BASELINE SURVEY OF MANINITA ISLAND, VAVA'U, KINGDOM OF TONGA

PRELIMINARY REPORT

FEBRUARY, 2002

Environment Consultants Fiji

TABLE OF CONTENTS

ABBREVIATIONS AND ACRONYMS

DBH	Diameter Breast Height (cm)
DOE	Department of the Environment
MFAT	Ministry of Foreign Affairs & Trade (NZ Government)
NZODA	New Zealand Overseas Development Administration
TRC	Tourism Resource Consultants

SUMMARY

INTRODUCTION

Maninita, the southernmost island of the Vava'u group is an important seabird nesting site and a proposed national protected area as originally identified by the Government of Tonga's Ministry of Lands, Survey and Natural Resources. The Tonga NZODA Nature Tourism Programme has responded to this and the increasing interest in the island from Vava'u's tourism sector by including a Maninita initiative as a component of its overall programme.

This draft report presents the preliminary findings of a baseline survey of Maninita. The final document will include any changes required as a result of a peer review of analyses, as well as redrafted figures and complete inclusion of all data as appendices.

RESULTS

Maninita is a 5.2 ha coralline island with a maximum height of less than 5m above sea level. 28 plant species were recorded on the island. Quantitative data on the island's vegetation was obtained from eight woodland sample plots comprising 24% of the woodland area, and twenty Strand Plots comprising 19% of the island's strand vegetation area. The dominant vegetation of the island is closed canopy *Pisonia* woodland, where *Pisonia* is overwhelmingly dominant – comprising 74% of trees. Only six other tree and shrub species were recorded in the woodland sample plots. In a few locations *Neisosperma* becomes dominant over small areas.

The peripheral strand vegetation is more diverse with 21 of the island's species occurring in the 20 sample plots. The strand vegetation extends from 5-20 m inland except in the southwestern corner where it extends over old sand ridges to 40m inland. As rats may be major seed predators and have a significant impact on regeneration, this was analysed in each of the 20 Strand Plots and 32 nested quadrats in the Woodland Plots,. Regeneration was rare to absent under the closed canopy woodland, the most common regeneration being vegetative regeneration of broken *Pisonia* branches or twigs. Regeneration was also limited in the Strand Plots occurring at slightly more than 1 per $10m^2$, though there was greater diversity, 14 species as opposed to four in the Woodland Plots.

A globally rare and threatened plant *Sesbania coccinea* is present on the island as 3-6 plants in two locations.

Eighteen species of bird were recorded on or around the island. There are only three species of resident, breeding land bird – *Foulehaio carunculata*, *Galirallus philippensis* and *Halcyon sancta*. Four seabirds nest on the island – the two species of *Anous,(A.minutes and A.solidus), Gygis alba* and *Sula sula*.

The number of breeding *Anous* was calculated through stratified sampling of `Apparently Occupied Nests' over 19% of the island area, yielding approximately 7,500 *A.minutus* and 850 *A.stolidus* nests. The number of breeding *Gygis* was calculated by running 1120 m of transects and using Distance Software yielding approximately 550 breeding pairs. These numbers represent populations of approximately 30,000 *A.minutus*, 3,400 *A stolidus* and 2,200 *Gygis* using the island.

Twelve *Sula sula* were nesting on Maninita, but up to 50 were observed roosting on the island at night.

A Bristle-thighed Curlew *Numenius tahitiensis*, a globally threatened species which migrates to the south Pacific from Alaska was recorded on Maninita's beach.

The only rat species trapped on the island was the Pacific Rat *Rattus exulans*, which from trapping rates, appears to occur at an exceedingly high density. – 114.3 rats per 100 corrected trap nights.

The flying fox *Pteropus tonganus* visited the island in small numbers during the preliminary survey in May but was not seen during the Baseline Survey.

Four terrestrial reptiles were recorded. By far the commonest was the gecko *Gehyra oceanica* which was encountered at a rate of 13.5/hr during directed searches at likely hiding locations. This was far more common than the 1.1/hr for the gecko *Lepidodactylus lugubris* and the less than 0.1/hr for the skink *Lipinia noctua*.

The skink *Emoia impar* was counted on a 610 m transect and Distance Software used to calculate densities. It was too rarely observed in the sparse to bare ground cover of the closed canopy woodland and strand vegetation to be analysed, but in the open canopy *Pisonia* woodland it was more common, because there was a dense groundcover. Here it occurred at a density of approximately 617 per ha.

1 INTRODUCTION

1.1 BACKGROUND TO THIS REPORT

Maninita has been the subject of at least two Ministry of Lands, Survey and Natural Resources' surveys which resulted in it being proposed as a Protected Area in the early 1990's. Lack of resources and alternative priorities have prevented the proposal being implemented.

In recent years, Vava'u's emerging tourism industry has identified Maninita as a valuable potential attraction and an increasing number of visitors are travelling to the island each year (refer Figure 1).

The Tonga NZODA Nature Tourism Programme has responded to both the Tongan government proposal and interest from the tourism sector by including a Maninita initiative as a component of its overall programme. The Vava'u Southern Islands project is tentatively listed as a NZODA aid programme for 2001 - 2004.

In May 2001 a short, multidisciplinary survey of Maninita was undertaken (TRC 2001) and the baseline survey, reported here, was commissioned as a result of that survey, following discussions between the project and the Government.

1.2 OBJECTIVE OF THE BASELINE SURVEY

The objective of the baseline survey was to describe and, where possible, quantify the terrestrial vertebrates and flora of Maninita island. The current intention is to remove the rats from Maninita and a baseline survey is necessary to evaluate the impact of rat removal. Taula and Lualoli islands were not surveyed during the current visit.

1.3 BASELINE SURVEY TEAM

The baseline survey team was:

- Filipe Tonga; Ta'anea, Vava'u;
- Paulo Tonga, Ta'anea, Vava'u;
- Lole Tonga, Ta'anea, Vava'u
- Jane Bachieri, Vava'u
- Dick Watling, Wildlife Biologist, Environment Consultants Fiji Ltd., Suva.

1.4 OVERVIEW OF ACTIVITIES

The team assembled for a co-ordination meeting in Neiafu in the afternoon of the 27th November 2001, before departing for the island at midday.

Activities thereafter were:
27/11/01 – pm. Set camp; reconnaissance of island; setting of rat traps
28/11/01 – am Commenced survey activities
1/12/01 – am Filipe Tonga departs; Jane Bachiari replaces;
4/12/01 – pm Jane Bachieri, Paula Tonga depart; Filipe Tonga, Lole Tonga replace;
8/12/01 – pm Team departs Maninita

1.5 STATUS OF THIS REPORT

This report presents the preliminary findings of a baseline survey of Maninita. The final report will include any changes required as a result of a peer review of analyses, as well as redrafted figures and complete inclusion of all data.

Insert Figure 1 – Location Map

Figure 1 Location Map

2 VEGETATION

2.1 METHODOLOGY

Four techniques were used to record the flora of Maninita:

- Unstandardised surveys to all parts of the island to locate all plant species;
- Eight 50 x 20 m Woodland Plots were established in the *Pisonia*-dominated woodland away from the strand vegetation; all trees over 10cm DBH were identified and measured;
- In each of the Woodland Plots, four nested quadrats (one in each corner) were established to enumerate regeneration; and,
- Twenty Strand Plots, 5 m wide and 10 m or more in length were set up at 50 m intervals around the circumference of the island; all the strand vegetation in the plot was identified, enumerated as far as possible and the plot drawn.
- The location of the Woodland and Strand Plots is illustrated in Figure

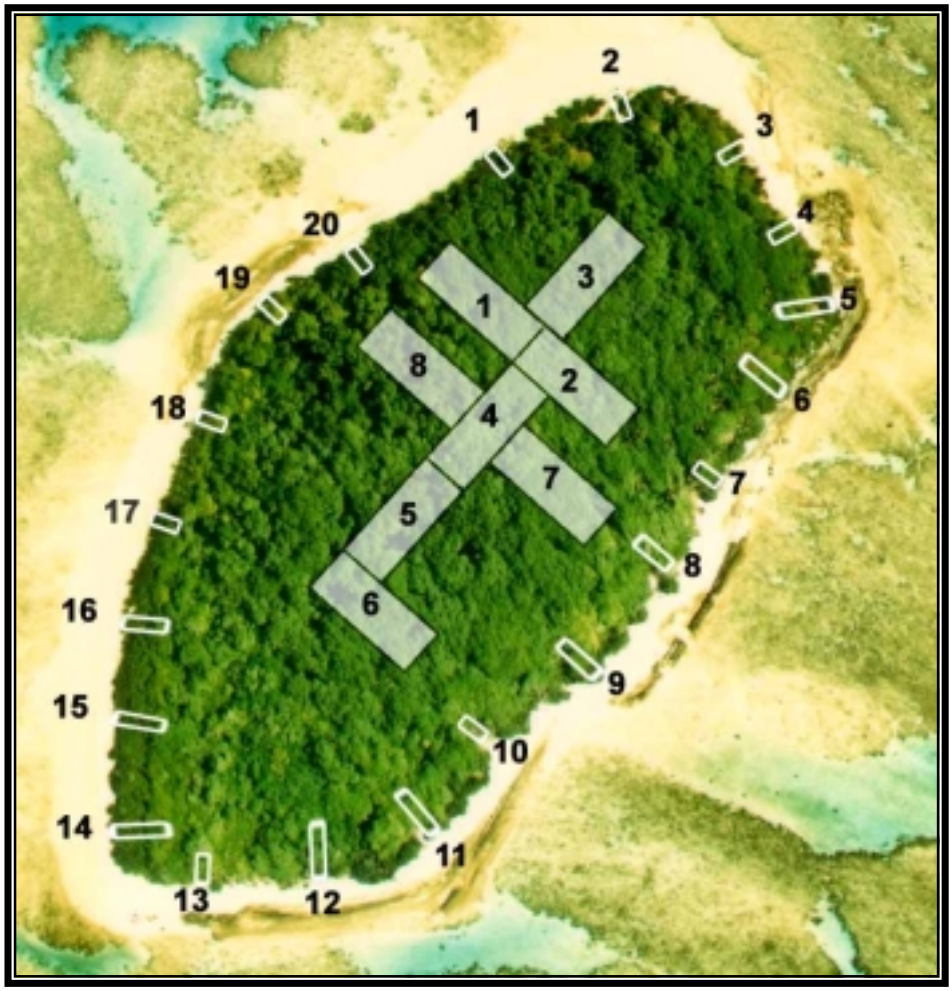

Figure 2 Location of Woodland (internal) and Strand (peripheral) Plots

2.2 COMPOSITION OF THE FLORA

28 plant species were recorded (refer Table 1).

Three vegetative associations can be readily distinguished:

- Strand vegetation at the beach-head which extends from the high tide mark to between 7 and c.25 m inland, the strand vegetation has its own zonation with larger trees, especially *Guettarda*, *Tournefortia*, *Neisosperma* and *Pisonia* behind shrubby *Suriana/Pemphis* and *Scaevola*. All the uncommon trees are found at the back of the strand vegetation before it merges into *Pisonia* woodland. In the southwest corner of the island the strand vegetation extends back to over 40 m;
- Some pure stands of *Neisosperma* with a canopy height of up to 10m; and,

- A woodland vastly dominated by *Pisonia* with a canopy height of between 7-15m, forms the central core on the island. The *Pisonia* trees are of impressive size, up to 15 m high and some with multi-boled trunks of over 6 m collective circumference. The canopy is dense and uniform and precludes almost all ground cover and regeneration except for an area in the centre of the island under the tallest trees where regeneration is quite dense and mixed with the fern *Phymatosorus scolopendria*.

Of particular conservation interest is the presence of 3-5 plants of the shrub *Sesbania coccinea*[1] on the eastern coast (coastal plot 8 and 5 m south of coastal plot 6) which Whistler (1992) indicates may be extinct in Tonga (refer Attachment 1).

Tongan Name	English Name	Scientific Name	Abundance
Trees			
Puko		*Pisonia grandis*	Abundant, dominant
Fao		*Neisosperma oppositofolium*	Abundant, dominant in certain areas
Puopua		*Guettarda speciosa*	Common
Touhouni	Tree Heliotrope	*Tournefortia argentia*	Common
Fotulona	Chinese Lantern	*Hernandia nymphaeifolia*	Uncommon
Telie'a manu		*Terminalia littoralis*	Uncommon
Nonu	Beach Mulberry	*Morinda citrifolia*	Uncommon
Pua taukanave	Cordia	*Cordia subcordata*	Uncommon
Niu	Coconut	*Cocos nucifera*	c. 10 bearing trees + stunted individuals
Fa	Pandanus	*Pandanus tectorius*	Uncommon– 3-4 trees
Tatangia		*Acacia simplex*	Uncommon – 3-4 trees
Futu	Fish Poison Tree	*Barringtonia asiatica*	Very uncommon – 2 trees recorded
Feta'u	Calophyllum	*Calophyllum inophyllum*	Very uncommon – 1 mature tree; 1 seedling recorded
Lekileki	Puzzle nut	*Xylocarpus moluccensis*	Uncommon, 5-6 seedlings recorded up to 50 cm. No mature trees recorded
Shrubs			
Ngingie		*Suriana maritima*	Abundant
Ngingie	Pemphis	*Pemphis acidula*	Abundant
Ngahu	Scaevola	*Scaevola taccada*	Abundant
		Clerodendron inerme	Uncommon – 1 plant recorded
		Sesbania coccinea	Uncommon, c.3-6 plants noted at 2 sites (refer Attachment 1)
		Sophora tomentosa	Uncommon, 3 plants noted at one site (Plot 2)
Herbs, Vines and Ground Layer			
		Lepturus repens	Uncommon
		? Stenotaphrum micranthum	Uncommon
Laufale		*Phymatosorus scolopendria*	Abundant
	Sea Purslane	*Sesuvium portulacastrum*	Very uncommon – 1 clump of less than 1m^2 recorded
Ate	Beach Sunflower	*Woolastonia biflora*	Uncommon, associated with *Sesbania*
		Cassytha filiformis	Common
Fue 'ae puaka	Morning Glory	*Ipomea macrantha*	Uncommon

Table 1 Plant Species recorded on Maninita

[1] Identification confirmed by Art Whistler, Honolulu

2.3 AREA OF VEGETATION ASSOCIATIONS

Figure 3 is a vegetation map for Maninita based on subjective mark up of the 1990 aerial photograph. The areas of the island's vegetation associations as depicted in Figure 3 were obtained by digitising the island and vegetation association boundaries for calculation with MapInfo software. The area calculations are derived from the known circumference of the island (899.9 m – measured during the survey using a hip-chain), and are presented in Table 2.

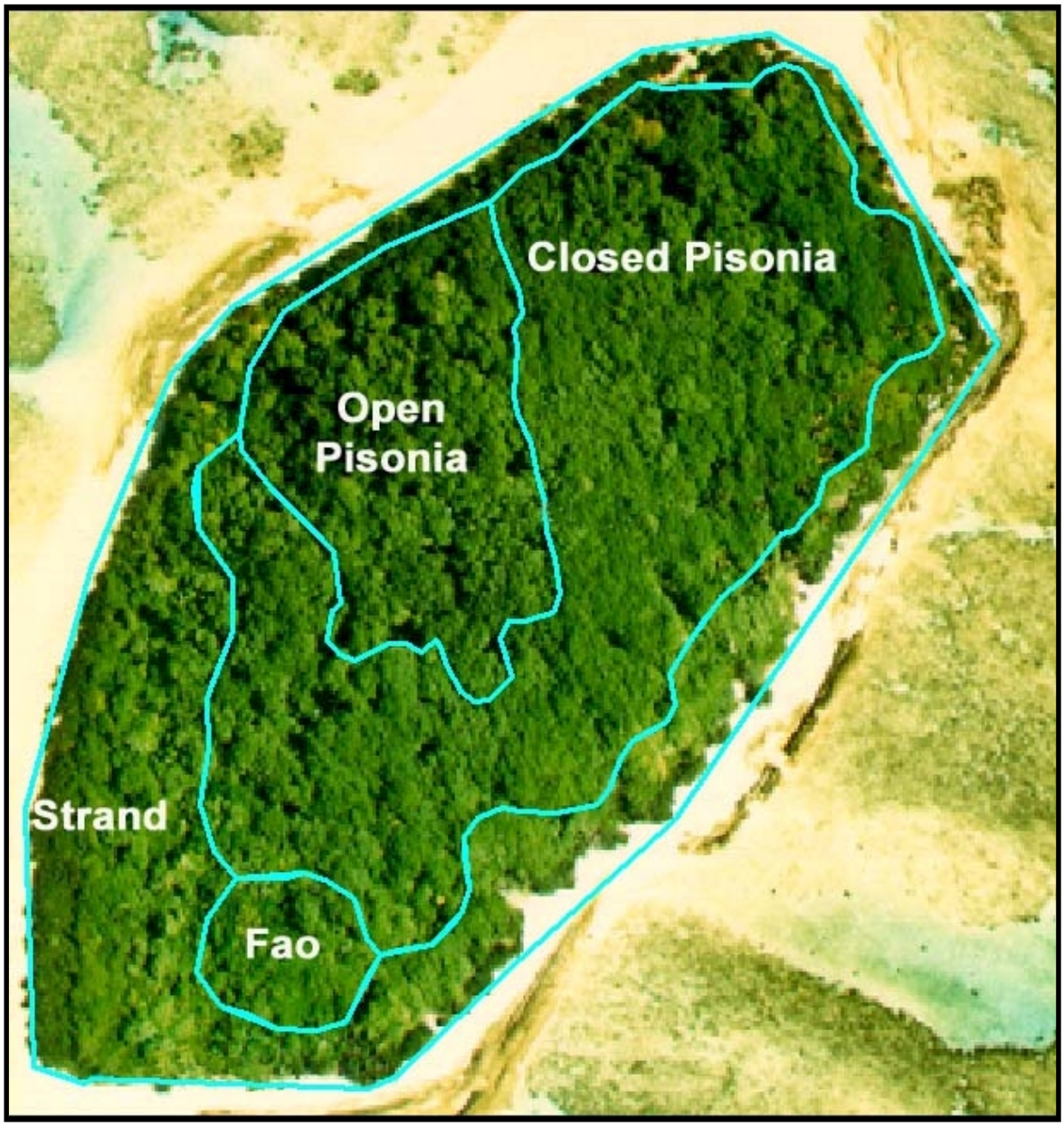

Figure 3 Vegetation Map of Maninita

Vegetation Association	Area (ha)	% of island	Area of Association Sampled (ha)	% of VA Sampled
Strand Vegetation	1.7	33%	0.15[1]	9%
Neisosperma	0.2	4%		
Closed Canopy *Pisonia*	2.4	47%	0.8[2]	24%
Open Canopy *Pisonia*	0.8	16%		
Island Area	5.1	100%	0.95	19%

Table 2 Area of Vegetation Associations and Sampling Effort (Note: 1 – Strand Plots; 2 – Woodland Plots).

2.4 STRAND PLOTS

2.4.1 Methods

Twenty Strand Plots were established to characterise the composition of the strand vegetation and enumerate typical associations.

Each of these was 5 m across the beach-head and ran a variable 10-20 m back into the vegetation. The distance was a minimum of 10 m and otherwise ran to the beginning of the woodland vegetation (ie unbroken canopy of woodland trees over 5m canopy height). The plot was then mapped using a tape measure around the perimeter to enable the vegetation to be plotted. All regeneration was measured (anything less than 1 m) and the diameter of trees larger than 10 cm at 25cm height above ground taken. In some plots the vegetation was too thick for individual plants to be distinguished, in such cases the vegetation was mapped collectively. The front of each plot was then photographed.

2.4.2 Description of Strand Vegetation

The strand (or beach) vegetation on Maninita occurs in a narrow belt from 5-20 m in width around the island. Only in the south-west corner does it extend inland – up to 40 m. The substrate here consists of a series of old sand ridges and the presence of some large, old and senescent *Pemphis* about 30 m inland indicates that this part of the coastline may be quite mobile. The strand vegetation consists of a core group of three shrubs (*Suriana, Pemphis* and *Scaevola*), one fern groundcover (*Phymatosorus*) and four[2] trees (*Tournefortia, Guettarda, Neisosperma* and *Pisonia*) as summarised in Table 3. 21 of the 28 plant species found on Maninita were recorded in the Strand Plots which had a combined area of 1.7 ha or 33% of the island.

Two abiotic factors have a major influence on the vegetation composition and form. Form is markedly affected by the prevailing wind, with the windward side, wedge-shaped and dominated on the outer edge by the shrubs *Scaevola* and/or *Suriana* before giving way to larger trees – *Pisonia, Tournefortia, Guettard*a etc. On the leeward side, there is no marked wind-formed wedge and the tree species appear closer to the beachline, albeit as smaller individuals, with a reduced or absent shrub

[2] *Hernandia* is not as common as indicated in Table xx

border. Sand depth has a marked affect on species composition with areas of shallow sand or exposed beach rock being colonised primarily by *Pemphis*.

Pisonia is the most frequently occurring species in the Strand Plots, a reflection on its presence at the `back' of the Plots before giving way to pure *Pisonia* woodland.

Trees & Shrubs	Index of Abundance			Frequency of Occurrence - %		
	Mature	Regeneration	Combined	Mature	Regeneration	Combined
Pisonia	235	45	280	80	20	80
Scaevola	160	20	180	70	15	75
Tournefortia	125	60	185	60	30	60
Guettarda	140	5	145	60	5	65
Pemphis	105	5	110	55	5	55
Suriana	130	20	150	45	5	45
Hernandia	30	50	80	20	20	40
Neisosperma	40	490	530	20	35	40
Terminalia	30	15	45	20	10	25
Cordia	15	0	15	10	0	10
Cocos	15	0	15	10	0	10
Morinda	10	0	10	10	0	10
Xylocarpus	0	10	10	0	10	10
Pandanus	5	10	15	5	10	10
Sophora	5	5	15	5	5	5
Sesbania	15	0	15	5	0	5
Woolastonia	100	15	100	5	5	5
Groundcover, vines etc.						
Cenchrus				10		10
Phymatosorus				40		40
Ipomea				10		10
Cassytha				5		5

Table 3 : Abundance and Occurrence of Plant Species in the Strand Plots

Note: 1/ Index of Abundance: Relates to the overall number of individual plants encountered in all the plots comhined. Calculated as Number/20 Plots x 100.
2/ Frequency of Occurrence: Relates to the number of Strand Plots in which it was found irrespective of how many individual plants were found. Calculated as a simple percentage.
3/ Groundcover, vines etc. Presence only was noted.

2.5 WOODLAND PLOTS

2.5.1 Methods

Eight Woodland Plots of 20 x 50 m were laid out as shown in Figure 1. The total area of the plots (0.8 ha) represented nearly 25% of the woodland vegetation on the island (refer Table 2) and given the lack of diversity of the vegetation (7 species) and dominance by a single species, this was considered an adequate sample. The plots were laid out and enumerated prior to the realisation that Open and Closed *Pisonia* associations could be distinguished and that there was sufficient area of Fao *Neisosperma* dominated woodland to warrant distinction as a separate vegetation association In the event both Open and Closed *Pisonia* were adequately sampled. *Neisosperma* dominated forest was not.

Enumeration of the Woodland Plots consisted of identifying every plant in the plot, and measuring DBH of those over 10cm. Four Regeneration Quadrats were also set up in each plot (refer section 2.6.1). Measurement of the DBH, indeed distinguishing

separate *Pisonia* trees was often quite subjective. The majority of *Pisonia* were multi-boled with irregular-shaped trunks, and many consisted of two or more trees `fused' into a single tree. Because of this basal area per hectare, a normal descriptor of forest, could not be accurately determined.

2.5.2 Description of Woodland Vegetation

Two thirds of the area of Maninita is covered by an almost pure stand of *Pisonia* with a canopy height of between 12-15m. These are large and impressive trees with circumferences of up to 6m and, for the most part, an unbroken canopy. The unbroken canopy almost completely prevents any regeneration or the growth of a herbaceous ground layer. Only in the west-central area is there a stand of open canopy *Pisonia*, here the tallest trees are found and there is a thick herb and shrub layer of *Phymatosorus* and regenerating *Pisonia* (refer Figure 3). Although *Neisosperma* and *Guettarda* were found in most plots with the occasional *Hernandia, Tournefortia, Morinda,* and *Pandanus,* together they form only a very small component of the vegetation type. In several locations, most notably in the south east corner, *Neisosperma*, becomes dominant and forms small pure stands with a canopy height up to 6 m.

Plot No	1	2	3	4	5	6	7	8	Total	%	Density trees/ha	mean/plot	Occurrence
Pisonia	17	20	28	18	26	23	42	25	199	73.7	248.75	24.9	8
Neisosperma		5	7	2	6	17	2	2	41	15.2	51.25	5.1	7
Guettarda		1	3	1	1	8	1		15	5.6	18.75	1.9	6
Hernandia		4	1				1		6	2.2	7.5	0.8	3
Morinda	1			5	1				7	2.6	8.75	0.9	3
Pandanus							1		1	0.4	1.25	0.1	1
Tournefortia						1			1	0.4	1.25	0.1	1
Total Trees in Plot	18	30	39	26	34	49	47	27	270	100.0	337.5	33.8	

Table 4 Species Composition in Woodland Sample Plots

2.5.3 Tree Height

Tree height was measured using a Suunto Clinometer. Two representative trees whose uppermost foliage could be clearly seen were randomly selected in each plot – in reality there was little or no selection as there was usually no more than 2 or 3 trees in each plot which could be viewed clearly enough to be measured accurately. With a clear view, the angle to the tree top was measured with the clinometer and the distance to the base of the tree measured with a tape measure and the height then calculated.

Tree height, in all cases *Pisonia* varied from a high of 14.05m in the open canopy woodland of Plot 8 to a low of 8.75 m in Plot 6, the southern most plot which was on the edge of beach ridges supporting strand vegetation (refer Table 5).

Plot #	1	2	3	4	5	6	7	8
Canopy Height (m)	13.6	10.75	13.6	13.75	12.55	10.75	11.5	14.05
	13.6	13.0	13.6		13.9	8.75	12.95	13.55

Table 5 Representative Canopy Height of *Pisonia* in Woodland Plots

2.6 REGENERATION

Information on regeneration is of importance because rats could be having a major selective impact on regeneration. Regeneration was measured in both the strand plots and in the regeneration quadrants.

2.6.1 Regeneration Quadrants

The 32 woodland plot regeneration quadrants were located in closed and open canopy *Pisonia* associations; the results are tabulated in Attachment xx and summarised in Table 6. Table 6 expresses the frequency of occurrence of regeneration in the quadrants as well as `measurable trees) and the estimated proportion of `bare ground'. As can be readily noted, the quadrants were very sparsely vegetated and the regeneration very limited and reflecting the canopy – vastly dominated by *Pisonia* with *Neisosperma* a distant second. The only ground cover encountered was the fern *Phymatosorus* which was found in nearly half the quadrants. Most of the *Pisonia* regeneration was from fallen *Pisonia* branches and twigs which had rooted and begun to produce leaves (refer Attachment xx).

		Occurrence	%
Regeneration	*Pisonia*	28	88
	Neisosperma	16	50
	Morinda	1	3
	Guettarda	1	3
Groundcover	*Phymatosorus*	14	44
Bare Ground	0-25%	1	3
	25-50%	4	13
	50-75%	17	53
	75-100%	10	31
Measurable Trees (>10 cm DBH)	*Pisonia*	19	59
	Neisosperma	3	9
	Morinda	1	3
	Cocos	1	3

Table 6 Summary of Regeneration Quadrants in Woodland Plots

2.6.2 Strand Plots

Regeneration in the Strand Plots was not common – 1 plant per 9.6 m^2, however, it was nonetheless far more diverse than in the regeneration quadrats of the Woodland Plots with 14 species recorded as opposed to four. Table 3 summarises the regeneration recorded. By far the commonest regeneration encountered was

Neisosperma and it was also found as regeneration in more plots than any other species, though this was in only seven (35%) of the plots.

2.7 PLANTED VEGETATION

There are about 20 mature coconut trees that appear to be planted in rows in a grove located on the north western end of the island, about half of which are bearing fruit. There were also three dead coconut trunks found among the live ones with no indication of cause of death. There were also young coconut trees of (three to five year old), found on the southern and at the north western ends of the island.

3 TERRESTRIAL VERTEBRATES

3.1 BIRDS

Eighteen species of bird were recorded on or around the island. There are only three species of resident, breeding land bird – *Foulehaio*, *Galirallus* and *Halcyon*. Four seabirds nest on the island – the two species of *Anous, Gygis* and *Sula sula*. Notes on each of these are given below. A Bristle-thighed Curlew *Numenius tahitiensis*, a globally threatened species which migrates to the south Pacific from Alaska was recorded on Maninita's beach.

3.1.1 Species Accounts

Motuku, Reef Heron, *Egretta sacra.* Either one or two grey phase birds seen nearly daily on the island but no sign of breeding

Veka, Banded Rail, *Gallirallus philippensis*. Surprisingly difficult to see and not very vocal; seen at both ends of the island, perhaps a single pair which would account for lack of vocalisation. Breeds, as hatchlings were noted during the December visit.

Fata, Bristle-thighed Curlew, *Numenius tahitiensis.* A single bird was seen each day during the May visit only. A northern migrant which is a globally threatened species with a Vulnerable Global Status (BirdLife International 2000)

Kiu, Eastern Golden Plover, *Pluvialis dominica*. A northern migrant which overwinters as it was seen during the May visit. More common during the baseline survey, seen daily with up to a dozen.

Wandering Tattler, *Heteroscelus incanus*. A northern migrant with one or two seen daily during the December visit.

Turnstone, *Arenaria tetanus*. A northern migrant, single birds seen during the baseline survey.

Ekiaki, Black-naped Tern, *Sterna sumatrana.* Resident in area, with upto a dozen birds roosting on the beach most days.

Ekiaki, Crested Tern, *Sterna bergii.* One pair resident in the area, visiting the island daily.

Ngongo, Brown Noddy, *Anous stolidus.* Common breeder on the island.

Ngongo, Black Noddy, *Anous minutus*. Common breeder on the island.

Tala, White Tern, *Gygis alba.* Common breeder on the island.

Lofa, Helekosi, Lesser Frigatebird, *Fregata ariel.* Non-breeding resident in the area. Up to twenty frigatebirds are seen daily over the island. Both species appear to be present in similar numbers.

Lofa, Helekosi, Greater Frigatebird, *Fregata minor.* Non-breeding resident in the area, refer *F.ariel*.

Ngutulei, Red-footed Booby, *Sula sula.* Breeds in small numbers on Maninita, but roosts in larger numbers.

Ngutulei, Brown Booby, *Sula leucogaster.* Non-breeding transient seen occasionally as single birds or pairs.

Lupe, Pacific Pigeon, *Ducula pacifica.* Visitor recorded as a singleton or two birds during the May visit, may breed but not present during the baseline survey.

Sikota, Collared Kingfisher, *Halcyon chloris*. Resident in small numbers (3-5), probably only 1 or at most 2 breeding pairs.

Fuleheu, Wattled Honeyeater, *Foulehaio carunculata.* Resident in small numbers (5-10), breeding during both visits.

3.1.2 Honeyeater and Kingfisher Counts

During the May visit, DW undertook a series of eight, five minute Point Counts of the *Foulehaio* (Wattled Honeyeater) and the *Halcyon* (White-collared Kingfisher) (see Bibby et al. 1992 for methodology). Three stations were selected and the standard 50m radius used, distinguishing those birds recorded inside and outside the 50m. The birds recorded outside were selectively recorded to ensure they would not be (or have been) counted in the adjacent station(s). In effect, this meant the island was divided into three bands for these counts. Similar counts could not be undertaken during the baseline survey because the noise and movement of nesting noddies and white terns prevented any semblance of an accurate count. The results are presented in Table 7 and compared with similar counts undertaken elsewhere in Vava'u by Steadman & Freifeld (1998). It is not realistic to extrapolate such counts to actual numbers or densities but they are useful in making comparisons wherever the same method is used (see Steadman & Freifeld,1998). It would appear that there is a comparatively high density of Wattled Honeyeaters on Maninita, and this is perhaps to be expected, given that there are no avian competitors. Since the call of the honeyeater is so loud and is the principle method of first detection (93% of encounters), combining the station counts with the counts outside the 50 m is a practical index for the entire island but is not a population count. From this is derived an index of abundance of 9.4 for the Wattled Honeyeater and 0.9 for the White-collared Kingfisher on Maninita

		Station			Stations combined
	N = 8	**a**	**b**	**c**	
Honeyeater (inside 50m)	Σ	32	23	20	75
	mean	4.0	2.9	2.5	**9.4**
Honeyeater (Steadman)	Mean of 1.5 birds per Mature Forest Station in Vava'u				
Honeyeater (inside and outside 50 m combined)	Σ	41	43	29	113
	mean	5.1	5.4	3.6	14.1
Kingfisher (inside 50 m)	Σ	2	3	2	7
	mean	0.3	0.4	0.3	0.9
Kingfisher (Steadman)	Mean of 0.6 birds per Mature Forest Station in Vava'u				
Kingfisher (inside and outside 50 m combined)	Σ	2	3	2	7
	mean	0.3	0.4	0.3	**0.9**

Table 7 Point Count Results for Wattled Honeyeater and White-collared Kingfishers

3.1.3 Noddy Breeding Density

3.1.3.1 Method

The method used for the noddys on Maninita was the standard `Apparently Occupied Nest-site' (AON). This is defined slightly differently for different species but could be adopted as follows for the noddys:

> *A substantial or well-constructed nest capable of holding an egg (and occupied by at least one bird on or within touching distance of the nest).*

Counts of AONs should be made in the late incubation to early nestling period when attendance at any given colony is likely to be at its greatest. The timing will differ between species and may need some refinement. Both noddys were nesting during the baseline survey. Most black noddys were incubating, a few were feeding hatchlings while a few were also constructing or repairing nests. It was more difficult to determine at what breeding stage most of the brown noddys were at, certainly all stages were observed. It is by no means certain that both species breed synchronously but clearly it was an appropriate time to undertake the count for the principle breeding bird on the island, the black noddy. For the counts on Maninita, the requirement for a bird to be within touching distance was ignored. It has been observed the black noddy nests deteriorate rapidly in Fijian/Tongan conditions and old nests are clearly not substantial if they survive to the following breeding season.

Given the uniformity of vegetation on the island it was decided that it was both practical and reasonable to stratify vegetation types and then sample these. Initially strand vegetation, closed canopy *Pisonia* woodland and open-canopy *Pisonia* woodland were distinguished but based on the results, the *Pisonia* woodland was combined and distinguished only from strand vegetation. Areas for vegetation associations are given in Table 2.

3.1.3.2 Results

Table 8 presents the numbers of noddys nesting in the woodland and strand plots and the extrapolated numbers for the island.

Species	Number of AON in sample plots		Density of AON in sample plots (AON/m2)		Extrapolated AON for whole island*		TOTAL NESTS ON MANINITA
	Strand	*Pisonia*	Strand	*Pisonia*	Strand	*Pisonia*	
Black Noddy	4	1733	0.003	0.22	52	7415	7467
Brown Noddy	15	154	0.01	0.02	174	674	848

Table 8 Nesting of Black and Brown Noddys on Maninita (* – refer Table 2 for vegetation association areas and sampling intensity)

The sample comprised 24% of the *Pisonia* Woodland area and 9% of the Strand Vegetation, combined the nest count sampled 19% of the island area.

Black Noddys are approximately 10 times as numerous as Brown Noddys and 7467 AON represents an adult population of close to 15,000. Juveniles, immatures and non-breeding adults make up the total population and it is normal for these to

comprise about 50%. Thus the population of Black Noddys on Maninita is approximately 30,000, and Brown Noddys approximately 3,400. While no comparable density figures have been located, Black Noddy's have been seen nesting elsewhere in the Pacific at densities far exceeding that which is found on Maninita at present and it is not unreasonable to believe that Maninita could support a ten-fold increase in numbers – 300,000 nests. Because of the difference in preferred nesting locations, Brown Noddy's would not be able to increase by a similar margin

3.1.4 White Tern Breeding

3.1.4.1 Method

White Terns have no nest, they lay their egg on bare branches or tree stumps, usually but not always trying to find a slight depression on which to lay the egg. The hatchlings remain on the branch and are fed by the adults. The Terns were censused on transects using Distance Software rather than by total counts of AON in sample plots. The location of the transects are shown in Figure 4. Transect 1 (720 m) was run through low stature woodland close to the back of strand vegetation, because it was thought that the white tern may be nesting at higher densities in this location. Transect 2 (400 m) ran through high stature *Pisonia* woodland with closed and open canopy sections distinguished. Based on an analysis of the results, there was little difference between the densities recorded on each transect and so the results were combined. The length of the transects were measured using a hip chain. The census was undertaken by three observers walking abreast 2 m. apart with the central observer viewing on both sides but taking specific responsibility for the central 2 m. The side observers searched only on their side of the transect centre line. Seven categories of observations were recorded (Table 9). Each observation-record was measured with a tape measure perpendicularly to the transect centre line. The side observers were only able to make observations from their counting position and not when they moved out to make a measurement.

Figure 4 Location of Transects for Censusing White Tern breeding

3.1.4.2 Results

Table 9 summarises the recorded observations on the combined transects by category. The Distance Software analysis is appended in full as Attachment xx.

The number of nesting White Terns on Maninita was calculated to be 547 breeding pairs, but the accuracy was quite low and there is the possibility of a wide margin of error (340-882). This figure corresponds (4 x) to a population of approximately 2,200 White Terns at Maninita.

Observations from the beach and from canoes off shore appeared to indicate that White Terns were as common as Noddys in the birds active above the island. This would seem to indicate a much larger non-breeding population of White Terns and it is possible that our baseline survey did not coincide with the peak of the breeding season.

No	%		Behaviour and/or Stage of Breeding
8	3	PA	Sitting/Perched adult first observed, left, no egg
25	10	S	Sitting adult first observed, remained, no egg seen
4	3	I	Sitting adult first observed, egg confirmed
45	19	E	Egg
100	42	P1	Hatchling - full down - no visible wing feathers
32	13	P2	Young with down - wing feathers in sheaths
23	10	P3	Young with feathers, traces of down, wing feathers developed
239	100%		

Table 9 White Terns – Transect Observations by Category

	Estimate	%CV	df	95% Confidence Interval	
Density (/ha)	107.13	15.08	3	66.476	172.66
Total number of nests	547	15.08	3	340	882

Table 10 Calculation of the Number of White Tern Nests on Maninita
(Transect length 1121 m; Distance Software – Half-normal/Cosine Model).

3.1.5 Red-footed Booby Breeding

A total count of Red-footed Booby nests was undertaken, by searching across the island. Apparently Occupied Nests were located only in Plots 4,5 and 8 and in trees immediately south of Plot 8. In all there were 12 AON on the island. Advanced nestlings could be seen in on four nests, adults were present on the other nests either incubating or protecting young nestlings. One nestling (full down, no wing feather sheaths) was dislodged by strong winds on the night of 4-5th December and was found dead the next morning under the tree in Plot 4.

Many more Red-footed Boobies roosted on Maninita at night and during days of strong wind than were nesting. At one time over 30 were counted and it is probable that upto 50 were roosting on the island during the survey.

3.2 MAMMALS

3.2.1 Bats

The Peka *Pteropus tonganus* visited the island in small numbers (c.5-10) each night during the May visit but did not roost on the island during the day. No Peka were seen during the baseline survey when seabird breeding was at its peak. In May, the Peka fed primarily on the few *Terminalia littoralis* trees on the island. Overall Maninita has little attractive food for fruit bats because both dominant trees – *Pisonia* and *Neisosperma* do not have fruit attractive to the bats, though they may feed on young leaves of *Pisonia* (McKonkey & Bull *in litt*.). In island situations bats regularly move between the islands and can travel quite long distances from roosting sites to feeding areas.

3.2.2 Rats

3.2.2.1 Methods

A simple rodent index line (Cunningham and Moors 1983) running N/S was set up during both visits. All rats caught were identified. Rats were sexed by external appearance and weighed. Some females were checked for reproductive condition (i.e. number of obvious embryos). A simple check of stomach contents was made on some rats.

May visit: The rodent trap line consisted initially of a line of 13 paired trap sets with additional traps adjacent to the camp site, subsequently increased to 46 traps on the second night. Trap sets were set c 20m apart. Most sets were placed on the ground, although a few were placed on low branches or stumps. Peanut butter bait was changed to coconut on the second night;

Baseline survey: A line of 22 traps was set north of the camp with additional traps set around the camp. All traps were placed off the ground on fallen or reclining tree trunks to minimise crab interference and baited with coconut.

3.2.2.2 Results

The only species trapped on the island was the Pacific Rat *Rattus exulans*, which from trapping rates, appears to occur on the island at a very high density. This was despite very little obvious rat sign on the island, e.g. droppings, chewed seabird carcasses, fruit and nuts gnawed on, relatively few rats seen during daylight hours (more seen during the baseline survey than in May). Stomach contents revealed that they were feeding mainly on vegetable matter, *Pisonia* leaves and young shoots were believed to be major components (Roberts, 2001).

May visit:

- Population density was at least 54.1/100 corrected trap nights
- Of four pregnant female rats, three (75%) had six embryos, one (25%) had three
- Fourteen (66%) out of 21 female rats were obviously pregnant or lactating (exposed nipples)
- Mean weight of adult males = 83.3g, range 57-104, females m = 76.9, r = 57-103

Baseline survey:

- Population density was at least 114.3/100 corrected trap nights; and,
- 138 rats were caught of which 131 were sexed at a ratio of 1:1.3 male: female

- Males averaged 53.6g (range 52-109), and females 62.2g (16-105), (anomalous averages because of the large number of juveniles caught - probably c.58%);
- Of four pregnant female rats examined, three (75%) had three embryos, one (25%) had five.

3.3 TERRESTRIAL REPTILES

3.3.1 Methods

Terrestrial reptiles were surveyed using standardised (baseline survey) and unstandardised (May visit) searches:

During the May visit, unstandardised searches were made in all likely microhabitats for fossorial species and by walking the entire island for heliophile skinks. Based on the experience during this visit, it was noted that overall skinks were present at a low density and it was believed that normal techniques for skink/gecko density calculation such as pit-fall traps and sticky paper would likely be unsuccessful, especially given the problems posed by the high density of hermit crabs.

Consequently during the baseline survey, the two standardised techniques were used were:

- Fixed transects were laid out (420 m of hip chain thread laid on the ground) in three specific vegetation associations – back of strand vegetation; closed canopy *Pisonia* woodland and open canopy *Pisonia* woodland (refer Figure 5). The transect was walked every two hours between 1000-1700 hrs when the weather was fine (no rain or strong wind). The perpendicular distance from the location where each skink was first noted to the thread was measured with a tape measure and then Distance software was used to calculate densities.
- Timed searches of all likely hiding places for fossorial geckos and skinks were undertaken and the results expressed in number of encounters per unit time. Although it was clear that the three fossorial species had to some degree different favoured habitats, searches tailored for individual species were not undertaken. All the habitats were combined as they were encountered in the timed searches.

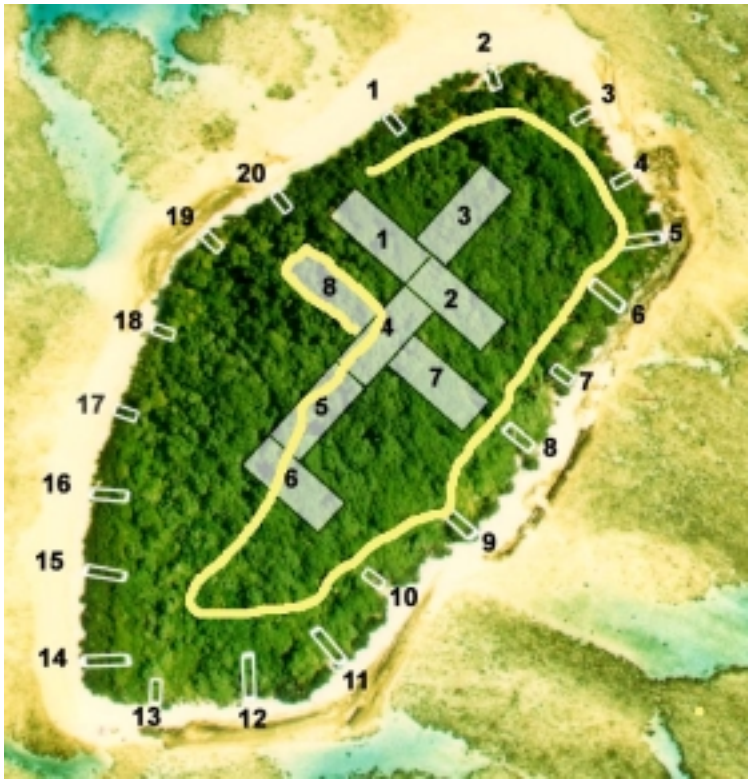

Figure 5 Location of Heliophile Skink Transect

3.3.2 Results

Four terrestrial reptiles were recorded:

- Oceanic Gecko *Gehyra oceanica*, an arboreal and nocturnal species which was found commonly in tree crevices and under loose bark in all habitats on the island, though it

was far less frequently encountered in closed *Pisonia* woodland than in the more diverse micro-habitats of the `back of the strand' vegetation ;

- The Mourning Gecko *Lepidodactylus lugubris*, which is a common gecko of houses and habitation, was found at low densities usually under loose bark of small branches in strand vegetation (especially Touhouni and Puopua);
- The Moth Skink *Lipinia noctua* was found at very low densities (a single individual recorded) in its usual habitat of rotten wood and under loose bark or detritus; and,
- The Blue-tailed Copper-striped Skink *Emoia impar* was recorded, but at relatively low densities. Only in the undergrowth of the open canopy *Pisonia* woodland was it found to be relatively common. Unfortunately, the rather rainy and cool windy weather during the baseline survey was not very conducive for good skink activity and it was readily apparent how sensitive they were to the weather – just not appearing at all until there was reasonable sunshine and dry ground and undergrowth. Three voucher specimens were collected to confirm the identity. It is possible but improbable given the low density of *Emoia* on Maninita that *E.cyanura* is also present.

Table 11 summarises the results of the searches

Species	Search Hours		Average Encounter/hour	
	Back of Strand	Closed *Pisonia*	`Back of Strand'	Closed *Pisonia*
Gehyra oceanica	5.5	2.5	13.5	1.4
G.oceanica- eggs	5.5	2.5	4.5	0
Lepidodactylus lugubris	5.5	2.5	1.1	0
Lipinia noctua	5.5	2.5	0.2	0

Table 11 Results of Searches for Fossorial Skinks and Geckos

Distance Software was used to calculate the density of *Emoia impar*, however, there were insufficient observations in the `Back of Strand' and `Closed Pisonia' vegetation associations to distinguish them or to use the software. This was so even when the two associations were combined which they are to present the results, Table 12. This paucity of observations of skinks over the majority of the island (4.3 ha or 84%) was attributed to the lack vegetative ground cover.

Vegetation Association	Individual Transect Distance (m)	Total Time spent on Transects (min)	Obser-vations	Encounters /hour	Density* (indiv/hectare)
`Back of Strand'	450	315	15	2.4	Insufficient observations to calculate
Closed *Pisonia*					Insufficient observations to calculate
Open-canopy *Pisonia*	160	144	35	14.6	617 +/- 260

Table 12 Results of *Emoia impar* Transect Counts

(Note: * Based on Distance Software, refer Attachment xX for calculations)

REFERENCES:

Bibby, C.J., N.D. Burgess and D.A. Hill 1992. *Bird Census Techniques*. Academic Press.

BirdLife International, 2000. *Threatened birds of the world.* Barcelona & Cambridge, UK: Lynx Edicions and BirdLife International

Cunningham and Moors 1983

McKonkey, K. & L. Bull 2001. Report of observations made on the flora and fauna of Maninita Island, Vava'u, Tonga. Unpublished report to Tourism Resource Consultants.

Roberts, A. 2001. Report on the potential for rat eradication on Maninita, Taula and Lualoli islands, Vava'u, Kingdom of Tonga. Unpublished report to Tourism Resource Consultants, Dept. of Conservation & MFAT, Government of New Zealand.

Steadman D.W. & H.B. Freifeld 1998. Distribution, Relative Abundance and Habitat Relationships of Landbirds in the Vava'u Group, Kingdom of Tonga. The Condor 100: 609-628.

Watling, D. 2001. *A Guide to the Birds of Fiji and Western Polynesia*. SPREP-Environment Consultants Fiji, Suva.

Whistler, W.A. 1992. *Flowers of the Pacific Island Seashore*. Isle Botanica, Honolulu.

ATTACHMENT 1

ATTACHMENT 2

ATTACHMENT 3