasive_Animals	Birds	Other Biota	Other comments
												Tanetanevao, Oketi vao, Kotia									flowering)
D3	29-Jul	James, Hoifua, Viliami, Sepulona, David	9.37am	Fine-breezy	0	37	473	Dominated by Fau. Also Ifi, Gatata, Motou, Tavahi, Masi ata, Fekika vao, Foui, Teeteemanu		Dom by Fau. Also Ahi va, Tava, Manonu, Kofi, Ifi	r	Dom by Fekika vao, Lopa, Ifi	r	M	L	Ifi, Laukaupouli	r	N	Lulu, Kulukulu	Y	Peka roost in Kotone tree (>20). WP 470). Pelagic Gecko. Harvesting of bark of Loupata in area, Abandoned Sigota nest
E3	29-Jul	James, Hoifua, Viliami, Sepulona, David	9.58am	Fine-breezy	0	38	474	Dominated by Tavahi. Also Fau, Foui, Motou, Filimoto, Fekika va, Filimoto		Dom by Fekika vao. Also Teeteemanu, Kofi, Tuitui, Nonu, Pula, Manonu, Mosooi, Masi ata, Lantana	r	Dom by Fekika vao. Also Teeteemanu, Ahi vao, Laukaupouli, Kavakavaulie, Teeteemanu	r	M	M	Pula tree, laukaupouli, Vaine kai	r	Y (YCA)	Kulukulu, Fulehehu	N	Lantana grows like a vine in places
D4	29-Jul	James, Hoifua, Viliami, Sepulona, David	11.05am	Fine-breezy	0	42	477	Dominated by Tuitui, and Fekika vao. Also Kotone, Masi ata, Ifi, Foui, Tavahi, Loupata		Dom by Fekika vao. Also Laukaupouli, Nonu, Ahi vao, Motou, Kofi, Masi ata, Foui, Kotia	r	Dom by Fekika vao. Also Nonu, Kofi	r	M	H	Laukaupouli, Vaine kai, Pula vine, Pakaka	r	N	Lupe, Fulehehu	N	Many vines (native and introduced)
C4	29-Jul	James, Hoifua, Viliami, Sepulona, David	11.25pm	Fine-breezy	0	42	478	Dominated by Masi ata and Tuitui. Also Foui, Kotone, Koka, Ovava		Dom by Fekika vao. Also Pula, Kotia, Tanetane vao, Kau	r	Dom by Laukaupouli, Fekika vao, Teeteemanu, Masi ata, Kofi, Nonu	D	M	M	Laukaupouli, Kotia, Pula, Kotia, Vaine kai	r	N	Fulehehu, Misi Tonga	Y	Crow butterflies, Pelagic gecko, Peka roost in Ovava tree (>50), WP 484. Large koka smothered in vines, possibly dying. Large Royal palm (WP

Block_Number	Date_Visited	Observers	Time_Start	Weather	Slope_Degrees	Elevation_M	WP_Number	Canopy_Description	Canopy_Invasive	Sub_canopy_description	Sub_canopy_invasive	Ground_cover	Ground_Cover_Invasive	Disturbance_Openness	Degreee_Invasion	Dom_Invasive_Plants	Invasive_Vines	Invasive_Animals	Birds	Other Biota	Other comments
																					484)
B4	29-Jul	James, Hoifua, Viliami, Sepulona, David	12.09pm	Fine-breezy	0	35	480	Dominated by Tavahi, Tuitui. Also Fekika vao, Loupata, Gatata, Kotone		Dom by Foui, Fekika vao, Loupata, Kotia, Nonu, Filimoto	r	Dom by Fekika vao, Kotone. Also Laukaupouli, Kotia, Kofi	r	M	H	Kotia, Pula vine, Laukaupouli, Kofi	r	N	Sigota, Fuleheu	N	Major trail crosses block
B5	29-Jul	James, Hoifua, Viliami, Sepulona, David	12.23pm	Fine-breezy	0		481	Dominated by Tavahi, Laupata. Aso Maamalava, Tuitui, Filimoto, Teeteemanu, Lopa	r	Dom by Tanetanevao, Fekika vao. Also Filimoto, Ahi vao		Dom by Fekika vao, Lopa. Also Laukaupouli, Kotone, Nonu	D	M	M	Lopa, Laukaupouli	r	N	Fuleheu, Misi Tonga	N	Chicken trap seen. Plantation area next to site (bananas, taro)
C5	29-Jul	James, Hoifua, Viliami, Sepulona, David	12.37pm	Fine-breezy	0	36	482	Dominated by Tavahi. Also Filimoto, Tuitui, Masi ata, Loupata		Dom by Fekika vao. Also Tanetanevao, Nonu, Pula, Mosooi, Motou, Lantana, Toi	r	Dom by Fekika vao. Also Kanume, Nonu, Kotone, Laukaupouli	r	M	M	Pula vine, Vaine kai, Lantana, Pula tree, Hikukuma	r	N	Pekapeka	Y	Honeybee nest in Tavahi tree. Major trail crosses block
D5	29-Jul	James, Hoifua, Viliami, Sepulona, David	12.57pm	Fine-breezy	0		483	Dominated by Laupata. Also Kotone and Fekika vao. Also Foui, Nonu and Pula	r	Dom by Fekika vao. Also Maamalava, Filimoto, Lesi, Lantana, Lopa, Laukaupouli, Tavahi	r	Dom by Fekika vao. Also Laukaupouli, Nonu, Kofi	r	M	M	Pula, Laukaupouli, Lopa, Kofi, Pula vine, Lantana	r	N	Moakaiavo, Lupe, Faleheu	N	
E5	29-Jul	James, Hoifua, Viliami, Sepulona, David	2.22pm	Fine-breezy	0		486	Dominated by Kotone and Fekika vao. Also Masi ata, Tuitui, Nonu, Loupata, Lasi	r	Dom by Fekika vao. Also Pula, Toi, Maamalava, Tavahi and Kotone		Dominated by Kotone, and Laukaupouli. Also Nonu and Fekikavao	D	M	H	Laukaupouli, Lesi, Nonu and Pula vine	r	N	N	Y	Peka roost in ovava tree (>30) WP 488. Old interpretive sign (WP 485). Many kotone seedlings (WP487)
F5	29-Jul	James, Hoifua, Viliami, Sepulona, David	2.45pm	Fine-breezy	0		490	Dominated by Fau. Also Foui, Toi		Maamalava		Dom by Ahi vao. Also Maamalava, Fekika vao, Gatata		H	M	Pula vine, Saafa	r	Y (pigs)	Veka, Lupe	N	Observations from edge of block. Grassy area is in

Block_Number	Date_Visited	Observers	Time_Start	Weather	Slope_Degrees	Elevation_M	WP_Number	Canopy_Description	Canopy_Invasive	Sub_canopy_description	Sub_canopy_invasive	Ground_cover	Ground_Cover_Invasive	Disturbance_Openness	Degreeee_Invasion	Dom_Invasive_Plants	Invasive_Vines	Invasive_Animals	Birds	Other Biota	Other comments
		avid																			middle of block. Many Fekika vao seedlings (WP 491)
G5	29-Jul	James, Hoifua, Viliami, Sepulona,D avid	3.07p m	Fine-breezy	0	55	492	Dominated by Fau. Also Laupata, Motou,Tavahi, Foui		Dominated by Fau. Also Moota, Motou, Fekika vao, Pula tree		Dominated by Ahi vao, Fekika vao. Also Motou, Nonu,Si, Kavakavaulie, Maamalava, Laukaupouli	r	H	L	Pula, Laukaupouli	r	Y (pigs)	Fuleheu, Lupe	N	Edge of forest with plantation area beyond
G6	29-Jul	James, Hoifua, Viliami, Sepulona,D avid	3.19p m	Fine-breezy	0		493	Dominated by Fau. Also Laupata, Masi ata		Dom by Fau. Also Motou, Fekika vao		Dom by Fekika vao. Also Masi ata, Nonu, Moota, Ti	r	L	L	Pula vine, Laukaupouli	r	Y (pigs)	Fuleheu	N	Very thick Fau thickets
F6	29-Jul	James, Hoifua, Viliami, Sepulona,D avid	3.35p m	Fine-breezy	0	31	494	Dominated by Foui, Fekika vao. Also Motou, Tavahi, Masi ata		Dom by Fekika vao. Also Motou,Foui, Unuoi		Dom by Fekika vao. Also Unuoi		H	H	Pula vine	r	N	Faleheu, Lupe	N	Major tree cutting- mostly Fekika vao. Large Sipi
E6	29-Jul	James, Hoifua, Viliami, Sepulona,D avid	4.08p m	Fine-breezy	0	40	495	Dominated by Fekika vao. Also Tavahi, Koka, Motou, Loupata, Teeteemanu		Dominated by Nonu, Fekikavao. Also Ahi vao, Motou, Loupata, Moli Tonga, Masi ata, Pula tree	r	Dom by Fekika vao. Also Hikukuma, Masi ata, Laukaupouli, Nonu, Pakaka	r	M	M	Pula vine. Also Laukaupouli, Nonu, Hikukuma, Pakaka	r	N	Moakaiavo	N	Major trail crosses block
D6	29-Jul	James, Hoifua, Viliami, Sepulona,D avid	4.24p m	Fine-breezy	0		496	Dominated by Filimoto and Tavahi. Also Motou, Teeteemanu, Gatata, Fekika vao		Dominated by Fekika vao. Also Ahi vao, Lesi, Tuitui, Motou and Loupata		Dom by Fekika vao. Also Nonu, Lopa, Tuitui	r	L	L	Pula vine, Nonu, Hiku kuma, Panama rubber (1)	r	N	Fuleheu, Kulukulu	Y	Peka roost in Gatata tree (>20)- WP 498One Panama rubber sapling (WP 497)

Block_Number	Date_Visited	Observers	Time_Start	Weather	Slope_Degrees	Elevation_M	WP_Number	Canopy_Description	Canopy_Invasive	Sub_canopy_description	Sub_canopy_invasive	Ground_cover	Ground_Cover_Invasive	Disturbance_Openness	Degreee_Invasion	Dom_Invasive_Plants	Invasive_Vines	Invasive_Animals	Birds	Other Biota	Other comments
E7	29-Jul	James, Hoifua, Viliami, Sepulona, David	4.46p m	Fine-breezy	0	39	499	Dominated by Tavahi, Foui. Also Tuitui, Motou, Fekikavao, Laupata, Teeteemanu		Ahi vao. Also Tanetanevao, Motou, Maamalava, Fekika vao		r	L	M	Vaine kai, pula vine, lopa, laukaupouli	r	N	Fuleheu	N	WP500 is a regeneration plot (1 acre) in 1991 involving removal of vines	
F7	29-Jul	James, Hoifua, Viliami, Sepulona, David	5.04p m	Fine-breezy	0	53	501	Dominated by Tavahi. Also Maamalava and Teeteemanu. Also Laupata, Foui, Filimoto		Ahi vao, Tanetanevao, Nonu, Fekika vao, Filimoto, Tavahi, Olamata, Unuoi		Dom by Fekika vao. Also with Ahi vao and Teeteemanu	L	L	Pula vine	r	N	Fuleheu	N	Open ground cover, good canopy	

Key: r= reported; D= Dominant; H= High; M= Medium; L = Low

Annex 3: Agenda and Attendance at Project Debriefing

Toloa Rainforest Restoration Plan Debriefing Agenda

1st August 2014

Venue: Department of Environment & Climate Change Conference Room

Time	Item	Facilitator
9:20	Opening Prayer	Rev.Feleti Atiola
9:30	Opening Remarks	Paula Ma'u
9:40	SPREP's Invasive Species Management Program	David Moverly
10:00	Presentation of Draft Restoration Plan	James Atherton
10:30	MORNING TEA	
10:50	Audience comments & questions on Draft Plan	James/Dave/Viliani
12:20pm	Final Remarks	Lupe Matoto
12.30	Closing Prayer and blessing the lunch	Rev. Sepuloni Folau

Attendance

Name	Organization
'Ana Fekau	MEECCDMMIC
Talo Fulivai	MEECCDMMIC
Lupe Matoto	MEECCDMMIC
Hoifua 'Aholahi	MEECCDMMIC
Michael Thomas	University of Hawaii
Eileen Fonua	MEECCDMMIC
Dorothy Foliaki	MEECCDMMIC
'Alifaleti 'Atiola	Tupou College Toloa
Sepuloni Folau	Akoteu, Nuku'alofa
Malakai Finau	MEECCDMMIC
David Moverley	SPREP
James Atherton	Consultant (SPREP)
Pelenatita Kara	CSFT
Viliani Hakaumotu	MEECCDMMIC
Paula Ma'u	MEECCDMMIC (CEO)
Lesieli Tu'ivai	MEECCDMMIC
Siosina Katoa	MEECCDMMIC
Losana Latu	MEECCDMMIC
Mele Lasike	MEECCDMMIC
Liliani Makasini	MEECCDMMIC
Malini Teulilo	MEECCDMMIC
Haunani Ngata	MEECCDMMIC
Sosaia Lepa	MEECCDMMIC
Saia Fonokalafi	MEECCDMMIC

Annex 4: Some Site and Species Photos



The survey team consisted of former Toloa Forest ranger Sepuloni Folau, David Moverley from SPREP, Hoifua Aholahi and Vili Hakumotu from the Ministry of Environment as well as the consultant. Photo taken by James Atherton.



A surprise finding in the forest- the Panama rubber tree (*Castilla elastica*), here being held by Sepuloni. Photo taken by James Atherton.



Cattle on the east side of the reserve within the fence. These cattle wander into the forest damaging trees. Photo taken by James Atherton.



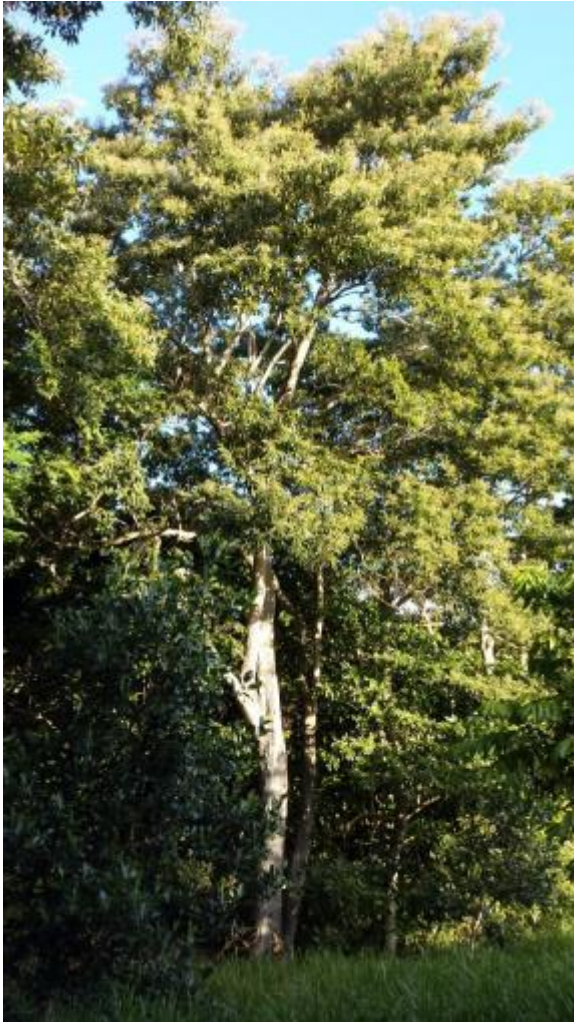
Tree harvesting for poles and for firewood by Tupou college students is a major threat to the forest. Photo taken by James Atherton.



Agricultural cropping occurs in some places within the reserve fence as here in the east side of the reserve. It is proposed that these areas be replanted with native trees to expand the forest in order to increase its resilience. Photo taken by James Atherton.



Lakaupouli (*Cestrum nocturnum*) is a major weed in much of the reserve. Photo taken by James Atherton.



Kotia (*Cordia alliodora*) is the major invasive tree in parts of the reserve, especially along the western edge. Photo taken by James Atherton.



Fau (*Hibiscus tiliaceus*) and invasive vines dominate the south eastern edge of the reserve. Photo taken by James Atherton.