A CONSERVATION SURVEY OF TOKELAU

October 2012

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Eco Oceania Pty Ltd Plan for Tokelau Administration and Critical Ecosystem Partnership Fund

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CONTENTS

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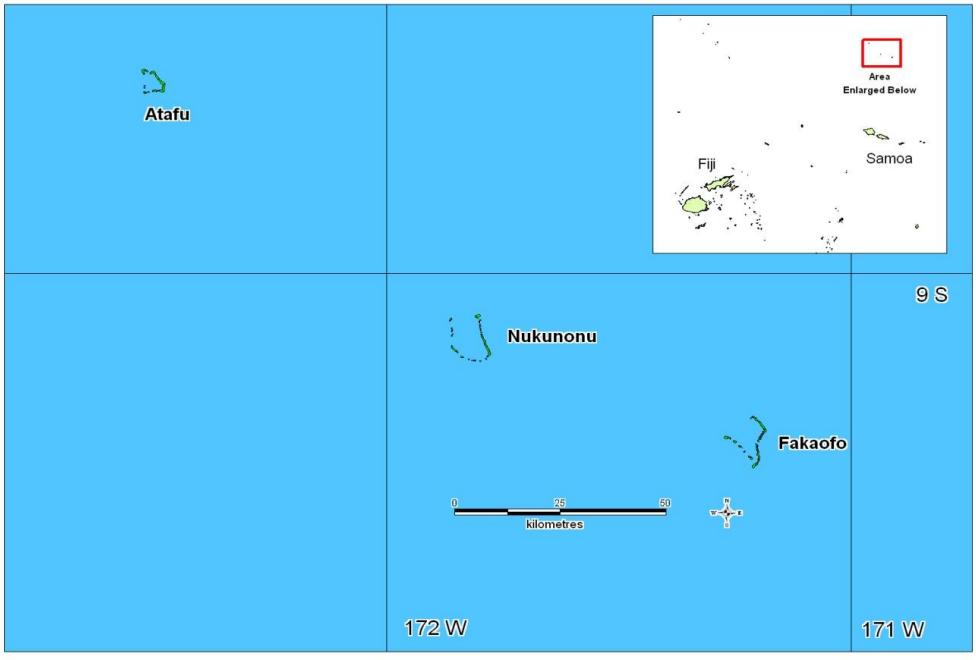

Tokelau - location map

EXECUTIVE SUMMARY

Surveys of indigenous biota and invasive species were undertaken at Tokelau in September-October 2011 and January 2012 and were funded by the Critical Ecosystem Partnership Fund of Conservation International. The purpose of the surveys was to identify biodiversity values, threats and potential conservation opportunities for the Tokelau administration. Participants included staff from BirdLife Pacific, Conservation International, EcoOceania Pty Ltd, Victoria University of Wellington, and Arthur Whistler, together with staff from each of the Tokelau atolls. The survey covered Atafu and Nukunonu in September-October 2011 and Fakaofo in January 2012.

A key finding was that the indigenous biota was showing some resilience to both the impacts of invasive species and cyclonic storms. Notably, several species of seabirds have recovered on all three atolls since comparable surveys were undertaken in the 1960s. Some biodiversity hotspots supporting important vegetation areas and/or bird populations were apparent, e.g. in the Hakea motu of Atafu and the NE and SE motu of Nukunonu and the NE motu of Fakaofo. The recoveries in the seabird populations appear to reflect a reduction in species harvesting over the years and possibly also the local removal of invasives from some motu. However there are ongoing threats from several key invasives already present – Pacific rats, feral house cats, feral pigs, yellow crazy ants and some weeds, e.g. Wedelia. On top of this the quarantine process at Apia and Tokelau is currently inadequate to prevent further invasives arriving from Apia, the main source of goods and supplies and therefore also invasives.

Key recommendations encompass the strengthening of biosecurity, eradicating or managing key invasive species, formalising of species harvesting protocols and documenting management approaches. Biosecurity needs to be strengthened as a matter of urgency and should include re-instating the quarantine process at Apia and each of the three atolls along with surveillance on vessels and on shore, together with training and resourcing of quarantine staff for all of the above. Eradications of invasive species should involve two approaches initially – site-led and species-led eradications. Site-led eradications focus on the total removal of rats and other invasives from the key biodiversity areas, with subsequent prevention of rats, cats and pigs from recolonising. Species-led management involve the total removal or control of invasive species that could potentially invade all of the motu (notably yellow crazy ants which have invaded the village motu at Atafu recently, but which are difficult to eradicate, while *Wedelia* is present on the inhabited motu of all three atolls – these invasives could access all motu). All of the biosecurity and management approaches should be prescriptive and supported by good documentation of activities using standard or simplified data sheets to ensure that Tokelau can learn from and improve on past actions. Finally, the above management approaches necessitate working closely with technical specialists along with relevant agencies locally, e.g. CI, SPC, Samoa Quarantine, Samoa Port Authority and SPREP.

KOTOKOTOGA

I na mahina o Hetema-Oketopa 2011 ma Ianuali 2012, na fakatino ai ni hakilikiliga i Tokelau mo te tulaga e iei ai te laufenua ma na manu fakalafuā, mae ko te fakatupega o tenei fakatinoga na maua mai i te Fakalapotopotoga mo te Fakahao a te Lalolagi.

Ko te kautu o te hakilikiliga tenei ko te fakamatea tena o te tāua, na fakapopolega vena ma ni auala ke fakahao ai na vaega uma mo Tokelau. Na fakatino tenei galuega e ni hui mai te BirdLife Pacific, Conservation International, EcoOceania Pty Ltd, Victoria University i Ueligitone, Arthur Whistler, fakatahi ai ai la ma na hui mai na kaufaigaluega a na Nuku. Na faktino tenei galuega i Atafu ma Nukunonu i na mahina o Hetema - Oketopa 2011 ma Fakaofo ia Ianuali 2012.

Ko he vaega tāua na mātau ko na lakau ma te laufenua e kitea e tau nafatia ma feolo na afainaga mai na manu fakalafuā vena ma na afā taluai. E iei foki te huiga na kitea ki ietahi manu lele i na kauafua e tolu i te tulaga kua feolo ai nei fakatuhatuha ki na hukehukega na fakataunuku i te 40 tauhaga taluai. Na aliga mai ai foki ietahi koga taua mo te laufenua ma na manu lele ft, i na motu i Hakea i Atafu ma te itu ki Matu Haute ma Hahae Haute i Nukuknonu ma Matu Haute i Fakaofo.

Ko te tulaga feololo e iei a ina manu lele e māfua ona kua lahi he kaia na manu i na tauhaga kua teka mae ko hove ko he tahi mafuaaga ko te kavekehega o ietahi manu fakalafuā i na tahi motu i te utafenua. Kae e iei pea te fakapopolega ki ni ietahi manu fakalafuā e iei i te taimi nei - e ve ko te kimoa, puhi, puā ma te lo, i eie foki te manu e takua ko te maina (myna) vena ma ietahi vao e ve ko te teisi. E atili foki ona ko te fefaiakiga ma te hiakiga o na uta mai Apia ki Tokelau e he i he tulaga lelei ke tau taofiofi ai ni meaola fakalafuā mai Apia, te koga e kaumai ai na koloa mae vena foki la ma na meaola fakalafuā.

Ko na fautuaga malohi e aofia ai te fakamalohia o te puipuiga main a meaola fakalafuā, fakaheai ma kavekehe ietahi meaola fakalafuā, fatu ni faiga ke fai fakalelei ai te kai o ietahi meaola ma vena ona fakapepa ma fakamaumau na auala e pulepule ai ienei vaega. E tatau ke kave te fakamuamua ki te vaega o te puipuiga mae e tatau ke toe kikila ai ki te fefaikiga o na vaega uma i Apia vena ma na kauafua e tolu, fakatahi ai ma te hiakiga o na vaka vena ma uta i gauta, mae ke aofia ai foki ni koleniga mo te kaufaigaluega e gafa ma te puipuiga ma te hiakiga o na vaega uma kua takua i luga.

E lua ia vaega e aofia mo te fakaheai o na meaola fakalafuā - fakaheai i te koga e maua ai ma te fakaheai o te itukaiga meaola. Ke fakaheai i te koga e maua ai, e fakamamafa lahi ke matuā fakaheai uma na kimoa ma ietahi meaola fakalafuā mai ni koga tāua o te laufenua, oi taumafai ai la ke na he toe maua ni kimoa, puhi ma ni puā. Kafai e taufai lava ke taofiofi te itukaiga meaola, e aofia ai la te matuā fakaheai lava o na meaola fakalafuā e mafai ke afia ai na motu ma te utafenua (e ve ko te matea o te afaina mai i na lo i Atafu, mae e matau e faigata ona fakaheai katoa, vena ma te teisi e maua uma i na kauafua e tolu - e ono afaina na motu uma i na meaola fakalafuā ienei).

Ko na galuega uma mo te puipuiga ma te pulepulega e tatau ke fakamaumau fakalelei ma fakaaoga ni pepa e faigofie ona fakaaoga mo na fakamaumauga kae ke lelei ai te agai ki mua fua agai ki na fakatinoga nae fai.

E tāua lele te galulue fakatahi ma na tino fakapitoa vena ma na fakalapotopotoga e ve ko te Fakalapotopotoga mo te Fakahao a te Lalolagi, SPC, Samoa Port Authority ma te SPREP.

GLOSSARY AND ACRONYMS

AT, FK, NN	Abbreviations for Atafu, Fakaofo and Nukunonu atolls in tables of report
Biota	All the plants and animals (birds, lizards, invertebrates, etc) of an area
Biodiversity hotspot	An area where the plants and animals are of particularly high diversity, and/or where there are rare or abundant species
Biosecurity	Quarantine actions undertaken to stop IAS from arriving (at Tokelau), together with surveillance and emergency responses to deal with any arrivals
BirdLife	An international bird protection agency with its Pacific branch based in Suva
Brodifacoum and Bromodiolone	Anticoagulant toxins in rodent baits commonly used in rat eradication or control on islands, vessels, etc – comes in pellet or wax block form. Bromodiolone has been used in Tokelau before
CEPF/CI	Critical Ecosystem Partnership Fund of Conservation International
Eradication	Total removal of all invasives from an entire location, e.g. a motu or atoll, as opposed to ongoing pest control which would be ineffective at Tokelau
GPS	Global Positioning System
IAS/Invasive	Invasive alien animal or plant species, e.g. yellow crazy ant, *Wedelia*, rats, all of which may impact severely on indigenous biota at Tokelau
Incursion	A term sometimes used for a newly invading IAS
Indicator species	Species or species groups, e.g. tern, whose numbers or productivity are useful in indicating the health of an ecosystem, or locating shoals of pelagic fish etc
Indigenous	Species found naturally in an area, e.g. all the seabirds at Tokelau are indigenous
Key biodiversity area	A biodiversity hotspot that is formally recognised as such by countries and agencies
Management or Control	Where eradication is not possible, feasible, or the environmental, social or financial costs are too high, Management or Control methods are used to keep the invasive species numbers at a level where their effects are minimalized. This applies to yellow crazy ants in particular."
Monitoring	Here refers to measuring changes in the numbers of native biota over time
Myna	Invasive birds which have had an incursion at Tokelau and which could establish and impact on Tokelau biota and fruit trees
PII	Pacific Invasives Initiative based in Auckland, NZ
PIPA	Phoenix Islands Protected Area, Kiribati, to the north of Tokelau
Rattus	A group of rats that includes *Rattus exulans* (Pacific rat), *R. norvegicus* (Norway rat), *R. rattus* (black or ship rat) and *R. tanezumi* (Asian black rat).
Rodent	Rats (mainly *Rattus* spp.) and mice (*Mus musculus*)
Roost site	A place (e.g. trees) where birds rest without nesting, e.g. night-time roosts of katafa
"Singapore daisy"	*Wedelia (Sphagneticola) trilobata*; An IAS not originally from Singapore, but Central America; expanding on all three Tokelau atolls
SPC	Secretariat for the Pacific Community based at Suva
Surveillance	Here refers to the ongoing search for IAS or their sign
SPREP	Secretariat for the Pacific Regional Environment Programme based at Apia
Terrestrial	On land as opposed to marine
YCA	The yellow crazy ant *Anoplolepis gracilipes,* an invasive species

1.0 INTRODUCTION

Tokelau comprises three atolls, Atafu (c.350 ha), Nukunonu (c.500 ha) and Fakaofo (c.400 ha) located midway between Samoa and the Phoenix Islands (Kiribati). Each of the three Tokelau atolls is inhabited by c.400-500 people, but permanent dwellings are confined to one or two motu on each atoll as has been the case historically (Huntsman and Hooper 1996). The vegetation of the three islands comprises varying areas of indigenous trees, including *Pisonia, Pandanus, Morinda and Tournefortia,* and coconut plantations. The motu are separated by channels with gaps of typically 30-100 m at low tide, sometimes more. The vertebrate fauna of the islands was documented in the 1960s (Wodzicki and Laird 1970) but there has been little survey effort since then.

The present survey undertaken in September-October 2011 and January 2012 is the first step towards assisting with ecological restoration of the atolls. It documents the fauna and flora values present and current threats (especially invasive species) to those values and provides recommendations on priority areas for protection and the feasibility of pest eradication and associated management and biosecurity. The general survey approach was developed during meetings with Casimilo Perez (General Manager of Office of Taupulega at Nukunonu) on 21 June 2008 and at later meetings in Apia with Kuresa Nassau (then Minister for the Environment) and with Joe and several of his managers at the Tokelau Administration and with CEPF/CI.

Key objectives of the survey were to:

- Determine broad vegetation patterns and important plant species present
- Determine bird species and their distribution, priority nesting areas and potential nesting areas
- Determine reptile distribution including actual and potential turtle breeding sites
- Determine invasive plant species (Singapore daisy, etc) and their distribution and threat
- Determine invasive vertebrates (rodents, mynas, etc) present and their distribution and threat
- Determine IAS invertebrates present including yellow crazy ants (YCA) and their distribution
- Survey physical and some other biological features of motu and atolls to help with evaluating opportunities for restoration.

By assessing the above it would be possible to determine the best areas and approaches for removing or managing invasive alien species (IAS) in parts of the group, improved biosecurity and possibly recommending changes to how humans exploit the fauna. For example, once pests are removed from individual motu or islands it allows the recovery of seabirds, landbirds, reptiles and other land biota as well as providing opportunities for re-colonisation or re-introduction of "lost" biota. IAS removal can also provide economic and health benefits via gardening, horticulture and improved water quality and possibly ecotourism, but gains need to be protected by improving quarantine methods.

2.0 PERSONNEL, TIMETABLE AND GENERAL METHODS

Many people assisted with planning and execution of this project (Appendix 1). Island counterparts and key contacts received draft and final survey plans in January-September 2011 to allow planning at the local level for meetings, lagoon transport, etc. The main survey took place between 23 September and 16 October 2011 and the general itinerary is provided in Appendix 2. Specialists in the main survey were Allan Burne and Monica Gruber (ants), James Atherton (GIS and general); Mere Valu and Ray Pierce (birds and invasives) and Art Whistler (plants). A follow-up survey was undertaken by Ray Pierce on Fakaofo in January 2012, while Monica and Samuel Gruber and Ray Pierce carried out follow-up visits to all three atolls in September 2012.

The approach at each atoll all involved 1-2 meetings, including debriefs, with Pulunuku and Taupalega along with field surveys. Nearly all motu at Atafu and Nukunonu and some on Fakaofo were visited during the daytime and walk-through surveys undertaken to describe the following:

- overall vegetation (dominant plant species) and any unusual species
- birds present (seen or heard and their approximate daytime numbers) and their breeding status if relevant (colony size, breeding stage, signs of impacts)
- supplementary information was collected by completing evening fly-on counts (birds returning to roost) and/or night at some selected motu to fully explore bird use
- reptiles and crabs were also noted, along with invasives and/or their sign.

More detailed methodologies are provided in the relevant sections.

3.0 VEGETATION AND PLANTS

3.1 Methods

This comprised a walk through survey of each motu with the dominant canopy species being recorded for each. Unusual species were noted together with invasive species damage e.g. pig rooting. A plant list was completed for Atafu and provisional lists for the other atolls.

3.2 Results

The vegetation of the Tokelau is dominated by planted and regenerating coconuts and a small number of other tree species notably *Pandanus tectorius, Tournefortia argentea, Guettarda speciosa, Pisonia grandis* (puka), *Cordia subcordata* and the seashore shrubs *Pemphis acidula* and *Scaevola taccada*. The understorey is dominated by seedlings of these species plus the ferns *Asplenium nidus* and *Phymatosorus grossus*.

A prolonged dry period at the atolls in 2011 has resulted in severe wilting and sometimes death of trees and seedlings, particularly at Nukunonu. Coconuts were hardest hit at Atafu where fruits were scarce and those seen were small. One relatively higher-elevation motu in the Hakea chain of Atafu was unusual in having plentiful nuts. In addition to this, puka trees were showing signs of disease stress, with much die-back apparent. However, in September 2012 all common species

were showing signs of recovery following frequent rain throughout the year.

Many weed species were present, particularly in the villages and adjacent livestock and dumps sites and some weed new species for Tokelau were recorded. A full plant report is appended along with details of dominant trees for each motu surveyed (Appendix 8).

Erosion and flooding was noticeable in several places, e.g. along the NE, E and S coasts of Atafu and Nukunonu.

4.0 BIRDS

4.1 Methods

Key methods included:

- Discuss with locals about locations of seabird colonies in the past, plus details of species, numbers, timeframes and observers; also details of unusual land-birds and turtle nesting areas, where possible documenting species, locations, numbers, timeframe, observer
- Walk-through surveys of the motu, lists of all bird species detected and their numbers
- Map locations of current or past colonies of seabirds and determine width of permanent water
- Complete annotated bird lists per atoll
- Complete seabird fly-ons at likely roosting areas
- Complete seabird transects Apia-Tokelau and within the group.

4.2 Results

Current status

Twenty species of indigenous birds were recorded from Tokelau in September 2011-January 2012, comprising 14 seabirds, 1 heron, 4 waders and a pigeon. At other times of the year the kaleva or long-tailed koel is a visitor from New Zealand and ducks (*Anas* spp.) visiting from the north. Key features of the bird fauna were:

- The numerical dominance of three species – lakia (black noddy), gogo (brown noddy) and akiaki (white tern) - each numbering in many thousands of pairs per atoll.
- Takupu (red-footed booby) breeding successfully on all three atolls with an estimated 1000 birds present at Atafu, 1500+ birds at Nukunonu and at least 600+ at Fakaofo, with a high proportion of juveniles at all. At least 180 occupied booby nests were on Atafu, all in the southern Hakea motu, an estimated 150+ nests at the SE corner of Nukunonu and many nests on the NE motu of Fakaofo.
- Fuakoo (brown booby) had nested successfully on the outer motu of Nukunonu recently.
- Katafa-koti (lesser frigatebirds) were present in the low hundreds at all three atolls (fly-on counts suggested 500+ roosting on each of Atafu and Nukunonu and 200+ at Fakaofo. No evidence of current or past breeding was found (no old nests seen and none reported). There was also a low proportion of juvenile frigatebirds present which suggested that these mainly adult frigatebirds congregate here from other breeding centres, e.g. Phoenix Islands to the north were many thousands of pairs breed. Given the high numbers of birds

present and the fact that several males at Atafu and Nukunonu had inflated gular sacs in September-October and one at Fakaofo in January, it would not be surprising if frigatebirds attempted to nest here in the near future.

- Tovivi (black-naped terns) were present in moderate numbers – conservative estimates of 60+ birds at Atafu, 100+ at Nukunonu and 40+ at Fakaofo. At the first two atolls there was active nesting on open and vegetated sandy flats but productivity was low.
- Additional species in lower numbers and breeding at the northern two atolls were Fuakoo (brown booby), Tavake-ulu-gahu (red-tailed tropicbird) and Tavake-ulu-puka (white-tailed tropicbird), while a few Katafa gogo (great frigatebirds) were seen amongst the flocks of Katafa-koti at all three atolls.
- Lupe (Pacific pigeons) were present in the larger forested motu of Atafu including the Village Motu, but they were rare on Nukunonu and Fakaofo.
- Visitors included a single Christmas shearwater flying over Atafu Village at 0650 h on 1 October, a first record for Tokelau (RP, Tene Aluia pers. obs.) and many wedge-tailed shearwaters offshore of all three atolls during several evenings.

Fig 4.1 – Tavake or red-tailed tropicbird approaching nest site in NE Nukunonu.

Fig 4.2 – Tovivi or black-naped tern chick on typical sandy nesting area at Nukunonu

Comparisons with 1960s data

Table 4.1 summarises comments on bird status from Wodzicki and Laird (1970) and the current 2011-12 survey. If the 1970s data were accurate, the populations of several bird species seem to have increased since the 1960s, notably Tavake, Talagogo, Katafa-koti, Takupu and Fuakoo. These observations are consistent with the views of several Taupulega and fishermen at Atafu and Nukunonu who believe bird numbers have largely increased in recent years/decades.

Table 4.1 – Comparison of bird numbers estimated present at the three motu in 2011 and indication of population change since 1960s (**bold = significant change**)
(Note 1960s data from Wodzicki and Laird 1970)

Species – refer Appendix for complete names	Atafu Sep 2011	Nukunonu Oct 2011	Fakaofo Jan 2012	Population change since 1960s
Tanguoua – WTSW	Offshore	Offshore	Offshore	No change
Christmas shearwater -CXSW	1	0	0	**First record**
Tavake-ulu-gahu - RTTB	3	20+B	0	**Increase at NN**
Tavake-ulu-puka – WTTB	1	10+B	0	**Increase at NN**
Katafa-koti - LEFB	500+NB	500+NB	200+NB	**Big increase at all**
Katafa Gogo – GRFB	<10NB	<10NB	<10 NB	No change
Takupu – RFB	1000+B	1500+B	600+	**Big increase at all**
Fuakoo – BRBO	10+B?	100+B	1 seen	**Increase at NN**
Hakea – MABO	1 NB	0	0	No change
Matuku – PRHE	30-50	50+B	20+	Possible increase
Tuli – PAGP	50+	50+	Present	No data
Vaha-vaha – RUTS	20+	30+	Present	No data
Kolili - WATA	50+	50+	Present	No data
Tiafee – BTCU	<10	c.20	Present	No data
Gogo - BNNO	10000+pB	10000+pB	Abundant	Possible increase
Lakia – BKNO	15000+pB	5000+pB	Abundant	Possible increase
Tovivi – BNTE	60+B	100+B	40+	**Increase at AT, NN**
Talagogo – SOTE	39+NB	1600pB	1 seen	**Increase at NN**
Akiaki – WHTE	5000+pB	5000+pB	Abundant	Possible increase
Lupe – PAPI	6 motu	1 motu	Present	**Apparent decline**
Kaleva – LTKO	Reported	Reported	Reported	No data

Note numbers refer to individuals unless indicated as pairs (p); B = breeding, NB = non-breeding.

Key bird areas and issues

The key breeding areas were as follows (refer also Fig 4.3-4.5 for key biodiversity areas and threats):

- Atafu - Hakea Motu where Takupu (red-footed boobies) successfully nest; also a Katafa (frigatebird) roost; some hunting issues
- Nukunonu - Whenua Loa and adjacent motu where Takupu successfully nest and Fuakoo and Katafa roost and potentially nest; possibly threatened by development (Section 10)

- Nukunonu - NE motu where Tavake-ulu-gahu (red-tailed tropicbirds) nest with possibly low success due to human and predator impacts
- Nukunonu - Tokelau Motu has a colony of Talagogo (sooty tern) but they have also nested in two of the S motu); threatened by cats, rats and people.

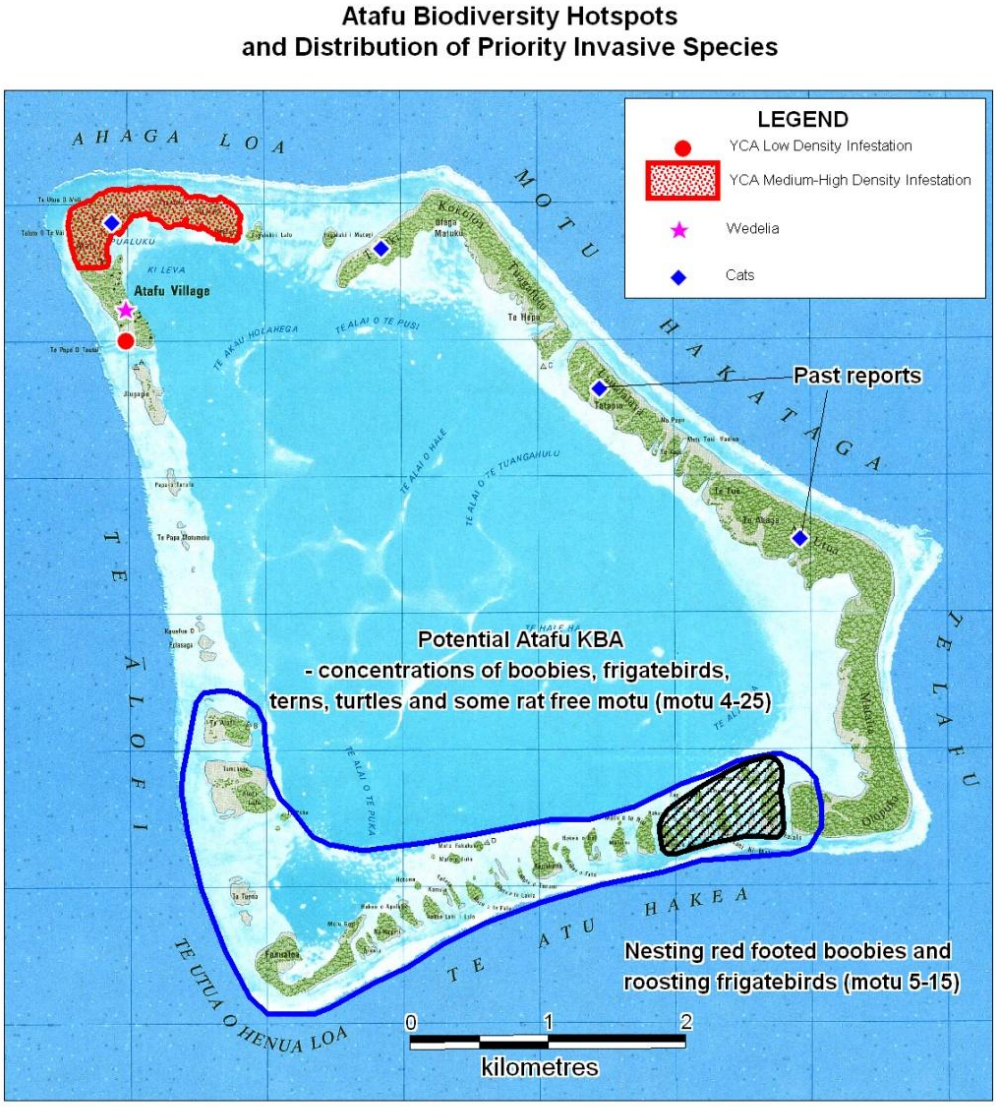

Fig 4.3 – Summary of Atafu hotspots, potential key biodiversity areas and key invasive issues

Fig 4.4 – Summary of Nukunonu hotspots, potential key biodiversity areas and key invasive issues

Fig 4.5 – Summary of Fakaofo hotspots and potential key biodiversity areas

5.0 REPTILES AND INVERTEBRATES

5.1 Methods

Reptiles were detected during walk through surveys and on some motu also during night surveys using headlamps. No targeted surveys of lizards was made given the local fauna is well known (e.g. Whitaker 1970). Similarly no specific invertebrate survey was undertaken other than for ants, but we recorded all major groups detected.

5.2 Results

Reptiles

Six species of reptile were recorded – a turtle species, 3 skinks and two geckoes. The threatened green turtle (*Chelonia mydas*) breeds on some motu at all three atolls with one motu in the NE Nukunonu area having received 7 visitations recently. Snake-eyed skinks (*Ablepharus boutonii)* and blue-tailed skinks (*Emoia cyanura*) were widespread and common on each atoll, but black skinks (*E. nigra*) were uncommon except in the area of pig pens and YCA infestation (Section 6) at the eastern half of the Atafu village motu. House geckos (*Hemidactylus frenatus*) were detected sporadically, but appeared to be widespread. There are no data available for comparing past turtle abundances, but some comments suggested that they are now much less common than a few decades ago. Key threats for turtles are human predation on adults (including breeding females) and eggs, plus egg predation by pigs. In addition cats and rats could potentially prey on hatchlings.

Invertebrates

Oga (coconut crabs) and tupa (*Cardisoma* crabs) were found and/or reported to be widespread and uncommon to moderately common at each atoll. Many oga were seen in the survey and others had been collected by villagers. All oga seen were sub-adults, suggesting that the populations have been harvested fairly intensively over a long period.

Three butterfly species were recorded – meadow argus (*Junonia villida*) (common and widespread on all three atolls), blue moon (*Hypolimnas bolinas*, which was common at Atafu, but fewer than 5 seen at Nukunonu (all on Village Motu) and none at Fakaofo, and a crow butterfly species (*Euploea* sp.) recorded only at Atafu Village motu.

Other groups included several spider groups (including orb webs, huntsman), moths, a red coloured dragonfly in several parts of all three atolls, neuropterans in the *Pemphis* of eastern Nukunonu. The prevailing dry period in September-October probably contributed to a lack of mosquito sightings, but mosquitoes were abundant during a wet season visit to Fakaofo in January. Many families of arachnids occur at Tokelau, including possibly an endemic species (A. Beavis pers. comm., Appendix 9)

6.0 ANTS

6.1 Yellow Crazy Ant in Tokelau

6.2 Background

Yellow crazy ants (YCA) were first reported on the Tokelau atolls in 1934, but were at low abundance until early in the 21st century, when they became a source of concern for the people of Nukunonu and Fakaofo. In 2005 cyclone Percy resulted in a decline in YCA abundance. In 2006, a poisoning programme led by Dr Kirsti Abbott (then of Victoria University of Wellington) was implemented by the communities of Nukunonu and Fakaofo, on inhabited motu only. At that time, YCA were absent from Atafu. The overall purpose of our assessment was to assess the current distribution of YCA on the three atolls, compare this with the earlier records of 2004-05, and identify management issues.

6.3 Aims and methods

The aim of the assessment was to address the following questions, some of which were additional to those originally scoped, but it became clear they also needed to be addressed:

1. How does the distribution and abundance of YCA compare to that in 2004-05?

   To answer this question we conducted searches for YCA on every motu on each atoll (excluding Fakaofo). For most motu where YCA were found we measured abundance using 'card counts', which is a count of the number of ants walking across a 10 x 10 cm card in 30 seconds. This quick measurement enables us to compare the relative abundance of ants on different motu, and helps to assess potential management approaches.

2. What is the extent of the distribution of YCA on Atafu?

   One concern we had was that the Taupulega of Atafu had raised the issue of YCA a long time before we arrived, yet we were not made aware of the presence of YCA on Atafu until shortly before our visit. It was clear that the concerns of the Taupulega of Atafu required us to determine the scope of the management effort there. Therefore, on Atafu we marked out the entire area of the infestation to assist with determining the requirements for poisoning if that were to be chosen as a management option.

3. Has the species composition of the ant communities changed (Nukunonu only)?

   Nukunonu was the only atoll where ant communities were assessed in 2004-05. A repeat assessment may help to identify differences between atoll wide events that can change ant communities (i.e. the effect of a cyclone), with events that affect individual motu (i.e. poisoning). This assessment captures ants using 'pitfall traps' dug into the ground and partly filled with a non-toxic killing agent and preservative. The ants captured are identified and counted. Many ants can only be identified confidently using a microscope, so this analysis was completed after the field survey.

4. Has poisoning reduced the distribution and abundance of YCA (Nukunonu only)?

   In 2004-05, the relative abundance of YCA was only assessed on Nukunonu atoll. Poisoning of YCA was undertaken on Nukunonu and Motuhaga only, shortly after cyclone Percy. Although cyclone Percy resulted in the removal of many YCA, they were still present in reasonable numbers prior to poisoning. The assessment of 2004-05 was repeated. The results of the species composition assessment may also help to separate the effects of the cyclone from the effects of poisoning.

5. Are there any new ant pests that may require management?
   We hand sampled foraging ants throughout the motu on each atoll. The ants were identified along with the pitfall caught ants.

6. Has the genetic form of YCA that was linked to higher abundance by Dr. Abbott invaded new motu or displaced the other genetic forms (all atolls)?

   Dr Abbott and her colleagues found that the most abundant YCA on Nukunonu were genetically distinct (referred to as haplotype D) from the less abundant YCA on other motu (referred to as haplotype A). If this is a consistent feature, it may be useful to incorporate genetic testing in management plans for YCA. Samples of YCA were taken from every motu on which they were detected. The genetic analysis was undertaken in the laboratory facilities at Victoria University.

6.4 Summary of results

1. How does the distribution and abundance of YCA compare to that in 2004-05?

   YCA were not present in Atafu in 2004/2005, and they are now only found at Atafu Vao and Village.
   YCA remain on Nukunonu and Motuhaga in very low abundance. On Te Fala, the northern end of Fenua Loa and Te Nonu abundance is relatively higher, but the ants are now absent from Tokelau, Pukapuka, Nukunonu, Motuhaga, Te Puka i Mua and Te Palaoa, where they were found in 2004-05 (Table 6.3.1). There are new invasions on Motu Akea and Te Afua. Unfortunately, because of time constraints, we were unable to survey Fakaofo outside of Fale. However, Mose Pelasio informed us that the YCA infestation on Fenua Fala was not seen as a serious problem.

Table 6.3.1: Summary of results for all atolls (only motu with YCA in 2004/2005 or 2011 are listed). Card counts were not made for Motu Akea and Te Afua, however, the ants were only found after a significant time searching the entire motu, thus abundance was clearly much lower than motu such as Te Nonu and Atafu Vao, where the ants are immediately obvious.

Atoll		YCA haplotype (genetic form)	
Motu	card count	2004/2005	2011
Atafu			
Atafu Vao (see map)	20, 52, 63	-	D
Atafu Village (see map)	0	-	D
Nukunonu			
Te Nonu	63	-	D
Te Puka i Mua	-	D	-
Nukunonu	0	D	D
Motuhaga	0	D	D
Te Palaoa	-	-	-
Te Fala	23	A	A
Pukapuka	-	A	-
Tokelau	-	A	-
Lalo	-	A	-
North of Fenua Loa	18		A
Motu Akea	low	-	D E
Te Afua	low	-	D
Fakaofo			
Fenua Fala	-	A,D	Need samples
Fale	low	-	D

2. What is the extent of the distribution of YCA on Atafu?

Although the YCA was first noticed approximately three years ago, it may have been in Atafu for longer, as the ant can remain at very low abundance for long periods. The Vao population to the east of the Atafu is highly abundant, and currently ends at the start of the village (Figure 6.3.1). We were also shown what appears to be a small, isolated population in a garden near the port (Figure 6.3.1). We were not able to find any other signs of the ant, despite luring with sugar and protein, and checking all nonu (a known favourite food source for YCA).
The YCA Vao population now covers approximately 37 hectares (Figure 6.3.1). It is difficult to predict with certainty how the invasion will progress, however, more likely than not the YCA population will continue to spread into the village. For example, on Christmas Island in the Indian Ocean, the ant is seen to spread in distribution up to 3 metres per week. Although unexplained declines or crashes of YCA populations do occur, it is more commonly observed that populations spread and increase in abundance. Thus it seems sensible to consider management of the population sooner rather than later.

Figure 6.3.1: Map of extent of YCA infestation on Atafu.

3. Has the species composition of the ant communities changed (Nukunonu only)?

   The ant community composition on Nukunonu has changed significantly since 2004. This potentially reflects an atoll wide event such as a cyclone, or repeated introductions.

4. Has poisoning reduced the distribution and abundance of YCA (Nukunonu only)?

   The results of the community composition analysis suggest that poisoning may have had little effect on YCA. This is a critical conclusion as it suggests that the type of poison used was not appropriate for YCA. We stress that this is in no way whatsoever the fault of Dr. Abbott and her team. Rather, very little was known in 2006 about YCA management, and Dr. Abbott and her

team used the best option available at the time. Subsequent advice from Dr. Ben Hoffmann (the expert on YCA management) has indicated that toxins that are appropriate for other ant species may not work as well for YCA. Of all the available toxins, the most effective on YCA is also the one with the most serious effects on non-target species (particularly invertebrates such as coconut crabs). This toxin is not recommended for widespread use on oceanic islands. Dr. Hoffmann instead recommends the use of Insect Growth Regulators (IGR) in situations of widespread abundances such as on Atafu. Insect Growth Regulators are a hormone rather than a toxin, and have limited effects on non-target species. The difficult aspects of this method are that treatment must be repeated up to three times within the dry season, and there are currently difficulties in obtaining permission to use the product. We are investigating this and other options for control of YCA. Small isolated infestations of YCA (such as those in Atafu village, Fale, Nukunonu and Motuhaga) may be able to be *carefully and judiciously* treated with poison to alleviate risk to native fauna and waterways.

5. Are there any new ant pests that may require management?

   No new ant pests have been identified in the current survey. However, in our brief survey of the hold of the MV Lady Naomi on our way to Tokelau we found seven of the 18 species found on Tokelau at present. This high proportion indicates how easy it is for invasions of ants to occur, particularly without any biosecurity measures in place.

6. Has the genetic form of YCA that was linked to higher abundance by Dr. Abbott invaded new motu or displaced the other genetic forms (all atolls)?

   Although samples still need to be processed from Fakaofo, it is certain that both infestations on Atafu are haplotype D (Table 6.3.1). Most new detections on Nukunonu are also of this haplotype, as well as one new detection of haplotype A, and the new haplotype E. The populations that have disappeared were haplotype A in three cases, and haplotype A in one case. Haplotype D is no longer linked to higher abundance.
   Although haplotype D is more prevalent, it seems probable that new arrivals from Samoa or other atolls are likely to be haplotype D or the new haplotype. As the abundance and effects of YCA no longer appear to be directly linked to the haplotype, there does not appear to be any need for genetic testing. Abundance of YCA would be a more useful indicator to monitor.

6.5 Outlook

Ants are very difficult to eradicate entirely. Eradication is therefore an unlikely outcome on Tokelau. YCA are likely to remain in Tokelau permanently, even if at low abundance. As abundance may increase without management (as seen on Atafu, and experienced in many other places, including earlier on Nukunonu and Fakaofo), management of the ant needs to be considered as a long term endeavour.

6.6 Recommendations

- Development of an ongoing, straightforward, practical plan and tools to manage the YCA invasion as a long term, chronic problem. Ideally this plan should cover three risk areas:

1. Biosecurity ex Apia: prevention of new invasions are much more desirable and manageable than the prospect of repeated poisoning attempts.

2. Management on invaded motu: to include monitoring of the invasion and poisoning as and when considered necessary. Quick and straightforward ways to assess the seriousness of the problem are needed to inform on decisions regarding poisoning – small isolated invasions are much easier to manage. Occasional large scale poisoning (as the current situation on Atafu indicates) may be occasionally required when monitoring and small-scale management is not working.

3. Prevention of spread to uninhabited motu: for conservation reasons, and to prevent populations from uninhabited motu re-invading the village motu.

- Aspects 2 and 3 of the plan need to provide a practical way for communities to manage YCA, rather than being reliant on outside help that is not always available when needed. We suggest that including the following may help to ensure this:

  - Step by step instructions for practical monitoring and management actions (this had been started by Dr. Abbott, but needs completion).

  - Contact details for further help and advice, suppliers of toxins and equipment (including alternative suppliers).

  - Details on how to determine the amount of toxin/hormone needed and full details on how it is to be used, stored and disposed of. It was a concern that on Fakaofo old toxin was still being used, and this was stored in a torn plastic bag with no indication of what chemical it contained. Also of concern is that no records have been kept of poisoning.

  - Laminated pages so that the plan can withstand the environment and be used 'in the field' by the people undertaking monitoring and management.

  - The plan could be written in both Tokelauan and English for clarity.

  - As a first step in developing and testing a plan to make sure it works for the communities of Tokelau, we suggest small-scale management of the YCA on Fale and a larger scale approach on Atafu. Lessons learned during this process will help to ensure the plan is workable, and also deals with the immediate needs of the communities on Fale and Atafu.

  - It is essential that the community representatives agree on the plan, and agree that such a plan will be of value. The technical manuals that Dr. Abbott drafted after the poisoning in 2006 were not completed in a part due to a perceived lack of interest from Tokelau once the abundance of the ant declined. If management is to be successful over the long term it is important that the community are closely involved and interested in the development of the proposed plan and ongoing monitoring and management.

7.0 INVASIVE MAMMALS, BIRDS, INVERTEBRATES AND WEEDS

7.1 Methods

Methods included:

- Walk through survey to detect presence/absence of rats, cats and pigs by sightings or sign. Cat sign was readily detected in soft sand particularly along the lagoon edge of the motu. Most rat sign was first detected by examining immature and opened coconut fruit for sign of gnawing. Sightings of all species, particularly rats, were more common after 1530 h, and we camped on some motu (Hakea Group on Atafu and Tokelau Motu on Nukunonu) to undertake night spot-light searches, trapping, etc.
- Follow-up spotlight surveys for rodents was undertaken on some priority motu
- Rodent specimens were trapped for confirming species
- The distribution of crab species was noted as this will be a factor in planning any rodent eradication in the future.

7.2 Results

Rats

Rats were present on most vegetated motu on Atafu and Nukunonu and limited motu surveys at Fakaofo suggested the same was true there. Trapping and spotlighting on several Hakea motu on Atafu produced nil returns suggesting that Pacific rats have been eradicated on many of the Hakea motu. Similarly no sign was found on a few of the southern motu on Nukunonu suggesting they were at low densities or absent. When rats were present they were generally at low levels on Atafu, whereas on Nukunonu they were generally common to abundant and active from mid afternoon on through the night.

The absence of rats from the Hakea motu and the low densities seen elsewhere on Atafu, appears to be the result of a sustained rat-baiting programme. The only bait found in storage on Atafu was Bromodiolone, blocks of which are nailed to coconut trees. The timing of each rat baiting episode is decided by the Atafu Taupulega and reportedly occurs annually in July-August preceding or coinciding with the onset of coconut flowering. Some motu are left unbaited to allow for the safe collection of coconut crabs. Meanwhile people are warned by Police to avoid crab collection in targeted motu for periods reported variously as 2-6 months, although some other residents said that they were unaware of this. The baiting is carried out by an island taskforce, but details of bait density are unknown and there appears to be no written record of the details - areas treated, when, how much bait, by whom etc.

Timing of baiting was not determined on Nukunonu and Fakaofo, and the lack of information may explain why rats were detected in higher numbers on some motu there than at Atafu. On Fakaofo, baiting has occurred both by attaching blocks to trees and placing them in tunnels in order to exclude large crabs. Although only a few rat specimens were collected, they were large for their species and larger than any Pacific rats that have been trapped on the nearby Phoenix Islands (Table 7.1). Specimens were provided to University of Auckland for DNA analysis.

Table 7.1 – *Rattus exulans* data from Nukunonu's Tokelau motu

Sex	N	Mean head and body length (and range in mm)	Mean tail length (and range in mm)	Mean weight (and range in g)
Male	5	147 (129-159)	157 (149-162)	96 (67-128)
Female	2	111.5 (105-118)	120.5 (118-123)	63 (58-68)

There had been reports of large rats on Fenua Falu at Fakaofo, which might be European rats or large specimens of Pacific rats. Rat traps were left with Tokelau staff to follow up on this, but no feedback was received.

House cats

Away from inhabited motu, footprints of feral house cats were detected on two Atafu motu (Te Oka and Long Motu), two Nukunonu motu (Tokelau and Fenua Loa) and were reported from NE motu at Fakaofo. Generally only isolated tracks were seen, but on Tokelau Motu at Nukunonu, there were several tracks representing at least 3 individuals (Fig 7.1), all converging near the sooty tern colony, on which they were impacting (chicks and adults had been killed). Several people told us that the cats had been dumped on these and other motu to "control rats" and /or because of "too many cats" at the villages.

Feral pig

Feral pigs were found at Nukunonu on Fenua Loa, Te Puka and on the 5 interconnected motu extending south from Fakanawa. These motu have been stocked with pigs by people, but there is a conscious attempt to remove large pigs for safety reasons. Many other motu were reportedly targets for introductions in the past, including particularly many of the north-eastern motu of Nukunonu.

Fig 7.1 - cat tracks leading to and from sooty tern colony on Tokelau motu

Chickens

Chickens were found on Te Puka Motu at Nukunonu and possibly occur in low densities elsewhere.

Mynas

During the initial half-day visit to Fale at Fakaofo in September 2011 we saw the remains of a myna (*Acridotheres* sp.) nest under a house eave in one inland corner of the motu. An egg had been collected from this nest in early 2011, destination unknown. Accounts from local staff (Mose Pelasio) and Alatina included the following details:

- firstly mynas had arrived via a NZ naval ship
- although a bounty of NZ$200 ha been placed on the birds, none were produced for the reward
- two birds were reported to have died separately on Fale, one from drowning in a water tank and one from being hit by a falling breadfruit and subsequently stood on and killed
- there were conflicting reports of the number of mynas seen alive in 2011 – one or two individuals
- in September 2011 one comment indicated that there were two mynas present at the same nesting house "about 3 months ago" and had laid an egg in the nest at an unknown date earlier in the year. This egg had been collected, but destination is unknown
- a single bird was reportedly seen by Alatina Mana on the radio mast at the Fale landing in late September 2011
- another single bird (possibly same one) was seen by Alatina feeding on breadfruit at Fenua Fala the same month and was described as black with orange bill and white in wing (indicating jungle myna, *A. fusca*).

In 16-17 January 2012 two visits were made to the neighbouring inhabited motu of Fenua Fala where the pig pens are currently located. No mynas were seen or heard here or elsewhere on this motu. Many people who visit the pig pens regularly in the early morning and evening were interviewed and none reported having seen any mynas there recently. Some of these people had seen them feeding on fruit of breadfruit trees in the Fenua Fala village in late 2010 and during 2011, but none recently.

In December 2011 a few sightings of a possible individual myna were reported from Nukunonu mainly in the vicinity of the pig pens (Mika Perez pers. comm.). The lack of myna sightings during our earlier visit to Nukunonu in October 2011 and later visit to Fakaofo in January 2012, suggests that at least one bird may have flown from Fakaofo to Nukunonu in November or December 2011, but there have been no further reports.

Footnote: Visits to Fakaofo and Nukunono in September 2012 produced no additional myna sightings or any reported sightings for 2012, suggesting a failure by mynas to establish

Invertebrates

The three atolls are infested with rhinoceros beetle, while whitefly appears to be confined to Fakaofo and mealy bug was also found invading there during the September 2012 visit. Manging these economic invasives and other invertebrates e.g. a stick insect needs to be addressed in

conjunction with SPC.

Weeds

On Nukunonu *Wedelia* is still present at the south end of the village but it is more fragmented in distribution than it was in June 2008 with new infestations extending to the dump area. There is a current programme at Nukunonu to remove infestations by digging out and burning (Mika Perez pers. comm.). Elsewhere, small plantings are also present at the Atafu and Fakaofo churches, and several incursions are establishing on Fenua Fala between the village and the dump site. The plants were desiccated during the dry period of September-October, but by January the Fakaofo plants were spreading prolifically.

Fig 7.2 – Wedelia at Nukunonu October 2011

Footnote – in September 2012 the species had proliferated on all three atolls following more equitable rainfall during 2012. On Nukunonu about 30 sites, many of them stemming from dropped or discarded plants, were documented along with a small infestation of *Gloriosa superba* (glory lily) – draft recommendations for management have been made – CI/CEPF action plan in prep.

8. POTENTIAL IMPACTS OF INVASIVES ON INDIGENOUS BIOTA

8.1 Methods

This survey assessed potential impacts of invasives largely in general terms based on other studies of mammalian impacts. However, we also carried out some basic work on YCAs and their possible impact on the very widespread Akiaki (white tern) in areas with and without YCAs. In several areas we recorded nesting or display trees, height of "nest", whether YCAs were detected on the tree, and the presence of a single bird or pair of Akiaki, along with egg, downy chick, pullus or flying juvenile. The proportion of successfully hatched nesting attempts (downy, pullus, juvenile) was compared between areas with different YCA and rat status. Unfortunately, the areas with and without YCAs also generally differed in other respects, e.g. the Atafu YCA site was in areas in which the birds had a limited selection of trees from which to choose whereas the YCA-free area also had many breadfruit trees; both sites supported rats and

cats, but the latter probably had more cats and fewer rats than the YCA site.

8.2 Results

Yellow crazy ant

There was no significant difference in Lakia (black noddy) breeding status in the ant-free and ant-infested areas of Atafu (Table 8.21). There was however an apparent relationship between Akiaki (white tern) productivity and YCA presence/absence. Akiaki breeding success was relatively low in all of the YCA-infested sectors of the islands we studied (Table 8.22, Fig 8.2). Elsewhere in Atafu on the outer motu it was noticeable that Akiaki were also breeding successfully, with scores of eggs, chicks and pulli being observed during our surveys and at lower elevations than in the YCA area.

Table 8.21 – Lakia nest status at Atafu Village Motu

Loc	N	Incubating	Downy	Pullus	Juvenile	Total young
Village	170	129	37	4	0	41 (24%)
Ant area	84	57	25	1	1	27 (32%)

Table 8.22 - Akiaki nest status at Tokelau

Loc	Rats	YCAs	N	Adult(s) only	Inc	Downy	Pullus	Juvenile	Total young
AT Village	L	Nil	46	7	15	10	11	3	24 (52%)
AT YCA	L	High	47	20	20	2	1	4	7 (15%)
NN Village	L	L	16	3	3	2	5	3	10 (62%)
NN Tokelau	H	Nil	28	11	9	5	2	1	8 (29%)
NN Eastern	L	Mod-H	21	8	10	1	2	0	3 (14%)
FK Fale	L	Nil	24		2	3	6	1	10 (42%)
FK Fenua Fala	L	High	38	32	3	1	1	1	3 (8%)

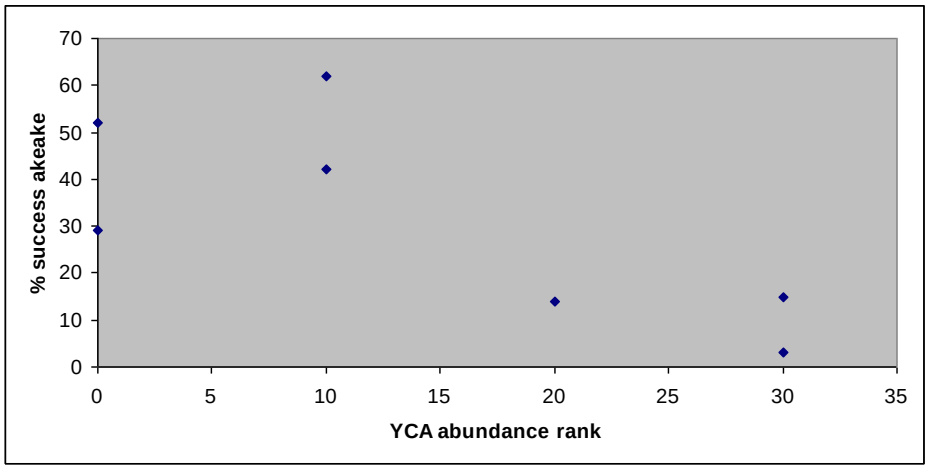

Fig 8.2 – Preliminary graph of "breeding success" of Akiaki in relation to rank of YCA abundance (0 = nil, 10 = low density, 20 = moderate density, 30 = high density).

These are only correlations however as other factors e.g. rat abundance and height of nest and whether the tree is dead or alive (and therefore vary in attractiveness to worker ants), could also affect Akiaki nesting success. For example rats were abundant at one of the study sites - Tokelau motu – which contained no YCAs and breeding success at 30% was the lowest of the 0-1 ranked YCA sites. Although no direct evidence of YCA predation was observed, one Akiaki was seen pecking at ants on its plumage. Clearly there is a need to examine the relationship between YCAs and seabirds in detail to verify their apparent impact on Akiaki nesting success. If white terns are impacted on by YCAs as seems to be the case, many other less common species such as ground-nesting Tovivi, Talagogo and species of boobies, tropicbirds etc, may be at higher risk than Akiaki.

General impacts of invasives

The general impacts of other invasives are well known internationally and likely Tokelauan impacts are summarised in the table below. Pacific rats are likely to have a severe impact on ground-nesting Tovivi (black-naped terns) and Talagogo (sooty terns), lizards and invertebrates. Cats and rats are likely to impact on these groups, plus larger birds including Tavake-ulu gahu (red-tailed tropicbird), boobies, as well as turtle eggs and/or hatchlings.

Table 8.3 – estimated impacts of invasives on different biota

Invasive	**Low-moderate impact on:**	**High-severe impact on:**
Pacific rat	Akiaki, noddies	Tovivi, talanono, lizards, invertebrates
Feral cat		Tavake-ulu-gahu, ground-nesting boobies, talagogo and tovivi, turtle hatchlings
Feral pig		Seedlings, ferns, water retention of ground; nests of Tavake-ulu-gahu, Fuakoo, Talagogo and Tovivi ; turtle nests
Myna	Fruit trees	High impact unlikely
Yellow crazy ant	Ants and other invertebrates; people; apparently Akiaki and possibly other terns, etc	Land crabs, potentially many seabird species if ants reach high abundance particularly if scale insects are also present, In this case *Pisonia* will also be affected
Weeds e.g. *Wedelia*		Evidence to date suggests Wedelia could have potentially high ecosystem impacts through smothering of native vegetation

Table 8.4 – Some other benefits of restoration for people

Why restore? What's in it for Tokelau community – some examples of multiple benefits of managing invasives		
Action	**Ecological effect**	**Human benefit**
Reduce harvest of terns, Tavake, Takupu, turtles etc.	Higher bird productivity, bigger seabird flocks	More nesting birds and turtles for harvesting sustainably in the future if needed; greater opportunity for eco-tourism; more seabird fish-indicator flocks (Talagogo and Tovivi)
Remove rats and cats	As above plus more seedlings, invertebrates, lizards, etc	As above plus healthier forest
Remove pigs	Improve forest understorey; increase in ground-nesting terns, tavake, boobies, turtles	Healthier forest including coconuts, more birds, turtles etc
Remove yellow crazy ants	Improve numbers of benign ants and other invertebrates, possibly also birds	Possibly improved pollination, less irritability to humans
Remove mynas if present	Possible slight impact on birds	Fruit no longer attacked

9.0 BIOSECURITY

Tokelau has prepared some National Biosecurity Guidelines (2003) but has yet to fully implement these. Poor biosecurity in the recent past has lead to the invasion of mynas to Fakaofo and yellow crazy ants to Atafu (and the other Tokelau atolls before then). Awareness of biosecurity was reasonably high at all three atolls but direct action was limited by staff, resources and planning. We met with Quarantine officials Mose and Alatina at Fakaofo, Ege Etueni at Atafu and Mika Perez at Nukunonu, who along with our observations, noted some key points:

- No biosecurity was in place for either of our trips to Tokelau
- At the Matautu wharf in Apia from where nearly all Tokelauan supplies are sourced, goods and supplies were transported from the wharf to the Lady Naomi hold directly by vehicle or person across the lowered ramp. There was no interest from the crew of the Lady Naomi at our offer of rat traps as a precaution against rodents. During the voyage 5-6 species of ants were identified on board the vessel
- There appeared to be little or no pest control in place at the Samoan Port Authority complex except for that performed by 3-4 marauding cats at the Apia wharf and these might not have been any match for the large Norway rats seen in this area in January 2012 and at earlier times. Yellow crazy ants extended to within 30 m of loading sites and on to the yacht marina.
- Although there was a potential quarantine shed at Fakaofo, the process of checking for invasives seems to have stopped at all of the Tokelau Islands and this is openly admitted by staff some of whom are working to control recently invaded species

- Only one quarantine position per atoll at present, but most believe two people are needed to work effectively, one for on boat and one for on shore biosecurity
- Some staff received biosecurity training at Apia, Samoa, but they recognise that they are in need of further training and they also need basic equipment including quarantine shed, herbicide and pesticide sprays, incinerator, etc.

In September-October 2011 the quarantine officer at Fakaofo (Alatina) was working on "white fly" control by removing the host plant "milk weed" *Euphorbia* sp. which is a recent arrival at the atoll. Other invasives present at Atafu and Nukunonu include rhinoceros beetle and a stick insect, the former of which the Fakaofo officer is beginning to address by burning coconut stumps inhabited by adults.

Clearly the biosecurity process needs to change at both the Apia departure point and at the Tokelau atolls. There are many additional invasives that can travel on the supply ships from Samoa to Tokelau including two other rat species, bulbuls, other ant species, giant African snails, weeds etc. (Table 9.1). Also, if invasives are removed from any of the Tokelau atolls there is currently a strong chance they will reinvade either from Apia or the other Tokelau atolls. Plans for additional transportation to Tokelau include a regular supply ship from New Zealand and an airport at Nukunonu and these plans appear to be progressing quickly. Both require biosecurity risk assessments and appropriate actions.

Table 9.1 – Preliminary biosecurity risk assessment and actions needed

Pathway	**Source**	**Main risks**	**Level of risk**	**Prevention measures and other actions needed**
Supply ships	Apia Cargo vessels are: - Samoa Express - Lady Naomi - MV Tokelau, The last two also taking passengers	Norway and black rat, mice, mynas, bulbuls, ants giant African snail,, other invertebrates, weeds	Extreme	Implement existing Tokelau Biosecurity Regulations, revise and implement new regulations as needed (prohibited/ permitted product lists, packing materials and standards for fresh produce (fruit/veg), etc. (Tokelau) Implement quarantine practise for all cargo, passengers departing Apia (Tokelau) Quarantine practised for all arrivals at Tokelau and inter-island, certification needed (Tokelau) Rodent control practised on all ships sailing to Tokelau and elsewhere (Tokelau/Samoa Pt Authority) Invasives management at Apia Port generally (Samoa Port Authority)
Other cargo ships	New Zealand	Rodents, invertebrates, weeds	High	Generally as for supply ships with the addition of quarantine measures at source
Tourist vessels	Multiple ports	Port-dependent	High	Generally as for supply ships

10.0 OTHER ENVIRONMENTAL ISSUES

Use of toxins

Anticoagulants have been used for rat control on the Tokelau atolls since the 1960s when Dr Wodzicki and others carried out pioneering work and recommended the use of warfarin to control rats. More recently Ridrat containing the active ingredient Bromodiolone has been used in the group and some comments on this are provided below:

- Bromodiolone is a second generation anticoagulant with significant persistence properties in invertebrates
- Anticoagulants have the potential to impact on birds such as Tiafee (bristle-thighed curlew) and Tuli (Pacific golden plover), particularly if they eat crabs that have been scavenging on baits
- It is not known if Kaleva (long-tailed cuckoo) could also be at risk in baited areas
- Pigs can scavenge on poison baits and therefore could obtain significant levels of Bromodiolone in their tissue, especially liver. Pig liver is a favoured food of Tokelauan people
- There appear to be no written guidelines accompanying the use of the toxin
- The Taupulega impose some precautions following rat baiting and these should be reviewed and revised if necessary
- There have been some significant ecological gains in removing rats from some motu and much more could be achieved.

The table below summarises some actions that could improve the safety and effectiveness of the rat baiting issues identified above.

Table 10.1 – Issues and possible actions re rat baiting

Issue	Recommended approach
Bromodiolone effects	Review the use of the toxin on the islands
Tiafee threat	Undertake poisoning when curlews are mainly absent (June-August)
Kaleva threat	Evaluate cuckoo diet to see if it consumes poison-scavenging invertebrates, lizards, etc (note that cuckoos are present in autumn-winter, coinciding with the time that baiting is traditionally undertaken
Pigs	Make people aware of issue and avoid liver etc in baited areas; remove pigs from the outer motu
Poisoning guidelines	Request poison guidelines from the NZ Department or company that has been providing the bait to help Taupulega with their recommendations
Eradications	Consider alternative approaches for use in the planned conservation areas – e.g. other anticoagulants such as PestOff (brodifacoum) could be used to eradicate rats from key motu where biodiversity values are already high and where reinvasion risk of rats is low and therefore provides benefits to biota from rat removal, plus no need to repeat poisoning

Airfield

The Tokelau administration and the New Zealand Government are investigating the feasibility of establishing a small airport at Nukunonu. A desk and field assessment on the island completed by engineering consultants is said to have concluded that the southern Fenua Loa Motu is the least costly and least damaging site available at Nukunonu (Zak Patelesio and Mika Perez pers. comm.). Our survey findings however seriously question the validity of the conclusion regarding least damaging site given the presence of many tall *Pisonia*, *Cordia* and other trees in that area and the fact that all of the nesting Takupu (red-footed boobies) and most roosting Katafa (frigatebirds) and Fuakoo (brown boobies) of Nukunonu occur in that area (Fig 10.1). We agree with the Taupulega that alternative sites need to be considered and that formal assessments of environmental effects are to be completed by qualified ecologists. We understand that the Tokelau Administration have approached SPREP to help conduct a comprehensive environmental and social impact assessment (Tepa Suaesi pers.comm).

Fig 10.1 – Roosting lesser frigatebirds, brown boobies and red-footed boobies at Punulai immediately south of Fenua Loa, Nukunonu

Harvesting fauna

We interviewed several people regarding species of birds harvested. Invariably the response was that few birds and eggs are harvested these days due to the availability and affordability of alternative food c.f. the opposite situation at Kiritimati (Pierce et al 2009). Six species are still frequently harvested however and a summary of the estimated current situation for harvesting is provided below.

Table 10.2 – Species of birds and other terrestrial fauna harvested (Y) or not harvested (N) at Tokelau in recent years

Species	**Y**	**N**	**Comment**
Green turtle	X		2 females carrying eggs taken at NN lagoon, on 9 Oct; eggs also said to be taken from nests. Taupulega impose limits
Oga; coconut crab	X		Common food at each atoll. Taupulega impose restrictions at times of poisoning at AT and for resourcing future feasts
Tupa; *Cardiosoma*	X		Restrictions imposed after poisoning
Tavake-ulu-gula – RTTB	X		Elders report they are not taken, but younger men at AT and NN indicate they sometimes take eggs, young and adults
Tavake-ulu-puka WTTB		X	Rare, mainly NN, said not to be taken
Katafa – LEFB	X		Occasionally hunted at night tree-roosts at AT, formerly also NN and FK
Katafa – GRFB		?	Rare bird; possibly rarely taken at AT and NN
Takupu – RFBO	X		Chicks, juveniles and adults taken at each atoll; remains of 4 pulli/juvs at Alofi Laititi, Atafu; 5 "pet" pulli at FK
Fuakoo – BNBO		?	Said to be not taken, but it is a vulnerable ground-nester
Hakea – MABO		X	Visitor
Matuku – PRHE		X	Said to be not taken at each atoll
Tuli – PGPL		X	Said to be not taken at each atoll
Vaha-vaha- RUTU		X	Said to be not taken at each atolls
Kolili – WATA		X	Said to be not taken at each atoll
Tiafee – BTCU		X	Said to be not taken at each atoll, formerly snared
Gogo – BNNO	X		Formerly eaten, council encourage AT residents to eat them
Lakia – BKNO	X		Residents eat them; water contamination issue
Tovivi – BNTE		?	Said to be no longer taken at each atoll
Talagogo – SOTO	X		Adults said to be netted at each atoll and one person said he caught 19 adults with a fishing line in 2012; remains of birds at fireplaces at Atafu (3-4 birds) and Tokelau Motu at Nukunonu (1 bird). Young men say they take eggs
Akiaki – WHTE		X	Said to be not taken at each atoll
Lupe – PAPI		X	Said to be not taken at each atoll
Kaleva – LTKO		X	Said to be not taken at each atoll

Rubbish

We encountered considerable locally derived rubbish especially on Atafu and Nukunonu. This included both accidental and deliberately dumped rubbish, notably suitcases and bins of old clothes on most of the Atafu motu plastic containers, plastic bags, bags and cases of nappies and even a computer monitor, washed up on the lagoon beach. These clearly pose a hazard to turtles, birds and marine mammals in the region.

Feedback from Pulunuku and Taupulega

Interim findings of the survey were presented to the Atafu Taupulega on our last day at Atafu. This covered YCA distribution, possible YCA impacts on terns and other birds, successful eradication of rats on many motu, positive seabird findings and a process for proceeding with

reporting and future management involving partnerships between the islands and external specialists. Taupulega were grateful for the opportunity to discuss all of the above with key comments being:

- Happy with process for their future input – this will include Tokelau office debrief and the Taupulega being able to provide further comment, including on a translated draft of the report if necessary.
- Keen for outside help in refining rat baiting, recording data etc, to maximize learning from rat eradication initiatives
- Keen to hear more about rodent toxin precautions and explore option of trapping rats in village and around livestock pens
- Keen to have a better understanding of YCA impacts on birds, crabs and people (rumours of infants being attacked in ears and eyes at Nukunonu in the past) and for a plan to be prepared for YCA management
- Keen for improved biosecurity at each of Apia (main source of invasives), Tokelau (example of rhinoceros beetle arriving with inter-atoll guests, Asian house geckos etc) and internal motu biosecurity, the latter to prevent rats and YCA (re)colonization of motu
- The Chairman summed up mentioning importance of birds and crabs to residents and the need to contain pests already present and others from arriving.

On Nukunonu we met with Taupulega only once, but over the 10 days we met with key elders individually including Mika Perez (Director Environment), Lui and Pio (Faipule). Key points were as follows:

- Need for improved biosecurity as per Atafu comments
- Interest in eradicating rats from outer motu to help protect birds, coconuts
- Birds have been eaten in the past but now only low hunting pressure
- Some interest in toxin side-effects but no-one was aware of specific toxins they had been using on Nukunonu in recent years or any documentation being kept (described as cakes nailed to trees so likely either Bromodiolone or Brodifacoum)
- No longer as concerned re YCAs which were reported to have declined post cyclones and some noticed a corresponding increase in a species of black ant
- Expressed a desire for YCA to be totally eradicated (less interested in 2012)
- Disappointed that most had not been informed beforehand of our visit and administration had made no plans for us to meet with Taupulega

On Fakaofo, we met with Taupalega on the first visit and the Pulunuku twice on the last trip. Key points were similar to those at Nukunonu with key interests being:

- Need to ensure improved biosecurity
- Keen to enhance rat control measures, e.g. best ways for total rat removal from key motu
- Interested in advice for sustaining harvest of oga and birds
- Interested in getting advice and help with agricultural pest issues, e.g. rhinoceros beetle, whitefly
- Ways of minimising Lakia impacts on water quality.

11. DISCUSSION AND RECOMMENDATIONS

The Tokelau atolls support ecosystems and species of high conservation value in their own right. They also provide an important link with other archipelagos including the Phoenix Islands to the north, the Cooks and Line Islands to the east and Samoan region to the south. The islands provide stepping stones for migratory marine and terrestrial species between the Samoan region and the Phoenix Islands and beyond. A number of threatened or significant species (e.g. Tiafee and Kaleva) depend on the presence of viable ecosystems in the Tokelau. Somewhat surprisingly, at least six species of seabird have recovered at the Tokelau over the past few decades, consistent with lower hunting pressure and some localised predator management.

As well as this the Tokelau have sustained a human population for hundreds or thousands of years and with appropriate management of threats the islands can continue to do so into the future. Threats to the recovery of ecosystems and species and the sustainable use of biota include impacts of invasive species, climate change and direct human impacts such as unsustainable development. Addressing these issues are paramount to the continued recovery of species and ongoing use of biota by the residents. In the short term urgent attention is needed to manage the impacts of existing invasives and to prevent further invasives from arriving. Together with this, the exploitation of some key biota species needs to be regulated in a more tightly way and monitored.

One tactical management approach that would be useful at Tokelau would be to nurture key biodiversity areas where the values are currently higher than elsewhere in the group and where opportunities for biota recovery are highest. Currently there is a marine conservation area at Fakaofo, but this is in a geographically different area to the highest terrestrial values at that island. The terrestrial biodiversity hotspots identified for each of the atolls in Section 4 could be improved by eradicating rats, cats and pigs in those areas, and having internal biosecurity to prevent other invasives (e.g. Wedelia, YCAs, pigs, cats, etc) from accessing or being taken to those areas, and by imposing a no-take on birdlife.

Overall we provide the following key recommendations:

- Revise and implement the National Biosecurity Guidelines to maintain effective biosecurity at source areas (especially Apia), en route to Tokelau and at the atolls. Focus on the highest risks e.g. ensure the wide suite of other potential invasives (e.g. Norway and black rat, African snail, more invasive ants, weeds, alien birds, etc) do not arrive

- With the help of CEPF funding, develop a biosecurity action plan to address the above biosecurity needs and work closely with agencies such as SPC, Samoa Quarantine, SPREP and MFAT to implement the plan

- With the help of CEPF funding, develop and implement an action plan to deal with existing invasives at Tokelau, including YCAs, rats, pigs, cats, mynas and weeds which are impacting on biota. Some of this will simply involve redirecting of effort and refining of methods as outlined in Section 10

- In developing action plans for invasive species, pay particular regard to protecting the key biodiversity hotspots (refer Figs 4.3-4.5) as well as overall island biosecurity

- For agricultural pest work closely with SPC

- Invasives action plans may require some research and trial work, for example to refine methods of control for YCAs prior to addressing management at e.g. Atafu; also developing a better understanding of the impacts of YCAs on specific biota such as ground-nesting terns. Tokelau staff should also collect some supplementary information on the rats present at Fakaofo and the changing behaviour and distribution of mynas at Tokelau, the latter through direct observations and encouraging reporting of sightings from local residents.

- Implement rules to prohibit or limit harvest of key sensitive species notably turtles, Oga (coconut crab), Tavake (red-tailed tropicbird), Katafa (frigatebirds), Takupu (red-footed booby) and Talagogo (sooty tern) and monitor their populations. It is possible that some of these species could be harvested sustainably in the future, but they need to undergo a recovery first. It is important to never kill breeding adults as these are the source of future generations of their species.

- If birds need to be harvested, this could be achieved sustainably for Lakia and Gogo if carefully planned and implemented. Local targeting of Lakia and Gogo is possibly the best interim approach to minimise water catchment contamination along with severe pruning of breadfruit trees. They favoured *ulu eleha* (Elice Islands' breadfruit) as opposed to the Samoan strain both of which were growing in Fale.

- For all environmental management work (e.g. rat baiting) keep good records of what was undertaken, when, where, by whom, and what the outcome was all of which will contribute to improved knowledge of effective management

- Implement an active programme to control rubbish disposal which should include a public awareness programme

- Ensure that qualified ecologists undertake an assessment of environmental effects is for the proposed runway at Nukunonu and any other future development proposals

It is proposed that further work at Tokelau will target action plans for biosecurity and environmental management, including invasives management and protecting sensitive fauna. Once these plans are finalised it is expected that funding will be able to be achieved more readily for the management implementation phases.

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- Atafu: Fala Iosefa (Director for Taupulega Office), Luisa Naseri-Sale (Environment Officer who also provided translation of executive summary), Kele Kalolo (Minister of Environment), Ege (Quarantine officer, Tene Aluia (our boat operator);
- Nukunonu: Zak Patelesio (contact and accommodation), Pio (Faipule), Mika Perez (Director of Environment), Viane and Tino, Ruevita Esekielu and Liliy (boat operators);
- Fakaofo: Foua Toloa (Ulu), Mose Pelasio (Environment contact), Alatina Mana and Tofiga Teao (Quarantine officers).
We thank staff of CEPF/CI and PII for their support of this project.

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Appendix 1 – Who's who for Tokelau conservation survey

Position	Key roles	Key personnel
Project Manager	• Overall project responsibility • Planning with Tokelau and specialists • Purchase equipment, etc • Bird/pest surveys • Reporting	Ray raypierce@bigpond.com ph +61 740930784 Samoa 20-23/ Sept 7504992
Director for Economic Development, Natural Resources & Environment	• Ray's first point of contact for Tokelau project • Responsible for assigning Tokelau staff for project tasks	Pouvave Fainuulelei, Director Economic Devpt, Natural Resources and Envt pouvave@hotmail.com +685 20822
Tokelau survey counterparts	• Facilitate local Tokelau involvement and logistics as instructed by Director and meeting needs of operational plan	Luisa Naseri-Sale lnaseri.sale@tokelau.tk with support of Feleti Tulafono tkvms@clear.net.nz
Minister of Transport	• MV Tokelau timetable and vessel logistics	Makalio Ioane, Tokelau Admin maka@lesamoa.net +685 7771807
Fakaofa coordination	• Faipule	Foua Toloa
	• Pulenuku (mayor)	Tinielu Tuumuli
	• Coordinator for Taupulega Office and main contact on atoll	Hina Puka-Tuia (main contact)
	• Pouvave's team members on atoll	Mose Pelasio (Policy Advisor), Feleti Tulafono (VMS Officer)
Nukunonu coordination	• Faipule	Pio Tuia
	• Pulenuku	Lino Isaia
	• General Manager for Taupulega Office - Main contact on atoll	Zak Patelesio
Atafu coordination	• Faipule	Kuresa Nasau
	• Pulenuku	Nouata Tufoua
	• Director for Taupulega Office – Main contact on atoll	Fala Iosefa
	• Pouvave's team member on atoll	Luisa Naseri-Sale (Environment Officer)
Pest vertebrate surveyor	• Survey rodents, cats, mynas etc • Collect field data • Capacity building local staff	Mere Valu, BirdLife mere@birdlifepacific.org.fj
Biosecurity, weeds,	• Project biosecurity	Ray Pierce

plants	• Survey and map plants • Capacity building local staff	Art Whistler
Pest invertebrate surveyor	• Yellow crazy ant distribution • Other IAS invertebrate risks • Capacity building local staff	Specialist, Monica Gruber and assistant Allan Burne Monica.Gruber@vuw.ac.nz
CI advisor	• Planning advice • Provisional field participation and GIS mapping	James Atherton, CI jatherton@conservation.org
PII advisor	• Planning advice	Souad Boudjelas, Bill Nagle s.boudjelas@auckland.ac.nz
Logistics support	• Coordinator Apia • Other general organisational tasks as agreed with the Project Mger	Ailani Tanielu

Appendix 2 - Tokelau bird names

Tokelau name	Species name	English name	Abbn	Family
Tangiuoua	*Puffinus pacificus*	Wedge-tailed shearwater	WTSW	Procellaridae
-	*Puffinus nativitatis*	Christmas shearwater	CXSW	Procellaridae
Tavake-ulu-gula	*Phaethon rubricauda*	Red-tailed tropicbird	RTTB	Phaethontidae
Tavake-ulu-puka	*Phaethon lepturus*	White-tailed tropicbird	WTTB	Phaethontidae
Hakea	*Sula dactylatra*	Masked booby	MABO	Sulidae
Fuakoo	*Sula leucogaster*	Brown booby	BNBO	Sulidae
Takupu	*Sula sula*	Red-footed booby	RFBO	Sulidae
Katafa Gogo	*Fregata minor*	Great frigatebird	GRFR	Fregatidae
Katafa-koti	*Fregata ariel*	Lesser frigatebird	LEFR	Fregatidae
Matuku	*Egretta sacra*	Pacific reef heron	PRHE	Ardeidae
Talagogo	*Sterna fuscata*	Sooty tern	SOTO	Sternidae
Tovivi	*Sterna sumatrana*	Black-naped tern	BNTE	Sternidae
Gogo	*Anous stolidus*	Brown noddy	BNNO	Sternidae
Lakia	*Anous minutus*	Black noddy	BKNO	Sternidae
Akiaki	*Gygis alba*	White tern	WHTE	Sternidae
Tuli	*Pluvialis fulva*	Pacific golden plover	PGPL	Charadridae
Kolili	*Heteroscelus incanus*	Wandering tattler	WATA	Scolopacidae
Tiafee	*Numenius tahitiensis*	Bristle-thighed curlew	BTCU	Scolopacidae
Vaha-vaha	*Arenaria interpres*	Ruddy turnstone	RUTU	Scolopacidae
Lupe	*Ducula pacifica*	Pacific pigeon	PAPI	Columbidae
Kaleva	*Eudynamis taitensis*	Long-tailed koel	LTKO	Cuculidae

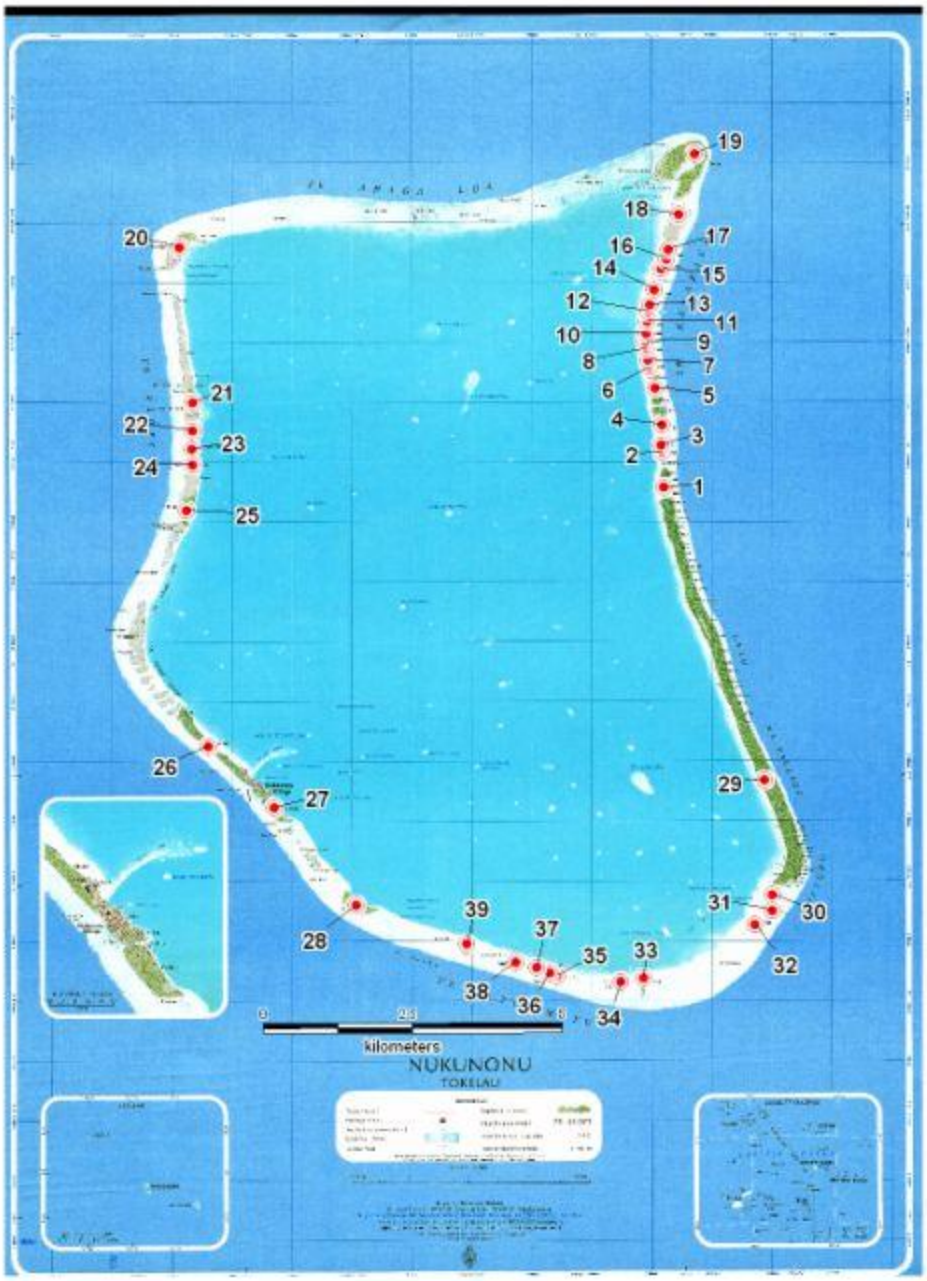
Appendix 3 - General Itinerary September-October 2011 and January 2012

Date	Activities
September-October 2011	
20-22	Team arrives in Apia, meeting with Joe (Tokelau GM) 22nd
23	Depart Apia on Lady Naomi 9 am, seabird transects all day
24	Arrive FK and spend 1000-1700 h ashore on Fale in meetings and discussions with Taupulega and staff; field surveys; depart for NN 1800 h
25	Arrive NN 0700; departed for AT 1400 h, seabird transects throughout day
26	Arrive AT 0800 h; met by our contact Fala, Liutu (Chair of Taupulega), Keli (Minister and Faipule); discussions with Taupulega; began surveys 1000 h
27	Continued surveys using Tene our boatman to cover southern motu
28	More surveys of SE motu with Tene; evening fly-on and camp-out at Hakea
29	Taupulega meeting morning and lunch discussions, meeting with Ege Etueni? pm. Surveyed and rat-trapped Village Motu; ant and seabird surveys
30	James and Art leave on MV Tokelau for Apia. Survey of terns/noddies and related productivity to YCA presence/absence
1-2	Continue ant and seabird surveys and discussions with staff
3	Taupulega meeting and discussion of key findings; several questions each way; team departs for NN on Samoan Express in evening
4	Arrive NN 0700 h; meet with Zac and Mika Perez (new Director Environment); Mere departs via FK for Apia on Samoan Express.
5	Meetings to secure boat services; ant and bird surveys Village Motu
6	Begin surveys eastern motu with boatmen Viane and Tino
7	Complete eastern motu surveys; Ray over-night on Tokelau Motu
8	Complete ant and biota surveys eastern motu and Te Puka
9	Attend Church service; ant pitfalls E motu; complete surveys Whenualoa-S motu
10	Collect ant samples; complete surveys of W motu; evening village party
11	Data analysis and report day, discussions with key people; paid boatmen, etc
12	Data analysis and reports, surveys of NN motu
13	Final NN surveys
14	Meetings with NN Taupulega and others
15	Depart NN on MV Tokelau; meetings ashore FK; depart to Apia late afternoon
16	MV Tokelau en route to Apia, seabird transects, arrive Apia 9 pm
17	Meetings and debriefs with Tokelau admin in Apia
18	Travel to NZ/Australia
January 2012	
12-13	RP travel to Apia; meet with Tokelau and CI staff
14-15	Travel to FK on MV Tokelau; seabird transects
16	Briefings with FK Pulenuku, survey Fenua Fala
17	Boat-based survey of outer motu
18	Follow up ant collections at Fenua Fala; debrief Pulunuku; depart for Apia
19	Seabird transects from MV Tokelau en route to Apia
20-21	Debriefs with Tokelau admin, CI/CEPF, UNEP
22-23	Travel to Australia

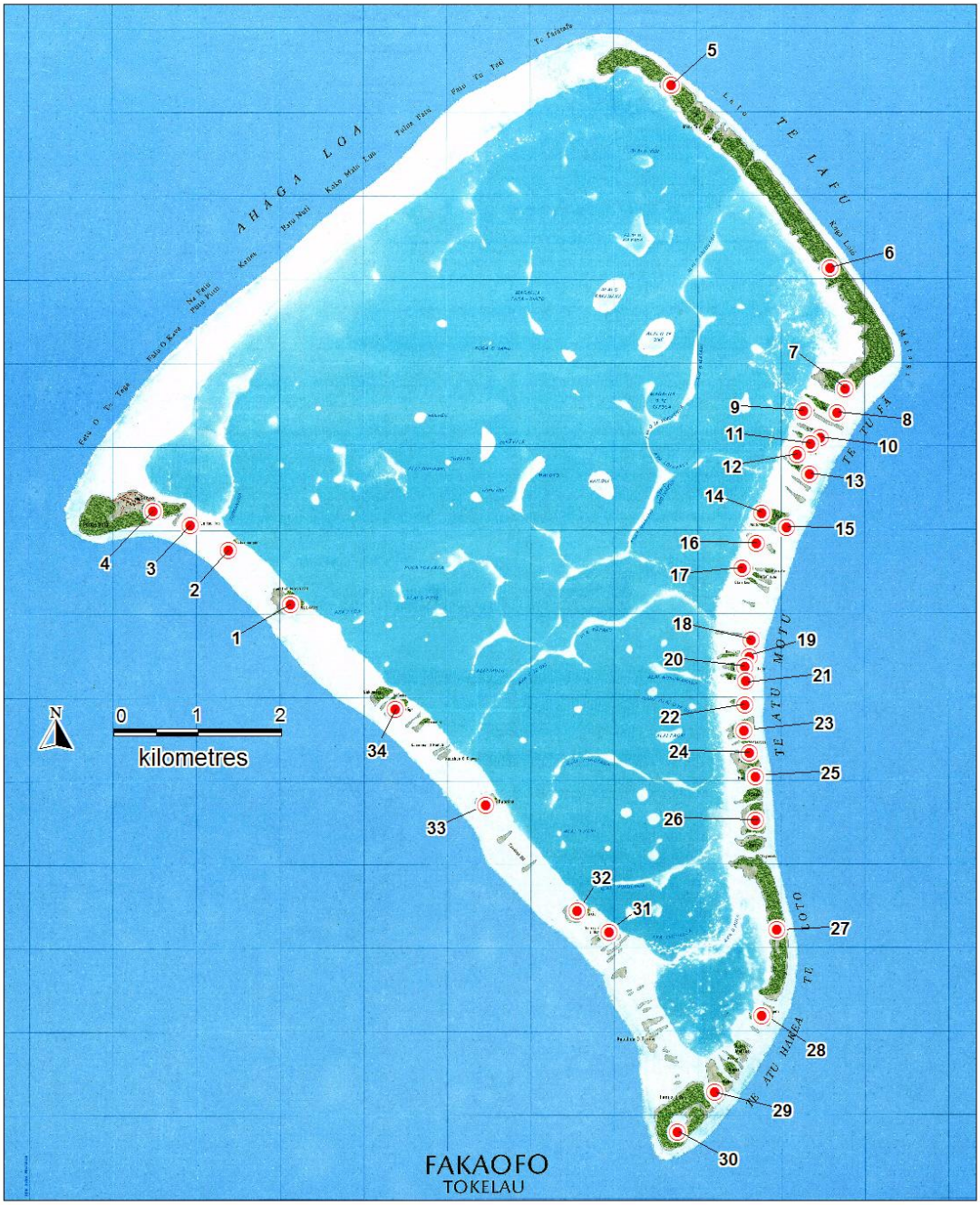
Appendix 4 – Locations of surveyed motu

Atafu Location Map Showing Survey Locations

Nukunonu survey locations



Fakaofo Location Map Showing Survey Locations



Appendix 5 – Summary of data collected – motu as per Appendix 4

Atafu Atoll – summary sheet Sept 2011

Motu #	1	2	3	4	5	6	7	8	9
Date	26-1	26/9	26/9	27/9	27/9	27/9	27/9	27/9	27/9
Time start	-	1030	1300	1030	1030	1050	1120	1130	1230
Area									
Habitat(1)	Vill C Pi Pa Co	C	C	-	C T G Pa Pe	C T G Pa Pe	C T Pi	C T Pi Pe	C Pe G
LT Channel(2)	100+	0	0	0	40	30	30	30	30
Visitation (3)	H	M	M	M	L	L	L	L	M
Dwellings (4)	P	S	S	S	0	0	0	0	S
Invasives									
Pacific rats	Y	Y	Y	Y	Y	Y	Y	?	Y
YCAs	Y	N	N	N	N	N	N	N	N
Wedellia	Y	N	N	N	N	N	N	N	N
Indigenous biota – individuals or as stated e.g. p = pairs									
Lizards	SES	SES	SES	BTS	-			SES	
Butterflies	Meadow argus present on most motu								
Coconut crab	Y	Y	Y	x	-			Y	Y
Tupa	Y	Y	Y	x	-			Y	Y
Hermit crab	Y	Y	Y	x	-				
RTTB	0	0	1	x	-			2	
WTTB	0	0	0	x	-				
RFB	0	0	0	x	0	0	0	27pB	
MABO	0	0	0	x	-				
BRBO	0	0	0	x	-				
GRFR	0	1	0	x	-			3R	
LEFR	Y	20	50	x	180R		Y	100R	
EREH	2+	4	3	x	-				
PGPL	30+	2	1	x	-				
WATA	P	5	3	x	-				
BTCU	P	1	1	x	-				
RUTU	P	1	2	x	-				
BKNT	5+	1	10	x	2A			12B	
SOTE	0	3	0	x	-				
BRNO	**Y**	**Y**	**Y**	x	**Y**	**Y**	Y		**Y**
BKNO	**Y**	**Y**	**Y**	x	**Y**	**Y**	**Y**		**Y**
WHTE	**Y**	**Y**	**Y**	x	**Y**	**Y**	**Y**		**Y**
PAPI	1+	1	1	x	-				
Others: turtle		2 nests		x	-				

Notes: 1. Habitat – dominant habitat BC = bare coral, C = coconut, Cem = cemetery, Co = Cordia, Gu Guettarda, Pa = Pandanus, Pe = Pemphis, Sc = *Scaevola*, To = Tournefortia, vill = village
2. LT channel = estimated distance of open water at low tide (m) from previous numbered motu
3. Human use – estimated low medium high visitation by locals, dwellings permanent (P) and seasonal (S)
4. Invasives and indigenous; - = not surveyed ashore, Y = present, **Y** = confirmed bird breeding, p = pairs, Re = reported, Ro = roosting. BTS = blue-tailed skink, SES = snake-eyed skink,

Atafu Atoll – summary sheet Sept 2011(2)

Motu #	10	11	12	13	14	15	16	17
Date	27/9	27/9	27/9	27/9	27/9	27/9	27/9	27/9
Time start	1300	1320	1350	1410	1430	1500	1520	1525
Area								
Habitat(1)	C Pe S Co Pi	C Pi Co	C Co Pi	C Pa Pi Co	C Co Pa	C Co Pi	C Pi	C Pa Pe
LT Channel(2)	60	0	30	80	90	150	150	30
Visitation (3)	M	M	M	M	M	M	L	L
Dwellings (4)	S	0	0	0	0	0	0	0
Invasives								
Pacific rats	N?	N?	N?	N?	Y	Y	?	?
YCAs	N	N	N	N	N	N	N	N
Other	N	N	N	N	N	N	N	N
Lizards	0	SES	0	0	SES	SES	0	0
Butterflies	Meadow argus present on most motu							
Coconut crab	Y	Y	Y	Y	Y	Y		
Tupa	Y	Y	Y	Y	Y	Y	Y	Y
Hermit crab	Y	Y	Y					
RTTB	0	0	0	0	0	0	0	0
WTTB	0	0	0	0		1	0	0
RFB	12pN	57pN	42pN	8pN	2pN	2pN	0	0
MABO	0	0	0	0	0	0	0	0
BRBO	0	0	0	0	0	0	0	0
GRFR	0	0	0	0	0	0	0	0
LEFR	0	0	0	0	0	0	0	0
EREH	1	3	0	0	0	0	0	0
BLRA	0	0	0	0	0	0	0	0
PGPL	0	0	0	0	0	1	0	0
WATA	0	0	0	0	0	1	0	0
BTCU	0	0	0	0	1	0	0	0
RUTU	3	0	0	0	1	0	0	0
BKNT	6ad	0	0	0	0	0	0	0
SOTE	0	0	0	0	0	0	0	0
BRNO	0	Y	0	0	0	0	0	0
BKNO	0	**Y**	0	**Y**	**Y**	**Y**	**Y**	**Y**
WHTE	**Y**	**Y**	0	**Y**	**Y**	**Y**	**Y**	**Y**
PAPI	0	0	0	0	0	0	0	0
Others: turtle	0	0	0	0	0	0	0	0

Atafu Atoll – summary sheet Sept 2011(3)

Motu #	18	19	20	21	22	23	24	25
Date	27/9	27/9	27/9	28/9	28/9	28/9	28/9	28/9
Time start	1540	1600	1620	1600+	1530+	1500+	1430+	1400+
Area								
Habitat(1)	C Pi	C Pi S	C Co Pe	C Gu Pi Co	C Pe Sc	C T Pi	C Gu Pe	C Co Sc To Pa Pi Pe
LT Channel(2)	30	100+	80+	20	1000	0	0	0
Visitation (3)	L	L	L	M	M	M	M	M
Dwellings (4)	0	0	0	1	1	0	1	1
Pacific rats	Y	?	?	Y?	N	?	?	Y
YCAs	N	N	N	N	N	N	N	N
Other	N	N	N	N	N	N	N	N
Lizards	0	0	0	SES	0	SES	SES	SES
Butterflies	Meadow argus present on most motu							
Coconut crab	0	0	0	Y	Y	Y	Y	?
Tupa	Y	Y	Y	Y	Y	Y	Y	Y
Hermit crab	0	0	0	Y	Y	Y	Y	Y
RTTB	0	0	0	0	0	0	0	0
WTTB	0	0	0	0	0	0	0	0
RFB	0	0	0	0	0	0	0	4D
MABO	0	0	0	0	0	0	0	0
BRBO	0	0	0	0	0	0	0	0
GRFR	0	0	0	0	0	0	0	0
LEFR	0	0	0	0	0	0	0	0
EREH	0	1	1	0	0	2 di	0	3dww
BLRA	0	0	0	0	0	0	0	0
PGPL	0	0	0	0	0	2	0	2
WATA	0	0	1	1	0	0	2	3
BTCU	0	0	1	0	0	0	1	0
RUTU	0	0	0	0	0	0	2	3
BKNT	0	0	**3pB**	0	1	4	0	4
SOTE	0	0	0	0	0	0	0	0
BRNO	0	0	0	**Y**	0	**Y**	0	**Y**
BKNO	**Y**	**Y**	0	**Y**	0	**Y**	0	**Y**
WHTE	**Y**	**Y**	0	**Y**	0	**Y**	0	**Y**
PAPI	0	0	0	2	0	2+	0	1
Others: turtle	0	0	0	2 nests	0	0	1	0

Nukunonu Atoll – summary sheet Oct 2011

Motu #	1	2	3	4	5	6	7	8	9
Date	6/10	6/10	6/10	6/10	6/10	6/10	6/10	6/10	6/10
Time start	1030	0940	1000	1140	1200	1230	1240	1300	1320
Area									
Habitat(1)	C To Sc Gu Pa	C To Sc Gu Pa	C To Sc	C, No To Sc Gu Pa	C To Sc Gu Pa	C To Sc Gu Pa	C To Sc Gu Pa	To Sc Gu Pa	C To Sc Gu Pa
LT Channel(2)	-	40	0	60	50	80	60	50	30
Visitation (3)	L	L	L	L	L	L	L	L	L
Dwellings (4)	0	0	0	0	0	0	0	0	0
Invasives									
Pacific rats	Y	Y	Y	?	Y	Y	Y	Y	Y
Cat	Y	N	N	N	N	N	N	N	N
YCAs	Y	Y	N	Y	N	N	N	N	N
Wedellia	N	N	N	N	N	N	N	N	N
Indigenous biota – individuals or as stated e.g. p = pairs									
Lizards	Snake-eyed skink present on most motu								
Butterflies	Meadow argus present on most motu								
Coconut crab	Sign seen on a few motu								
Tupa	Seen a few motu								
Hermit crab	Not recorded								
RTTB	0	0	0	0	0	0	0	0	0
WTTB	0	0	0	0	0	0	0	0	0
RFB	0	0	0	1	0	0	0	0	0
MABO	0	0	0	0	0	0	0	0	0
BRBO	0	0	0	0	0	0	0	0	0
GRFR	0	0	0	0	0	0	0	0	0
LEFR	0	0	0	0	0	0	0	0	0
EREH	0	1	0	0	1	0	0	0	0
PGPL	0	0	0	0	1	0	0	0	0
WATA	0	2	0	0	3	0	0	0	2
BTCU	0	1	0	0	3	0	0	0	1
RUTU	0	0	0	0	0	0	0	0	0
BKNT	0	1	2	15B	0	0	8B	0	0
SOTE	0	0	0	0	0	0	0	0	0
BRNO	0	B	0	B	B	0	P	0	B
BKNO	0	B	0	B	B	0	0	0	B
WHTE	0	B	0	B	B	0	B	B	B
PAPI	0	0	0	0	0	0	0	0	0
Others: turtle	0	0	0	0	0	0	0	0	0

Notes: 1. Habitat – dominant habitat BC = bare coral, S = *Scaevola* etc scrub, F = indigenous forest, CP = coconut plantation

2. LT channel = distance of open water at low tide (m)

3. Human use – estimated low medium high visitation by locals, dwellings permanent (P) and seasonal (S).

Motu names – 1. Lalo; 2. Te Fala; 3. Tagamaka; 4. Te Nonu; 5. Pukapuka; 6. Vaivaimai; 7.Te Kawakawa 1; 8. Te Kawakawa 2; 9 Te Kawakaw 3.

Nukunonu Atoll summary sheet (2)

Motu #	10	11	12	13	14	15	16	17	18
Date	6/10	6/10	6/10	6/10	6/10	7/10	7/10	7/10	7/10
Time start	1340	1355	1415	1425	1445	1250	1320	1345	1400
Area									
Habitat(1)	C To Sc Gu	C To Sc Gu	C To Sc		C Sc Pa Pi	C Sc Pa To	C To Sc Gu Pa	C To Sc Gu Pa	C Sc Gu Pa
LT Channel(2)	40	50	150	20	150	200	50	0	500
Visitation (3)	L	L	L	L	L	L	L	L	L
Dwellings (4)	0	0	0	0	0	0	0	0	0
Invasives									
Pacific rats	Sign detected on some								
Cat	No sign detected								
YCAs	N	N	N	N	N	N	N	N	N
Widellia	Nil								
Indigenous biota – individuals or as stated e.g. p = pairs									
Lizards	Snake-eyed skink present on most motu								
Butterflies	Meadow argus present on most motu								
Coconut crab	Possible sign seen on a few motu								
Tupa	Seen a few motu								
Hermit crab	Few recorded								
RTTB	0	4	1	0	4	1	3	2	0
WTTB	0	0	0	0	0	0	0	0	0
RFB	0	1	0	0	0	0	0	0	0
MABO	0	0	0	0	0	0	0	0	0
BRBO	0	0	0	0	0	0	0	0	0
GRFR	0	0	0	0	0	0	0	0	0
LEFR	0	0	0	0	0	0	0	0	0
EREH	1	0	0	0	1	0	0	2	0
PGPL	0	1	0	0	0	0	0	0	0
WATA	0	0	0	0	0	0	0	0	0
BTCU	0	2	0	0	0	0	0	0	0
RUTU	0	0	0	0	0	0	0	2	0
BKNT	0	0	3	20	2	26	0	0	6
SOTE	0	0	0	0	0	0	0	0	0
BRNO	0	0	0	0	0	0	Y	Y	Y
BKNO	0	0	0	0	0	0	Y	0	0
WHTE	0	0	0	0	0	0	Y	Y	Y
PAPI	0	0	0	0	0	0	0	0	0
Others: turtle	0	0	0	0	0	0	0	0	7 nests

Nukunonu –summary sheet Sept 2011 (3)

Motu #	26/27	19	28	20	21	22	23	24	25
Date	4-10	6-7		10/10	10/10	10/10	10/10	10/10	10/10
Time start	-	-		1300	1400	1440	1500	1520	1530
Area									
Habitat(1)	C Pi Pa Gu To	C Pi P Gu Sc		C Pa Pi Gu Sc To No Pe	C Pa Pi Gu Sc To No Pe	C Pa To Sc Gu Pe Pi	C Pa Pe Gu Sc	C Pe Sc Cas	C Gu Sc No
LT Channel(2)	1500	500		2000	200	0	0	0	0
Visitation (3)	H	M		M	M	L	L	L	M
Dwellings (4)	c.100	0		0	0	0	0	0	0
Pacific rats	YY	N	Y	Y	Y	Y	Y	Y	?
Cats	Y	Y	N	N	N	N	N	N	N
YCAs	Y	N	N	N	N	N	N	N	N
Widellia	Y	N	N	N	N	N	N	N	N
Pigs	N	N	Y	Y	Y	Y	Y	Y	Y
N									
Lizards	SES	SES BTS		-	SES	-	-	-	-
Butterflies	Orchard throughout								
Coconut crab	N	Y		N	N	0	0	0	0
Tupa	N	Y		N	N	0	0	0	0
Hermit crab	Y	Y		N	N	0	0	0	0
RTTB	0	0		0	0	0	0	0	0
WTTB	0	2		1	0	0	0	0	0
RFB	0	40+		0	0	0	0	0	0
MABO	0	0		0	0	0	0	0	0
BRBO	0	0		0	0	0	0	0	0
GRFR	0	0		0	0	0	0	0	0
LEFR	0	28		0	0	0	0	0	0
EREH	5	3+		1	0	0	0	0	1
PGPL	2	2		0	0	0	0	0	1
WATA	3	2		1	0	0	0	0	1
BTCU	2	2		1	0	0	0	0	1
RUTU	2	2		0	0	0	0	0	0
BKNT	0	2		1p	1p	1p	0	0	1p
SOTE	0	1800p		0	0	0	0	0	0
BRNO	B	B		B	P	P	B	0	0
BKNO	B	B		B	0	0	0	0	0
WHTE	B	B		B	B	B	B	0	P
PAPI	0	0		0	0	0	0	0	0
Others: turtle	0	0		0	0	0	0	0	0

Nukunonu – summary sheet (4)

Motu #	29	30	31	32	33	34	35	36	37	38	39
Date	9/10	9/10	9/10	9/10	9/10	9/10	9/10	9/10	9/10	9/10	9/10
Time start	1330	1400	1420	1435	1450	1520	1535	1550	1610	1630	1645
Area											
Habitat(1)	C Pi Pa Co Sc To Gu	C Pi Pa Co Sc To Gu	Pe	C Pa Sc To Gu	C Pa Sc To	C Gu Sc Pa	C Pa Pi Sc To	C Gu Pa Pi Sc To	C Gu Pa Sc To	C Gu No Pa Sc To	C Gu Pa Pi Sc To
LT Channel(2)	-	40	200	100	1000	30	200	200	50	500	300
Visitation (3)	M	M	L	L	M	M	M	M	M	M	H
Dwellings (4)	0	0	0	0	0	0	0	0	1	0	1
Pacific rats	Y	Y	-	Y	Y	Y	?	?	?	?	Y
Cats	Y	N	-	N	N	N	N	N	N	N	N
YCAs	N	N	-	N	Y	N	N	N	N	N	Y
Pigs	Y	N	-	N	N	N	N	N	N	N	Y
Chicken	N	N	-	N	N	N	N	N	N	N	Y
Widellia	N	N	-	N	N	N	N	N	N	N	N
Lizards	SES BTS	SES	-	0	0	0	0	0	0	0	SES
Butterflies	Orchard throughout										
Coconut crab	P	P	-	0	0	0	0	0	0	0	0
Tupa	P	0	-	0	0	0	0	0	0	0	0
Hermit crab	P	P	-	P	P	P	P	P	P	P	P
RTTB	0	0	0	0	0	0	0	0	0	0	0
WTTB	0	1	0	0	0	0	0	0	0	0	1
RFB	500+	200=	0	0	0	0	0	0	0	0	0
MABO	0	0	0	0	0	0	0	0	0	0	0
BRBO	10=	20=	0	0	0	0	0	0	0	0	0
GRFR	1+	3	0	0	0	0	0	0	0	0	0
LEFR	100+	160+	0	0	0	0	0	0	0	0	0
EREH	0	0	0	0	2	0	0	0	0	1	3
PGPL	0	0	0	0	0	0	0	0	0	0	3
WATA	0	0	0	0	0	0	0	0	0	0	2
BTCU	0	0	0	0	0	0	0	0	0	0	0
RUTU	0	0	0	0	0	0	0	0	0	0	2
BKNT	0	0	16	4	1	1P B	2P B	1	1P	0	1
SOTE	0	0	0	0	0	1	0	0	0	0	0
BRNO	B	B	150	0	P	0	P	P	0	P	B
BKNO	B	B	0	0	0	0	0	0	0	0	B
WHTE	B	B	0	P	B	0	P	P	P	P	B
PAPI	1	0	0	0	0	0	0	0	0	0	0
Others: turtle	0	0	0	P	0	0	0	0	0	0	0

Fakaofo Atoll – summary sheet January 2012

Motu #	1	2	3	4	5	6	7	8	9
Date	16-18	17	17	16-18	17	17	17	17	17
Time start	-	-	-	-	0935	1025	1045	1115	1125
Area									
Habitat(1)	Vill C Bf	C Cem	C	C Pa Gu Pe To Co	C Pa Gu Pe Sc To Co	C Pa Gu Pe Sc To Co	C Pa Gu Pe Sc To Co	C Co	C Co Pa
LT Channel(2)	-	100	100	100+	1000+	20	20	100	50
Visitation (3)	H	H	H	H	L	L	L	L	L
Dwellings (3)	P	0	P	P	S	0	0	0	0
Invasives (4)									
Pacific rats	Y	-	-	Y	Y	-	-	-	-
YCAs	Y	Re	Re	Y	Y	-	-	-	-
Widellia	Y	-	-	Y	N	-	-	-	-
Indigenous biota – individuals or as stated e.g. p = pairs									
Lizards	SES	-	-	SES BTS	SES	-	-	-	-
Butterflies	Wet weather during survey								
Coconut crab	N	-	-	-	Y	-	-	-	-
Tupa	N	-	-	Y	Y	-	-	-	-
Hermit crab	Y	-	-	Y	Y	-	-	-	-
RTTB	0	0	0	0	0	0	0	0	0
WTTB	0	0	0	0	0	0	0	0	0
RFB	0	0	0	0	**100+p**	0	0	10	0
MABO	0	0	0	0	0	0	0	0	0
BRBO	0	0	0	0	0	0	0	0	0
GRFR	0	1	0		0	0	0	2	0
LEFR	0	0	0	0	0	0	Y	110Ro	0
EREH	3+	4	3	2	0	0	0	0	0
PGPL	30+	2	1	Y	0	0	0	0	0
WATA	Y	5	3	Y	Y	0	0	0	0
BTCU	Y	1	1	0	0	0	0	0	0
RUTU	Y	1	2	Y	0	0	0		0
BKNT	5+	1	10	2	2	0	0	0	0
SOTE	0	3	0	0	1	0	0	0	0
BRNO	**Y**	**Y**	**Y**	**Y**	**Y**	Y	Y	Y	0
BKNO	**Y**	**Y**	**Y**	**Y**	**Y**	Y	Y	Y	0
WHTE	**Y**	**Y**	**Y**	**Y**	**Y**	Y	Y	Y	0
PAPI	-	-	-	-	-	-	-	-	-
Others: turtle	-	-	-	-	-	-	Re	-	-

Fakaofo Atoll – summary sheet Jan 2012 (2)

Motu #	10	11	12	13	14	15	16	17
Date	17	17	17	17	17	17	17	17
Time start	1130	1140	1145	1150	1155	1200	1200	1212
Area								
Habitat(1)	C Co Pi	C Pa Gu	C Gu Pa	C Gu Sc	C Gu Pa Sc	C Gu Pa	C	C Pa Gu
LT Channel(2)	150	50	50	50	500+	30	100	200
Visitation (3)	L	L	L	L	L	L	L	L
Dwellings (4)	S	0	0	0	0	0	0	0
Invasives								
Pacific rats	-	-	-	-	-	-	-	-
YCAs	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-
Lizards	-							
Butterflies	-							
Coconut crab	-	-	-	-	-	-	-	-
Tupa	-	-	-	-	-	-	-	-
Hermit crab	-	-	-	-	-	-	-	-
RTTB	0	0	0	0	0	0	0	0
WTTB	0	0	0	0	0	0	0	0
RFB	**50+p**	0	0	0	0	0	0	0
MABO	0	0	0	0	0	0	0	0
BRBO	0	0	0	0	0	0	0	0
GRFR	0	0	0	0	0	0	0	0
LEFR	0	0	0	0	0	0	0	0
EREH	0	0	0	0	0	0	0	0
BLRA	0	0	0	0	0	0	0	0
PGPL	0	0	0	0	0	0	0	0
WATA	0	0	0	0	0	0	0	0
BTCU	0	0	0	0	0	0	0	0
RUTU	0	0	0	0	0	0	0	0
BKNT	0	4	0	0	4	0	0	0
SOTE	0	0	0	0	0	0	0	0
BRNO	Y	Y	Y	Y	Y	0	Y	Y
BKNO	Y	Y	0	Y	Y	0	0	0
WHTE	Y	Y	Y	Y	Y	0	0	Y
PAPI	-	-	-	-	-	-	-	-
Others: turtle	-	-	-	-	-	-	-	-

Fakaofo Atoll – summary sheet Jan 2012 (3)

Motu #	18	19	20	21	22	23	24	25
Date	17	17	17	17	17	17	17	17
Time start	1215				1230			
Area								
Habitat(1)	Pe	C Gu Pe	C Gu Pe	Co Gu Pe	C Pa Gu	C Pa Gu Pe	C Gu Pe	C Gu Pe
LT Channel(2)	200	300	50	20	100	100	50	20
Visitation (3)	L	L	L	L	L	L	L	L
Dwellings (4)								
Invasives								
Pacific rats	-	-	-	-	-	-	-	-
YCAs	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-
Lizards								
Butterflies								
Coconut crab	-	-	-	-	-	-	-	-
Tupa	-	-	-	-	-	-	-	-
Hermit crab	-	-	-	-	-	-	-	-
RTTB	0	0	0	0	0	0	0	0
WTTB	0	0	0	0	0	0	0	0
RFB	0	0	0	0	0	0	0	0
MABO	0	0	0	0	0	0	0	0
BRBO	0	0	0	0	0	0	0	0
GRFR	0	0	0	0	0	0	0	0
LEFR	0	0	0	0	0	0	0	0
EREH	1	0	0	0	1	0	1	0
BLRA	0	0	0	0	0	0	0	0
PGPL	0	0	0	0	0	0	0	0
WATA	0	0	0	0	0	0	0	0
BTCU	0	0	0	0	0	0	0	0
RUTU	0	0	0	0	0	0	0	0
BKNT	0	0	0	0	0	0	1	0
SOTE	0	0	0	0	0	0	0	0
BRNO	0	0	0	0	Y	Y	0	Y
BKNO	0	0	0	0	Y	Y	0	0
WHTE	0	Y	Y	Y	Y	Y	0	Y
PAPI	0	0	0	0	0	0	0	0
Others: turtle	0	0	0	0	0	0	0	0

Fakaofo Atoll – summary sheet Jan 2012 (4)

Motu #	26	27	28	29	30	31	32	33	34
Date	17	17	17	17	17	17	17	17	17
Time start	1245	1250	1300			1320			1340
Area									
Habitat(1)	C Pe Gu	C Gu Pe	C Co Pe	C Gu Pe	C Sc Gu	C To Pe	C Gu Co	C Gu Pa	C Gu Pa
LT Channel(2)	100	50	100	200	100	500+	200	500+	500+
Visitation (3)	L	L	L	L	L	L	L	L	M
Dwellings (4)									
Invasives									
Pacific rats	-	-	-	-	-	-	-	-	-
YCAs	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-
Lizards	-	-	-	-	-	-	-	-	-
Butterflies									
Coconut crab	-	-	-	-	-	-	-	-	-
Tupa	-	-	-	-	-	-	-	-	-
Hermit crab	-	-	-	-	-	-	-	-	-
RTTB	0	0	0	0	0	0	0	0	0
WTTB	0	0	0	0	0	0	0	0	0
RFB	0	0	0	0	0	0	0	0	0
MABO	0	0	0	0	0	0	0	0	0
BRBO	0	0	0	0	0	0	0	0	0
GRFR	0	0	0	0	0	0	0	0	0
LEFR	0	0	0	0	0	0	0	0	0
EREH	0	2	0	0	0	0	0	1	1
BLRA	0	0	0	0	0	0	0	0	0
PGPL	0	0	0	0	0	0	0	0	0
WATA	0	0	0	0	0	0	0	0	0
BTCU	0	0	0	0	0	0	0	0	0
RUTU	0	0	0	0	0	0	0	0	0
BKNT	3	0	0	0	0	3	0	0	3
SOTE	0	0	0	0	0	0	0	0	0
BRNO	Y	200+	Y	Y	500+	Y	Y	Y	Y
BKNO	Y	0	Y	Y	Y	0	Y	0	Y
WHTE	Y	Y	Y	Y	Y	Y	Y	Y	Y
PAPI	0	0	0	0	0	0	0	0	0
Others: turtle	-	-	-	-	Re	-	-	-	-

Appendix 6 – GPS points and motu names

1 - Atafu

No.	Motu name	Grid ref
1	Te Oki	8 32.301; 172 30.152
2	Laualalava	8 32.722; 172 29.234
3	Nau utua	8 32.442; 172 28.423
4	Te Olopuka	8 34.382; 172 28.304 pulaka pits
5		Hakea Islets east end
6		
7	Sakea o Lupo	8 34.310; 172 28.596 frigates
8	Sakea Lasi	8 34.348; 172 28.630 frigates 100+
9		8 34.469; 172 28.681
	Tangi a tu li	8 34.394; 172 28.717 camp
10		8 34.415; 172 28.793
11	Sakea o Simi	8 34.485; 172 28.832 7 traps
12	Tulua Kava	8 34.519; 172 28.844 4 traps
13		8 34.482; 172 28.911
14		8 34.497; 172 29.032 BTCU
15		8 34.618; 172 29.128
16		8 34.578; 172 29.256
17		8 34.576; 172 29.242
18	Kena Kena	8 34. 541; 172 29.322
19		8 34.659; 172 29.434
20		8 34.547; 172 29.573
c.8 motu between 20 and 21 were not visited		
21	Alofi laititi	8 34.078; 172 35.522 poaching
22	Tama sepo	Very small
23	Alofi lapoa	8 34.327; 172 35.542
24	Te puka	8 34.408; 172 30.361 green turtle
25	Fenua loa	8 34.938; 172 30.328
LA4	Northern Pisonia on S Whenua Loa	9 11.677; 171 46.463
LA5	2 trees FROM BOAT	9 11.929; 171 46.371
LA6	Tree FROM BOAT	9 12.057; 171 46.331
LA7	N tip of line	9 12.083; 171 46.319
LA7	S tip of line	9 12 .111; 171 46.304
LA8	N tip of line	9 12.178; 171 46.270
LA8	S tip of line	9 12.362; 171 46.218
LA9	2 trees	9 12.580; 171 46.214

2 - Nukunonu

No.	Motu name	Grid ref lat (S) and longitude (W)
MH1	Motuhaga	9 12.178; 171 50.747
MH2	Motuhaga	9 12.282; 171 50.704
MH3	Motuhaga	9 12.308; 171 50.646
NN2	Nukunonu 2	9 11.835; 171 51.142
NN1	Nukunonu 2	9 11.575; 171 51.412
TM1	Te Puka I mua	9 13.004; 171.50.045
TM2	Te Puka I mua	9 13.035; 171 50.002
LA2	Lalo	9 09.483; 171 47.213
LA!	Lalo	9 09.441; 171 47.233
TF1	Te Fala	9 09.291; 171 47.270
TF2	Te Fala	9 09.293; 171 47.261
TF3	Te Fala	9 09.231; 171 47.266
TN2	Te Nonu	9 08.772; 171 47.277
TN1	Te Nonu	9 08.719; 171 47.284
PK1	Pukapuka	9 08.504; 171 47.325
PK2	Pukapuka	9 08.451; 171 47.325
TP1	Te Palaoa	9 07.490; 171 47.349
TP2	Te Palaoa	9 07.465; 171 47.337
TO1	Tokelau	9 06.597; 171 47.098
TO2	Tokelau	9 06.493; 171 47.202

3 - Fakaofo

No.	Motu name	Grid ref
1	Fale	
2	Te afua tau tahi	
3	Te afua tau lui	
4	Fenua fala	9 22.445; 171 15.759
5	Mulifenua	9 19.635; 171 12.711
6	Te lafu	
7	Matangi	
8	Palea	
9	Olokolaga	
10	Otoka	
11	Kaivave	
12	Heketai	
13	Motuloa	
14	Motuakea	9 22.536; 171 11.805
15	Niue/Otafi	
16	Fugalei	

17	Otafi Lahi	
18	Vaigagie	
19	Nukuheheke	
20	Nukumahaga lahi	
21	Nukumahaga iti	
22	Teoko	
23	Vagai	
24	Vaiaha	
25	Falatutahi	
26	Te atu motu	
27	Teloto	
28	Motu	
29	Teatuhakea	
30	Fenualoa	
31	Kanafuoa	
32	Nukulokia	
33	Papaloa	
34	Patalego	

Appendix 7 - Daily totals for pelagic observations Samoa-Tokelau return September-October 2011 and January 2012

Transect leg	Ap-Fk	Fk	Nu-Fk	Fk-Ap	Ap-Sw	Sw-Fk	Fk-Sw	Sw-Ap
Date	26 Se	5 Oc	15-16 Oc	16 Oc	14 Jan	15 Jan	18 Jan	19 Jan
Hours	8	11	8	8	6.5	9.5	7	7
Obs	RP MV	MV	RP	RP	RP	RP	RP	RP
Mottled petrel			2	1				
Kermadec petrel			1					
White-necked petrel					1			1
Black-winged petrel			1					
Collared petrel				2				7
Gould’s petrel								1
Bulwer’s petrel						1		8
Wedge-tailed shearwater			1		11	7	5	117
Sooty shearwater	6		3					
Audubon's shearwater	2			2				4
Unidentified petrel		5						
Leach’s storm-petrel								3
Red-tailed tropicbird	1	1						
White-tailed tropicbird	2		1	2				
Masked booby								
Red-footed booby	20	46	38	13	2	8	9	270
Brown booby	1	2	1					2
Great frigatebird								1
Lesser frigatebird	3	11	4		2		1	5
Reef heron		1						
Pomarine skua						1		
Sooty tern	8	3		31	2	6	2	50
Bridled tern				2				7
Brown noddy	23	4	2	30	5	1		39
Black noddy	10	95	85	0	1			
White tern	25	85	76	19	3	14	12	104
Golden plover			3					
Ruddy turnstone		1						
Dolphin sp.					50+	c.50		
False killer whale					1			
Green turtle					1			
Floating debris					12	1		4

Appendix 8 – Plant report

THE FLORA AND VEGETATION

OF TOKELAU

by

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Report Prepared for Eco Oceania Pty. Ltd.

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1. INTRODUCTION

Tokelau is a small archipelago in the South Pacific Ocean at latitude 8–10º S and longitude 171–173º W, and lying about 580 km (360 mi) nearly due north of Samoa, east of Tuvalu, south of the Phoenix Islands, southwest of the more distant Line Islands, and northwest of the Cook Islands. It comprises three tropical coral atolls, Atafu in the northwest, Nukunonu in the southeast, and Fakaʻofo in the between (Fig. 1). These atolls have a combined land area (comprised of sand islets known as *motu*) of about 10.8 km^2 and a maximum elevation of about 5 m. A fourth island that is culturally, historically, and geographically, but not politically, part of the Tokelau chain is Swains Island (Olohega), under United States control since about 1900. Swains was claimed by the United States pursuant to the Guano Islands Act, as were the other three islands of Tokelau, but claims to the latter were relinguished by a treaty in 1979. In the draft constitution of Tokelau, subject to the Tokelauan self-determination referendum in 2006, Olohega is claimed as part of Tokelau, a claim surrendered in the same 1979 treaty that established a boundary between American Samoa and Tokelau. This report only includes work on the three main islands, but when Swains is included, it can be referred to as the Tokelau Archipelago rather than "Tokelau" the political entity.

The population of Tokelau was estimated to be about 1,400 in 2009, but many more now live in New Zealand, where they have citizenship. There is no official capital of Tokelau, but the country is managed by an office in Apia, Samoa. The atolls have been populated by Polynesians for about 1000 years, but it wasn't until the 18th century that Tokelau as an entity came to exist. A series of wars at that time united these previously fiercely independent atolls. At the end of the wars, Fakaʻofo had conquered Atafu and Nukunonu, bringing them under the rule of the god Tui Tokelau and creating the first united entity. Soon afterwards, Tokelau came to the attention of passing English and U.S. ships. Whalers frequented the atolls in the 1820s, and in the middle of the 19th century missionary groups began devoting time to the spiritual well-being of the Tokelauans. From the 1840s to the 1860s, first Catholic, then Protestant missionaries from Samoa converted the people of the three atolls to Christianity. In 1889 the Tokelau Islands were made a British protectorate, and in 1925 were transferred to New Zealand administration. It has been a semi-independent country since 2006.

The climate in Tokelau is wet tropical with the temperatures almost always 18–35° C. According to Wodzicki (1968), "During the six months from October to March, north and north-easterly winds prevail, accompanied by thunderstorms and heavy passing showers (average total 175 cm); and from April to September, when south-easterlies predominate, the rainfall decreases (average total 125 cm) and periods of drought may be experienced. The lowest mean monthly rainfall recorded is 19.25 cm." During La Niña climate events, there is often a period of winter drought, which was particularly evident during the present visit (September 2011). This may have serious effects on some of the rare plants found on the atoll.

According to Parham (1971), the dry land largely comprises "coral sand and rubble overlying the hard coral 'limestone' with some areas of deposited coral reef blocks or boulders up to an elevation of 5 m. Through this loose rubble and sand most of the rain drains away immediately, leaching out much, if not all, organic matter. Consequently, in open exposed areas or on the beach front, the vegetation is limited to those plants, which are lime- and drought-tolerant and which are capable of resisting, without serious damage, the effects of salt-laden winds. The bird's nest fern, *Asplenium nidus*, is planted in the sand near the houses, for the

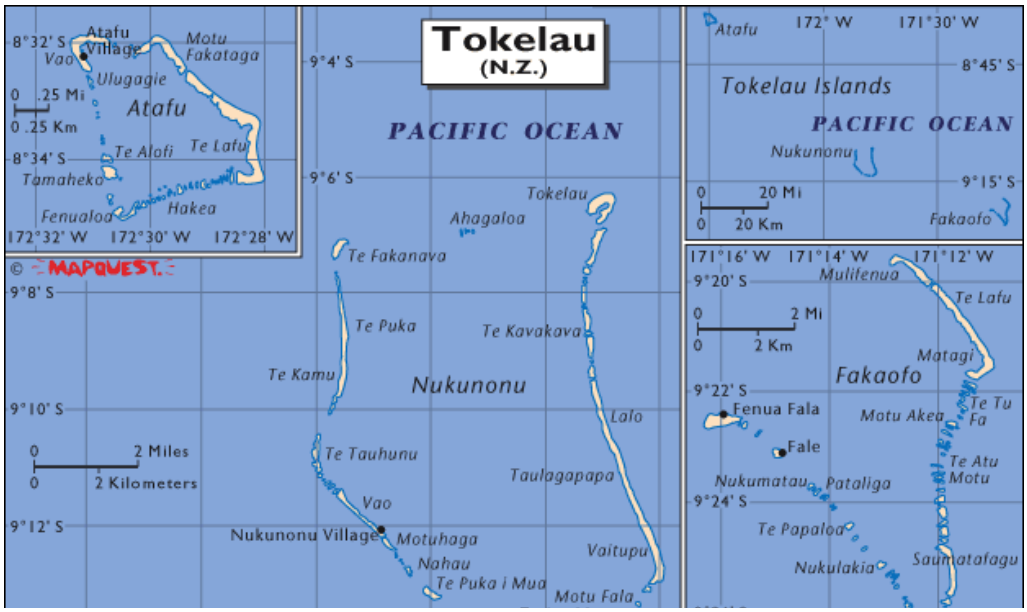

Fig. 1. Tokelau Maps.

young fronds which are edible and used as spinach. Other plants, such as the introduced and cultivated varieties of *Musa*, *Dioscorea* and *Carica*, exhibit heavy chlorosis from excess lime, and rarely produce worthwhile crops. During prolonged dry spells, even coconuts and breadfruit suffer severely."

2. PREVIOUS BOTANICAL WORK

The first plant collections made in Tokelau date to 1839, when botanists from the U.S. Exploring expedition gathered specimens from the islands. Pickering (1876) noted that specimens were collected on Swains Island, Fakaʻofo, and Atafu, but that these were lost "by shipwreck." However, he noted "Lists of the plants growing upon them [the three islands visited] were communicated to me by Mr. Rich [the ship's botanist]." No other botanical observations were published in that report.

The next known plant collections in Tokelau date to 1924 when E.H. Bryan Jr. visited Fakaʻofo. Bryan (in Evenhuis 2007) briefly described the vegetation as follows:

> "Each of the little islets marked "typical" consists of a more or less circular, low mass of sand, gravel, coral and soil, rising perhaps 6 to 10 feet above the reef and covered (like a pincushion) with an open stand of tall coconut palms, some landing out over the beach. Below the coconut palms there may be a fringe of Scaevola [*Scaevola taccada*] bushes and low Tournefortia trees [*Tournefortia argentea*], with perhaps a few Pemphis bushes [*Pemphis acidula*]. In the middle is a tuft (of greater or less extent) consisting of Buka [*Pisonia grandis*], Puapua trees [*Guettarda speciosa*], Pandanus (called "fala") [*Pandanus tectorius*], occasionally Kou [*Cordia subcordata*], Ipomoea [*Ipomoea macrantha*]. The underbrush consists of bird's-nest [*Asplenium nidus*], maile [*Phymatosorus*

grossus] and brake ferns [*Nephrolepis hirsutula*?], and a very little purple flowered Boerhaavia [sic; *Boerhavia tetrandra*] and bunch and mat grass [*Lepturus* spp.]."

Bryan landed at the village on Atafu Motu and described it botanically as follows:

"Between the houses and stone lined gravel walks, the ground is thickly planted with bananas, noni [*Morinda citrifolia*], breadfruit, Pandanus, coconut palms, talotalo [*Crinum xanthophyllum*], Pua (a gardenia-like plant with a stiff ovate leaf and sweet scented, white flower) [*Gardenia taitensis*], and kou [*Cordia subcordata*]."

He also visited the large motu, now inhabited, at the northwest corner of Fakaʻofo, and described it botanically as follows:

"Fonua fala is one of the most luxuriantly covered of the islets, with the largest taro patches and extensive patches of bananas. The east end is largely covered by an open stand of coconuts with fringe of Scaevola, Tournefortia, Fala (Pandanus), Puapua, noni, and Pemphis and underfoot maile and brake ferns, bunch grass, mat grass, tolo (beach runner with yellow flower and burr) [*Triumfetta procumbens*], Boerhaavia and dodder [*Cassytha filiformis*]. But as one goes W. it gradually becomes moister and denser with fewer coconuts and patches of buka, kou (= kauoa), puka vaka [*Hernandia nymphaeifolia*], fau (a fiber plant) [*Pipturus argenteus*], and (Tiale) a gardenia-like plant with ovate leaves and sweet smelling flowers [*Gardenia taitensis*]. The undergrowth adds birds-nest fern, sensitive plant (purple flowers) [*Mimosa pudica*?], an herb legume with twice pinnate leaves [this does not match anything recorded from Tokelau except *Mimosa pudica*], and such weeds as burr grass [*Cenchrus echinatus*], nut grass [*Cyperus rotundus*], the "Honolulu weed" [the purple flowered, dandy-lion-like weed and a tall mint-like weed called [left blank, ed.; it is not clear what this species is, because the only purple-flowered Asteraceae known from Tokelau is Vernonia cinerea, which in no way looks like a dandelion]. A few small Papaya trees (called ese)."

Sensitive plant (*Mimosa pudica*) has not been recorded again from Tokelau. Bryan's Tokelau specimens, numbering about 18 (nos. 55–72), are stored at the Bishop Museum herbarium in Honolulu.

Further collections were made by K. Wodzicki during his visit to Nukunonu in 1967. These collections, which are stored at the Christchurch herbarium, were listed in a publication on the flora and vegetation of Nukunonu published by Parham (1971). Parham noted "collections made by Dr K. Wodzicki and his colleagues at Nukunonu atoll during two visits, the first from November 1966 to February 1967, the second from April to June 1968, comprised 119 field numbers from 13 localities on 11 different motu, totaling 60 species, of which 40 are here regarded as indigenous and 20 as introduced (13 cultivated, 7 adventive). Since no published records of plants collected on Nukunonu by previous workers have been found, the list of species is included here, together with the local names which have been carefully checked on the spot

and recorded by Dr Wodzicki (1967 and 1968) in consultation with the elders of the community."

Parham described the vegetation of Nukunonu, dividing it into "plants of the foreshore," "plants of the beach-crest," and "plants of the plants of the central zone." He further divided the middle zone into "the *Scaevola taccada* fringing-scrub community," the "*Pemphis acidula* scrub facies," the "*Messerschmidia argentea* [*Tournefortia argentea*] facies," and the "*Pandanus*/*Guettarda speciosa* facies." His description, edited for clarity and grammar, is shown in Appendix 3 at the end of the present report.

Parham also quoted van Steenis (1958) in his discussion of the littoral vegetation in the tropical Pacific:

> "the [vegetation] of the sandy beach in a broad sense consists of two parts, (1) the mostly herbaceous, largely creeping flora on the seaward face, the *pes-caprae* formation, and (2) behind it, the largely ligneous *Barringtonia* fringe-forest. These two formations can occur one without the other, the first only on accrescent coasts where sand accumulates, and the second on the sand-ridge [beach crest]. In certain associations no morning glory (*Ipomoea*) is present and, if there is excess of sand. *Barringtonia* need not always be present." Since at the present time, neither *Ipomoea pes-caprae* nor *Barringtonia asiatica* are known to occur in the Tokelau Islands in a wild state, the Tokelau coastal communities correspond in only a limited sense with facies of these two widespread tropical shore formations. This may be a temporary situation owing either to the present unstable nature of the beaches and coastal fringes which have been eroded by heavy seas in recent years, or to the felling of *Barringtonia asiatica* and other trees by the inhabitants."

Another collection was made on the three islands by P. Woodward, who visited the three atolls in 1965. His collections, which number about 179 specimens, are stored in the personal collection of the author at the University of Hawai'i herbarium. His numbers run from 8–71 for Faka'ofo, 72–135 for Nukunonu, and 136–187 for Atafu, but about 14 of these numbers could not be located. His collections also often appear to have duplicates in consecutive numbers, e.g., one species may have three or more consecutive numbers indicating they are duplicates rather than separate collections. The specimens are in the personal collections of the author, possibly with some duplicates at the Bishop Museum herbarium.

The most recent collections were made by the present author, who visited Tokelau in 1980 and 1983, and during the present project in September of 2011. He stayed for ten days on Faka'ofo in 1980, collecting there, and on Atafu and Nukunonu on the way there. In 1983 he made a second visit to Tokelau, where he collected again on Atafu over a four-day period. During the present project, he collected on Faka'ofo and Atafu. Together, his specimens number about 140 (including some ornamentals), which are stored in his private collection at the University of Hawai'i herbarium. The collection numbers from Nukunonu are 4577–4599; the numbers from Atafu are 4600–4620, 5745–5770, and 12745–12768; and the numbers from Faka'ofo are 4621–4658 and 12737–12744. Based upon his work in 1980 and 1983, Whistler (1988) published an ethnobotanical study of Tokelau, in which most of the names of the species present in Tokelau are recorded. Other than vouchers mentioned in that publication, his specimen records have not been published. Whistler (1983) previously published a flora and

vegetation of Swains Island, but the results of that work are not included here since it is currently outside of the political entity of Tokelau. Because of the absence of a comprehensive floristic work in the archipelago, no "flora of Tokelau" has ever been published, and the checklist presented below is the first one presented other than the notes included in Parham (1971).

3. METHODOLOGY

The first task in this study was to go through the author's flora data and prepare a preliminary checklist of species that might be included in this report. His flora data is based primarily upon collection data (specimens collected in Tokelau) from all previous collectors, and the author's personal experience and collections in the islands. A preliminary checklist was prepared, which included island distributions within the archipelago for each species. This was done to facilitate the collection of new species and new island records in the archipelago during the present fieldwork.

The original plan of the botanical survey was to spend several days on each of the atolls. However, because of problems with shipping schedules, only two atolls could be visited—Nukunonu and Atafu. However, once the project began, further scheduling problems arose. After the researchers had spent four days on Atafu, their departure ship was suddenly diverted directly to Samoa because of an emergency medical evacuation. This resulted in the official end to the botanical survey (although four other, non-botanical scientists where able to alter their return schedules and spend some time on Nukunonu, returning on a different ship). The necessary omission was somewhat ameliorated by the fact that the author has done considerable botanical research on Fakaʻofo for ten days in 1980, and has also made collections that year on the other two islands (and for four days on Atafu in 1983). Consequently, the present botanical report is based upon the current work and that of the author in the 1980s. Also included are photos taken by R. Pierce on Nukunonu, which included some new island records, and even a new native species.

During the fieldwork, checklists were made of all species encountered. These species were eventually divided into native plants, naturalized alien plants (adventive species of "weeds"), and cultivated plants (although the latter are not considered in this report because of their irrelevance to the biodiversity of Tokelau). Extensive notes on the vegetation of the main (inhabited) motu and the outer motus were made. Notes on the vegetation of Fakaʻofo were also made during the 1980 visit, including the results from one forest plot that was sampled. After the present field surveys, the notes were written up into the present report. Special emphasis was put on species that could be considered rare, threatened, or endangered (see discussion). The specimens collected were taken to Honolulu and included in the collections of the author at the University of Hawaiʻi herbarium.

4. VEGETATION OF TOKELAU

The vegetation of Tokelau can be divided into three plant communities—Ruderal Vegetation, Coconut Forest, and Littoral Strand. For this report, only the vegetation of Atafu

was studied firsthand, but the author did similar work on Fakaʻofo in 1980, and the notes from that work were incorporated into the present study.

4.1. Ruderal Vegetation

Ruderal vegetation comprises village lands that are under active management for trails, roads, village greens, gardens, and plantations (mostly pulaka "pits"). It is characterized by regular or frequent management, which prevents it from undergoing the natural process of "plant succession" that would eventually would return it to a natural type of vegetation (i.e., back to Littoral Strand). Traditional Polynesian village green areas are not very evident in Tokelau because of the sandy soil (and lately, the drought). These areas are better described as patches of herbaceous vegetation around houses that are periodically cut or weeded. Where it does occur, it often comprises lawns that are regularly or periodically cut or mowed. Because of this maintenance, species that creep rather than stand tall are favored, and grasses such as *Zoysia tenuifolia* (temple grass) and *Eleusine indica* (goosegrass) may predominate. Nearly all of the adventive species recorded in Tokelau occur in these village areas. Roads and distinct trails occupy very little of the land area of Tokelau, and are almost entirely on the inhabited motus (only about four of which occur in Tokelau).

Pulaka pits are found in excavations that extend down to the brackish water lens in the center of some of the larger motus. The dominant cultivated plant here, pulaka (*Cyrtosperma chamissonis*, giant swamp taro), is a giant aroid that is able to tolerate and even thrive in brackish water in the sandy soil. The only other cultivated plant found in these wetlands is taro (*Colocasia esculenta*), but it is uncommon overall and found in only a few places in Tokelau. Few weedy species are found here, partly because the pits are situated mostly on uninhabited motus that generally have few weedy species, and few weedy species in Tokelau can survive in wetlands. On Atafu, in fact, only two weedy species were noted from the pulaka pits examined there (*Phyllanthus amarus* and *Laportea ruderalis*), neither of which is a wetland species. Some abandoned pits were seen on Atafu and were virtually devoid of any plant species. During the author's visit to Fakaʻofo in 1980, pulaka pits were reported to be present on nine motus. Marshy areas, probably formerly covered with pulaka, were found were found on Fenua Fala, the larger of the two inhabited motus of Fakaʻofo. These were dominated by *Paspalum vaginatum* (marsh grass), a species that is otherwise absent from Tokelau (but present on Swains Island).

4.2. Coconut Forest

Most of the land surface of Tokelau is currently covered with what can be classified as Coconut Forest, but vegetation dominated by these palms is difficult to classify. Although coconuts are probably native to Tokelau (since they are known to be native in the Old World Tropics as far east as the Society Islands), they were probably originally just one of several native tree species dominating the motus. They apparently do not fare well in competition with other native littoral forest species, and were perhaps restricted mostly to the seaward margins of the forest. But because the tree was so important to the early inhabitants (and still is), they were probably cultivated in plantations at the expense of the native littoral forest that was felled.

Coconut-dominated areas sometimes appear to be managed plantations, in which the ground cover is maintained by cutting, but when abandoned, it becomes dense with ground cover. When abandoned for a long time, it becomes overgrown with native littoral forest trees, and eventually

will revert to littoral forest with coconuts present. So distinguishing it from littoral forest is sometimes difficult because they can just be different ends of a series of plant succession changes leading from Coconut Forest to Littoral Strand (more precisely, littoral forest). Most of the Coconut Forest in Tokelau has a dense ground cover dominated by germinating and young coconuts. Also present are variously sized littoral forest trees, principally *Pandanus tectorius* (screwpine), *Guettarda speciosa*, *Cordia subcordata*, *Pisonia grandis*, and *Morinda citrifolia* (Indian mulberry). The dominant herbaceous species are the ferns *Asplenium nidus* (bird's-nest fern) and *Phymatosorus grossus*. Other than these two ferns, herbaceous and shrubby species are scarce in shady Coconut Forest. Only one species of vine is typical in this habit, *Ipomoea macrantha*, but it is not very common. In clearings in this forest, however, *Scaevola taccada* may predominate, and sometime the littoral grass *Lepturus repens*.

4.3. Littoral Strand

Littoral Strand refers to the natural vegetation occurring on tropical seashores and dominated by plant species whose presence and distribution are affected either directly or indirectly by the sea. Littoral Strand probably comprised virtually all of the original vegetation of Tokelau, and differs from most inland vegetation in the Pacific islands in both its extent (area) and distribution. It occupies a very narrow area on the immediate coast less than 100 m wide, but because atoll motus are narrow, it typically covers the whole islet. Littoral Strand typically exhibits zonation into several zones that run roughly parallel to the coastline. Zones recognized on some coasts in the Pacific islands include herbaceous strand, littoral shrubland, *Pandanus* scrub, and littoral forest.

The environmental conditions present on the rock, sand, and coral rubble motus are very harsh. Although Tokelau has a relatively wet climate (other than a La Niña drought as was occurring during the study), the substratum may retain little water for plant growth. The substratum itself is a limiting factor, either because of low organic content (e.g., sandy beaches) or absence of soil (e.g., rocky coasts); in the latter case, the plants must root in cracks in the rock surface. The most critical environmental factor, however, is the effect of the sea. The sea winds are salty, the ground water is saline or brackish, and occasional high waves, some with destructive force, can inundate the area during storms or tsunamis, leaving behind pools of sea water. Littoral species, therefore, must have some degree of salt-tolerance to survive the harsh saline conditions.

Temperature is another important environmental factor. The rock, sand, or coral rubble on which the plants grow is exposed to the sun in open areas, resulting in a high ground temperature during sunny days. Most littoral plants are heliophytes ("sun plants") that require bright sunlight for establishment and growth, a need that generally excludes them from shady forest habitats. The physiological characteristics littoral plants share account for their typical restriction to a narrow zone of vegetation along the shore—they are limited inland by competition from the more vigorous species of the lowland forest (on high islands anyway), and seaward by the ocean.

Although plant species in Littoral Strand come in several different "life forms" (e.g., tree, shrub, vine, etc.), they have important characteristics in common besides their physiological similarities. Most have buoyant, saltwater-resistant seeds or fruits that can be carried for long distances by sea currents. Most of those lacking this characteristic instead have sticky fruits that adhere to seabird feathers (e.g., *Pisonia grandis*), or fruits that are eaten and transported internally by seabirds or migratory birds visiting the islands. These dispersal characteristics

account for the wide distributions of most littoral species: few Pacific littoral species are endemic, and none in Tokelau are.

As noted above, littoral strand can sometimes be divided into zones based upon life form and species composition. On some Pacific island shores, there is a distinct herbaceous zone (sometimes called "herbaceous strand") dominated by vines, grasses and sedges, and, to a lesser extent, other herbs. Common vine species found in this habit include *Ipomoea pes-caprae* (beach morning glory), *Vigna marina* (beach pea), and *Canavalia* spp; common grass species include *Lepturus repens, Thuarea involuta,* and *Stenotaphrum micranthum*. However, in Tokelau this zone is not very well developed, and all but two of these species are absent from the archipelago, and one of them, *Ipomoea pes-caprae,* was actually recorded for the first time this year on all three islands, but it is currently rare. The only areas that could be classified as herbaceous strand in Tokelau are dominated by *Lepturus repens*, but these are mostly sparsely vegetated.

A littoral shrubland zone is much more common in Tokelau. The dominant species here are the shrubs *Scaevola taccada* and *Pemphis acidula*. Littoral shrubland usually forms a fringe on the seaward margin of littoral forest. Sometimes this fringe is distinct, but often the shrubs are intermixed with low growing littoral forest trees, which can make the existence of two distinct zones impossible to maintain. *Scaevola taccada* is the most characteristic species of this zone on the Pacific islands, both volcanic and coralline. It sometimes forms open or closed patches on the Tokelau motus. *Pemphis acidula*, which in the Pacific is mostly restricted to coralline islands, is very common in Tokelau. It often forms relative large, pure shrubby stands, particularly on rocky surfaces. The littoral shrubland areas on Atafu were virtually monodominant, with no species present other than *Scaevola taccada* or *Pemphis acidula*. The species often forms a low scrubby cover on seashore rocks, but when conditions are right, it can become a small tree. *Pandanus tectorius* (screwpine) often forms pure zones called *Pandanus* scrub, but this was not noticed during the work in Tokelau. It is, however, a major component of the fringe and interior of littoral forest and Coconut Forest.

One other plant not mentioned yet is sometimes common in the littoral strand—*Cassytha filiformis*. This green to orange, leafless vine occurs as a parasite on littoral shrubs, herbs, and sometimes trees. It forms suckers called haustoria that become imbedded in the host plant tissue and serve to absorb the host plant's nutrients.

Littoral forest is composed of several common tree species in Tokelau, most notably the previously discussed coconuts and screwpines, and *Cordia subcordata*, *Hernandia nymphaeifolia* (Chinese-lantern tree), *Guettarda speciosa*, *Pisonia grandis*, *Tournefortia argentea* (tree heliotrope), and *Morinda citrifolia* (Indian mulberry). *Cordia subcordata* sometimes forms dense monodominant forests, but it is not clear if these are natural. On Atafu there is a large piggery comprised of numerous, individually enclosed pigpens surrounded by a rock wall. The whole complex is shaded by a dense, monodominant forest of *Cordia*

Table 1. Littoral Forest plot on Faka'ofo sampled by the author in 1980.

Species	*Tokelau*	No. of	No. of Trees	Basal	Relative
	Name	Trees	>15 cm dbh	Area (cm^2)	Dominance

Hernandia nymphaeifolia		*puka ama*	47			17			
20,126	88%								
Cocos nucifera		niu		4			4		
2,420	11%								
Pisonia grandis		puka kakai	2			1			
294	1%								
Morinda citrifolia		nonu	1			0			
5	+								
		Totals	54			22			
22,845									

subcordata. This tree is the most valuable carving wood on the island, and was the source of wood used to construct the traditional sewn-plank canoes.

Hernandia nymphaeifolia also sometimes forms monodominant forest. The author sampled one plot of this in 1980 on Fenua Fala motu at Faka‘ofo. The results of this, presented in Table 1, show that *Hernandia nymphaeifolia* was the dominant tree with 88% relative dominance. It is unclear if this type of forest is common on the other motus and on the other two Tokelau islands, because no *Hernandia*-dominated forest was noted during the recent work on Atafu, but this species is well adapted to the sandy atoll habitat. Another species that can dominate in Tokelau littoral forests is *Pisonia grandis*. This tree often is huge, and it forms a monodominant forest on Rose Atoll in American Samoa to the south.

Two other littoral forest trees are questionably native to Tokelau. *Barringtonia asiatica* (fish-poison tree) is rare on the islands. During the work on Atafu, it was found only on a single motu, and it is similarly rare on the other two atolls. It is considered here to be native, but it is possible that it was introduced to Tokelau for use as a fish poison. *Calophyllum inophyllum* (Alexandrian laurel) is also rare in Tokelau. It occurs mostly in villages and is used as a shade tree. On Atafu, only a single other tree is known outside the one inhabited motu, and that individual tree is near a landing place on the adjacent motu. It is considered here to be an ancient introduction to Tokelau that does not spread on its own around the islands.

The floor of littoral forest in Tokelau can be open, but in some places *Asplenium nidus* (bird’s-nest fern) and *Phymatosorus grossus* (another fern) may be common or abundant. Both are can grow as epiphytes or terrestrial ferns. Few species able to grow in the shady, somewhat saline environment, and none of them are very common. The most common ground species are probably the ferns *Asplenium nidus* (bird’s-nest fern) and *Phymatosorus grossus*, both of which grow as epiphytes (plants that grow other trees) as well as on the ground (terrestrial).

5. FLORA OF TOKELAU

The “flora” of an area is usually thought of as a list (or book) that includes all the plants occurring in that area. This list can include all flowering plants, all vascular plants (flowering plants, gymnosperms, and ferns), or all plants (including algae, lichens, etc.). Together the flowering plants, gymnosperms, and ferns are often referred to as “higher plants,” a category known scientifically as Tracheophyta. The higher plants are divided into two main groups—ferns, which are placed in the Pteridophyta, and seed plants, which are placed in the

Spermatophyta. Between the ferns and seed plants, but typically included in the pteridophytes, is a heterogeneous assemblage of plants called "fern allies," which in Tokelau comprises only the genus *Psilotum* (one species, but a second one occurs on Swains Island).

The seed plants are divided into two groups: Gymnospermae (called gymnosperms, or sometimes, conifers), and Angiospermae (flowering plants). No native gymnosperms are found in Tokelau. The angiosperms are divided into two groups: monocots and dicots. These two groups are further divided into groups called "orders," and orders are divided into "families," which range in size from a single species to thousands of species. Orders are not commonly used, but families are. All family names can be identified by the ending "-ceae." For example, the grass family, the largest one in Tokelau, is called the Poaceae, and the largest dicot family, the spurge family, is called Euphorbiaceae. The species recorded in the checklist of the flora of Tokelau (Appendix I) are divided into the three groups (ferns and fern allies; dicots; and monocots), which are then divided alphabetically into families and then into species.

Plant species can be classified by their distribution: they are either *native*, i.e., they occur naturally in the area after arriving by non-human transport, or they are *alien*, i.e., they are introduced species having arrived by direct or indirect human transport. Alien species can be further divided into species introduced by the Tokelauans (i.e., they were brought in prior to ca. 1800, and are called *Polynesian introductions*) and those introduced in modern times (i.e., after ca. 1800, and called *modern introductions*) by Europeans or by Tokelauans traveling by means of western transport (mostly by ship). Alien plants can also be divided another way into *intentional introductions* (plants brought intentionally, usually useful plants) and *unintentional introductions* (plants accidentally arriving in Tokelau, typically weeds).

Native plants can be divided into two categories, *endemic* and *indigenous*. Endemic means restricted to a certain area; plants endemic to Tokelau would be found only in Tokelau. Indigenous, in its current usage, refers to native species with a wider distribution (i.e., those naturally found in Tokelau as well as elsewhere). These terms are relative, because their meaning depends upon how the "area" is defined. For example, a plant occurring in Samoa and Tokelau could be referred to as endemic to western Polynesia, but then it would be indigenous to these two areas when they are treated individually. However, in practical usage endemism is usually applied to countries, archipelagoes, or islands. It is a moot point, however, because there are no endemic plant species in Tokelau.

5.1. Native Flora

The native flora of Tokelau is recognized here to comprise 36 native vascular plant species. This figure is much lower than for the adjacent Samoa, which has about 550 native species of flowering plants (Whistler, pers. research), largely because of small size, low elevation (a maximum of 5 m), and the lack of variety of habitats on the atolls. The native plants of Tokelau are very similar in number and composition to those of Tuvalu to the west and the Northern Cooks to the east, which have a similar atoll habitat. The number of native species differs from what other authors have reported. Parham (1971), for example, noted 40 native Tokelau species. However, the present author's work over the last four decades in the Pacific has led him to believe that some of the species considered to be native by Parham are actually Polynesian introductions. An example of this is *Ficus tinctoria* (dyer's fig or *mati*). It is native to Samoa and other high islands in the region, but does not appear to be able to maintain itself on

the Tokelau atolls without human intervention. It was probably introduced for use as a minor fruit tree (small edible figs).

The checklist of the flora is shown in Appendix 1, with the 36 native species shown in bold. Faka‘ofo is home to 33 of these, Atafu to 27, and Nukunonu to 30. The figures for Nukunonu may be a little low because this is the island on which the author has done virtually no fieldwork.

5.2. Alien Flora

In addition to the 36 native species, 50 naturalized species (“adventives” or “weeds”) are known from the atolls. Naturalized plants are usually alien (non-native) species that have arrived and become established enough to maintain themselves without active human intervention. Most of them, however, require sunny disturbed habitats, a habitat type that scarcely occurs in Tokelau other than by the actions of man. The other major category of plants comprises cultivated species—those plants who presence on the islands are directly dependent upon man. Plants are cultivated for food, medicine, and as ornamentals. The separation between naturalized species and cultivated species is not always distinct, because some species produce seeds and spread only a short distance away from where they are planted. These species are called “casual adventives,” and in which category (or both) they should be put is not always clear. Nearly all of the naturalized weeds are found on the main inhabited motus; few of them have become established on the uninhabited ones. See the checklist in Appendix 1 for the naturalized species, which are shown in italic (not bold) type.

5.3. Invasive Species

One of the major botanical concerns in South Pacific islands it invasive species. Weedy species often arrive in an area and proliferate, disrupting the ecology and threatening the unique biodiversity of the islands. Prior to the arrival the European era (beginning ca. 1839), only a few plants in Tokelau would be classified as alien weeds—undesirable non-native species that spread by themselves. This may have included only *Eleusine indica* (goosegrass), *Acalypha lanceolata*, and *Rorippa sarmentosa*. Most of the other ancient Polynesian weeds were either unsuited to the atoll habitat or just hadn’t made it there yet. None of those would be considered to be serious invasives.

Since that time another 47 or so species have arrived and become established in Tokelau, mostly in village areas. The fact that only three of the 29 weedy species now known from Atafu were found during the present survey on any of the uninhabited motus is a good sign, and even those three were minor weeds restricted to only a few places. The one species that has gotten a lot of attention lately is *Wedelia trilobata* (wedelia). This creeping daisy with attractive yellow flowers can, under the right conditions, form a dense groundcover that excludes nearly all other species. It has been known from Tokelau for several years, but was perhaps collected as a voucher specimen for the first time during the present survey (on all three atolls). It is planted as an ornamental ground cover, and was noted in several places on the islands. It can get out of hand under the right conditions, but this may not happen on the sandy soil of Tokelau. Other than *Wedelia*, no other species recorded in Tokelau appear to be a threat to the environment or biodiversity of the islands.

5.4. New Tokelau Records

During the present fieldwork, a number of new species records have been recorded for Tokelau. Four new native species have been collected: *Hibiscus tiliaceus* (beach hibiscus) from Atafu; *Portulaca lutea* (sea purslane) from Atafu; *Ipomoea pes-caprae* (beach morning-glory) from Atafu, Faka'ofo, and Nukunonu; and *Syringodium isoetifolium* from Nukunonu. It is unlikely than many more native species will be found in the future, other than new arrivals. Twelve alien weedy species were also collected from Tokelau for the first time during the present fieldwork: *Wedelia trilobata*, *Cleome viscosa*, *Kalanchoë pinnata* (life plant), *Acalypha indica*, *Chamaesyce hypericifolia*, *Chamaesyce hyssopifolia*, *Chamaesyce thymifolia*, *Physalis angulata*, *Solanum americanum*, *Stachytarpheta cayennensis*, *Cyperus compressus*, and *Chloris barbata*.

6. RARE PLANT SPECIES

The definitions of the terms "rare," "threatened," and "endangered" are viewed in different ways in different places. The United States Interior Department's Fish and Wildlife Service (FWS) has primary responsibility for terrestrial and freshwater plants, as provided for in the Endangered Species Act (ESA) of 1973. Under the ESA, plant species may be listed as either "endangered" or "threatened." Endangered means a species is in danger of extinction throughout all or a significant portion of its range. Threatened means a species is likely to become endangered within the foreseeable future. As of March 2008, the FWS had listed 1,925 species worldwide as endangered or threatened, 1,351 of which occur in the U.S. The term "rare" has no legal meaning, but is used in this report to mean "difficult to find."

The main international agency in charge of rare plants is the International Union for the Conservation of Nature (IUCN), which produces a list of these species called the "Red List". Based upon frequency and distribution, the IUCN system divides plants into nine categories: Extinct (EX); Extinct in the Wild (EW); Critically Endangered (CR); Endangered (EN); Vulnerable (VU); Near Threatened (NT); Least Concern (LC); Data Deficient (DD); and Not Evaluated (NE). Assigning plants to these somewhat complicated categories is based upon a lot of data, data that is almost entirely lacking in Tokelau. The definitions of these IUCN categories can be seen in Appendix 2.

New Zealand, which has a very active program for protecting its rare plants, uses its own system of classification. Townsend et al. (2008) has developed the New Zealand Threat Classification System so that every native organism existing in the wild in New Zealand can be assigned a threat status. The species on the list are divided into two main groups: those that are able to be evaluated and those that cannot. Those that cannot be evaluated, for whatever reason, are assigned the category "Data Deficient" (as on the IUCN Red List). The categories with sufficient data for evaluation are as follows.

1. Extinct—Plants that are, without a doubt, no longer found in New Zealand. This actually includes plants that are extinct (no longer exist on the planet) and extirpated (no longer exist in New Zealand). As de Lange et al. (2010) note, it is nearly impossible to prove that a plant is extinct, and there are plant species that have been listed thus and subsequently rediscovered. Species extinct in the wild but remaining in cultivation are not included in

this category, nor are species that arrived by chance but did not become established ("vagrants").

2. Threatened—Plants that are on the road to extinction. This category is subdivided into several smaller categories based upon the population size and the current and predicted decline rate for the taxon: (1) Nationally Critical; (2) Nationally Endangered; and (3) Nationally Vulnerable. Sixteen additional qualifiers are used in this system, such as "extinct in the wild," "range restricted," and "island endemic."
3. At Risk—Plants that are at some risk of extinction but are not as yet directly threatened.
4. Not Threatened—Species that have been evaluated but have been determined not to be endangered or threatened in the country.

6.1. Criteria Used for Determining Rare Tokelau Plants

After considering the available data, the author established criteria for inclusion on the list of rare plants of Tokelau. In the end, four criteria were used: (1) rarity of collections; (2) rarity of modern collections; (3) restricted distribution in Tokelau, i.e., restricted to only one island; and (4) field experience of the author.

Rarity of collection was determined by examining the collection data of Tokelau species. This data is found in the pertinent literature, on dozens of herbarium specimens, and some visual records (the latter category lacks voucher specimens), but this location data is not very precise and is sometimes limited to just the atoll on which the plant was collected. The data for many of the recorded species is found in the publication of Parham (1971), but most of it is found on the labels of specimens collected by E.H. Bryan and P. Woodward stored at the Bishop Museum and the University of Hawai'i herbarium, and the collections of the author stored at the latter repository.

No fixed number of collections was used to determine whether or not a species is rare in Tokelau. More important are the dates of collection. The lack of modern collections is a possible indicator that they are becoming rare and in need of protection. For example, *Solanum viride* has about eight recorded collections, only one of which dates to after 1979. Likewise, *Pipturus argenteus* has 15, only two of them since 1979. All other things being equal, species restricted to a single island are more likely to be extirpated than species found on two or three. But when it is all summed up, it is the opinion of the author, who has made three collecting trips to Tokelau, that carried them most weight in selecting which species should be considered to be rare.

6.2. Reasons for Rarity

There are a number of reasons why plants are rare in Tokelau, some of them due to the activities of man, some to chance, and some to natural causes. These reasons can be put into several categories: (1) loss of habitat; (2) competition, especially from introduced invasive species; (3) abandonment of cultigens; and (4) natural rarity. Plants that have died off over their entire range are referred to as extinct. Species that have died off in only part of their range are referred to as being extirpated from those places. Since no plants are endemic to Tokelau, none are extinct.

Loss of habitat after the arrival of the first Polynesian settlers centuries ago is probably the most serious cause of plants becoming rare in Tokelau. Before the arrival of the settlers, the

islands were probably entirely covered with Littoral Strand vegetation, mostly littoral forest. Although most of this has been removed over the centuries and replaced by coconut-dominated vegetation, most of the original species are probably still present, but some in much fewer numbers. Competition with other species does not appear to be as important in Tokelau as it is on high islands in the region. This is partly because few of the weedy species in the region are able to survive the atoll habitat, and if they do successfully arrive in Tokelau and become established, they are usually restricted to village areas, where they do little harm. As noted above, only one plant (*Wedelia trilobata*) is even worth considering as invasive. Another cause for rarity in high islands, herbivory, is not applicable to Tokelau, since few if any herbivores are found on the atolls.

The abandonment of cultigens is the major reason for the extirpation or near extirpation of some ancient Polynesian cultivated plants from Tokelau. The ancient Polynesians carried the plants that were useful to them, and maintained these plants through cultivation. However, in the European era many new and better species were introduced, which led to some of the "canoe plants" no longer being cultivated. Two good examples of this are *Ficus tinctoria* (dyer's fig) and *Pipturus argenteus* (no common name). The fig, which is native to most high islands of the region, is used as a minor fruit tree, but has now become rare because it does not spread by itself. It relies on human intervention (planting of seedlings) for its continued presence in Tokelau, but it has fallen into disuse. *Pipturus argenteus* is also native to most of the high islands of the region. It was probably a Polynesian introduction to Tokelau, where its bark was used to make fishing line. Because of the introduction of manufactured fishing line, it is no longer used for this purpose, and since it does not reproduce well by itself on the atolls, it has nearly disappeared (it was not found on Atafu during the present fieldwork).

Some species are probably naturally rare in Tokelau, for a variety of reasons. The most common reason is probably the chance recent arrival of species that have not had enough time to spread. A good example of this might be *Terminalia samoensis*, which is known in Tokelau from only a single collection from Fakaʻofo. Another example is *Hibiscus tiliaceus* (beach hibiscus) that was recorded in Tokelau for the first time during the present fieldwork.

Rare plants can be divided into three categories: endemic species restricted only to that area; indigenous plants also found elsewhere; and non-native cultural plants. Tokelau has no plant species in the most important category, endemic species. The second most important category includes only widespread littoral species, most of which, with perhaps only two exceptions, are common elsewhere in the Pacific. Only about three species belong in the third category, rare cultural plants.

Because most of the species that are rare in Tokelau are common elsewhere, only three of them have been selected for further consideration (see below). After the selection, a species profile was prepared for each (Appendix 3). This included the following preliminary information: (1) species name; (2) botanical family to which the species belongs; (3) author(s) of the species name; (4) synonyms of the species name, and their authors; (5) Tokelau name (if any); (6) English name (if any); (7) status (e.g., rare endemic); (8) reason for listing as a rare plant; and (9) suggested action for protecting the species. This was followed by information about the range, habitat, distribution (in and out of Tokelau), frequency, and any ethnobotanical uses. Then a botanical description was written for each species, using previous literature, field descriptions made by the author, and descriptions based on botanical collections stored in the Bishop Museum and the University of Hawaiʻi Joseph F. Rock herbaria, as well as live material

collected in the field. Finally, the sites of collection of all known specimens of the rare plants were recorded.

6.3. Rare Indigenous Species

Indigenous species differ from endemic species mainly in their extent of distribution: an endemic species is restricted to a single area (typically an island, archipelago, or country) while indigenous species are found in more than one place. (Some are pantropic, i.e., found throughout the tropics.) The more important of the two, in terms of rare plants, is the endemic category because if they are rare in one place (i.e., the place to which they are native), they are rare globally. However, Tokelau has no endemic species. Indigenous species can be rare in some places and common in others, but some are rare throughout their range (and these are the ones of particular concern).

An indigenous plant can be rare for a number of reasons. The species may be at its geographical limit, and is rare because it is a recent natural arrival without much time to spread, or because it is at its climatic limit (e.g., it may require a wetter or drier, or a colder or warmer climate than that found in Tokelau in order to flourish). It may also be rare because of edaphic factors, e.g., it may thrive only on lava flows, which are absent from Tokelau. The indigenous species included here are mostly littoral species, since lowland forest species are virtually absent from the archipelago.

Table 2. Indigenous Species Rare in Tokelau.

Species	*Tokelau Name*	A[1]	F[2]	N[3]	Reason for Rarity
Achyranthes velutina	*tamatama*	A	F	N	Disappearing, reasons uncertain
Barringtonia asiatica	*futu*	A	F?	N	Natural rarity
Eleocharis geniculata	----------	--	F	--	Lack of natural habitat (wetland)
Hedyotis romanzoffiensis	*kautokiaveka* A	F	N		Disappearing, reasons uncertain
Hibiscus tiliaceus	*fau*		A	--	-- Recent arrival
Ipomoea pes-caprae	----------	A	F	N	Recent arrival
Mariscus javanicus	----------	--	F	--	Lack of natural habitat (wetland)
Paspalum vaginatum	----------	--	F	--	Lack of natural habitat (wetland)
Portulaca lutea	*katuli*			A	-- -- Natural rarity
Portulaca samoensis	*katuli*	--	F	N	Natural rarity or competition
Procris pedunculata	*gahe vao*	A	F	N	Recent drought?

Pteris tripartita	----------	--	F	--		
Unsuitable habitat						
Syringodium isoetifolium	---------	--	--	N		Newly recorded aquatic plant
Terminalia samoensis	*talie*	--	F	--		Natural rarity
Vittaria elongata	----------	--	--	N		
Unsuitable habitat						

[1]Atafu. [2]Faka'ofo. [3]Nukunonu.

The plants considered rare in Tokelau are shown in Table 2. Four species on the list are species that were recorded for the first time during the present survey—*Ipomoea pes-caprae* (beach morning-glory), *Hibiscus tiliaceus* (beach hibiscus), *Portulaca lutea*, and *Syringodium isoetifolium*. They can be expected to be rare since they apparently new arrivals. The latter species is a sea grass that may be common, but which had escaped detection because no terrestrial botanists or marine collectors (phycologists) noticed it before. Four of the species are probably rare because of lack of habitat. This includes the wetland species *Mariscus javanicus*, *Paspalum vaginatum* (marsh grass), and *Eleocharis geniculata*, and the somewhat weedy fern *Pteris tripartita*, which occurs in agricultural areas (and may not even be native).

Two of the rare tree species may just be naturally rare. They may spread to islands and become established, and later disappear because of an inability to compete with the other native species. This includes *Barringtonia asiatica* (fish-poison tree) and *Terminalia samoensis*. It also includes the fern *Vittaria elongata*, which is an epiphytic lowland forest fern possibly not well suited to littoral forest. *Portulaca samoensis* may fit into the same category, or it may be negatively impacted by competition with weedy introduced species. The reason for the apparent rarity of *Procris pedunculata* (on Atafu at least) may be due to recent drought conditions, which adversely affects this epiphytic herb. The cause of the apparent increasing rarity of the two remaining two species, *Achyranthes velutina* and *Hedyotis romanzoffiensis*, is unclear. These are restricted to atolls in the central Pacific, and may be threatened throughout their range. These two are consequently recommended for inclusion on a Red List of Tokelau plants. See Appendix 3 for their profiles.

6.4. Rare Cultural Plants

Threatened or endangered plants are usually native species, most commonly, endemic ones. However, two other types of species are included on this enumeration of rare Tokelauan plants—rare Polynesian cultigens and rare Polynesian adventives. Whether a species is native or alien is sometimes difficult to determine, but several factors have to be considered in ascertaining this: (1) method of dispersal (especially whether or not it produces dispersible seeds); (2) known range outside of Tokelau; (3) whether or not there is a natural habitat for it to occupy in Tokelau; and (4) and if the plant has been decreasing in abundance in recent times. A plant with no natural means of dispersing across the ocean to Tokelau is almost certainly an alien species. A good example of this is the *Artocarpus altilis* (breadfruit), which has large fruits that lack viable seeds (or if seeds are present, they cannot be naturally dispersed to Tokelau from their overseas source area). If a plant is not found on adjacent islands (e.g., Samoa and Fiji), but much farther away (e.g., Australia), is it is most likely an alien species (and usually of modern introduction).

Prior to the arrival of Polynesians, most of Tokelau was covered with a dense littoral forest. Disturbed habitats in pre-Polynesian Tokelau were minimal and occurred mostly after drastic climatic events (e.g., cyclones, volcanic eruptions). Hence light-loving inland species had relatively little area to colonize. Alien plant species are often unable to compete with native species in undisturbed habitats, but may be common in disturbed habitats because they are planted there. When these plants are no longer desired or cultivated, they may eventually disappear. Consequently, useful plants present before the European era that have become uncommon in recent times, are usually alien species (mostly Polynesian cultigens).

Table 3. Rare Cultural Plants in Tokelau.

Species	*Tokelau Name*	A[1]	F[2]	N[3]	Reason for Rarity
Ficus tinctoria	*mati*	A	F	N	No longer used or cultivated
Pipturus argenteus	*fau*	A	F	N	No longer used or cultivated
Rorippa sarmentosa	----------	--	F	--	No longer used or cultivated?
Pandanus tectorius vars.	*fala*	A	F	N	No longer cultivated
Solanum viride	*polo*	A	F	N	No longer used or cultivated

[1]Atafu. [2]Faka‘ofo. [3]Nukunonu.

The Polynesian cultigens comprise traditionally cultivated plant species that were brought by the ancient voyagers. These plants are often unable to produce and spread by themselves, and need care by humans (e.g., weeding, planting, etc.) in order to survive in places where they have been introduced. During the modern period, many entirely new cultigens have been introduced, and many of these are so superior to the older cultigens that cultivation of the latter group has diminished or ceased. Because of the absence of the care needed by these species to survive, they have gradually disappeared. Five plants in this category are shown in Table 3.

Perhaps the rarest of these plants is *Solanum viride* (cannibal cherry). Its fruits were probably used as a minor food source and for fruit leis, but since the introduction of so many other plants during the European era, it is no longer cultivated and has become rare in open areas on the edge of littoral forest. *Ficus tinctoria* is a fruit tree that is infrequently used nowadays, and its cultivation is not longer practiced. Since it is unable to complete very well with native species, it is slowly disappearing. The same is the case for *Pipturus argenteus*, as noted above. The fourth plant, *Rorippa sarmentosa* (Polynesian cress), was collected once in Tokelau, on Faka‘ofo, where it is probably used to make an herbal medicine for infants. It is not clear, however, whether it is a modern or ancient introduction to Tokelau.

The last plant, *Pandanus tectorius* (screwpine), is rare only on the varietal level. At least 19 edible varieties were noted by to occur in Tokelau (Whistler 1988), but these are now

disappearing. To perpetuate them, branches must be planted because the fruits ties produce the "wild type" when planted. Because this deliberate replanting of the branches is disappearing, so are the varieties.

Rare Polynesian adventives (weeds) comprise plants unintentionally introduced to Tokelau before the European era, but which have become rare or have disappeared because of competition from more recently introduced weeds. There is possibly only one weed that may fit into this category, *Acalypha lanceolata*, but it is clear if it is rare, or even whether it was an ancient rather than a modern introduction to Tokelau. It is consequently not included in Table 3.

From the list of fifteen rare native flowering plant species listed in Table 2 and the five cultural plants listed in Table 3, three have been selected for recommendation for inclusion on the Red List of Tokelau plants produced by the IUCN. These three, *Hedyotis romanzoffiensis*, *Achyranthes velutina*, and *Solanum viride*, are discussed in more detail below.

7. DISCUSSION AND RECOMMENDATIONS

Most of the vegetation of Tokelau is highly disturbed, but nevertheless is dominated by native species. The only major exception is village areas, where alien weedy species predominate. Most of the motus are covered with forests dominated by coconut palms mixed with variable amounts of native littoral species.

The native and naturalized flora of Tokelau is defined here as comprising 36 native species and 50 naturalized species (weeds), as is shown in Appendix 1. During the fieldwork on Atafu, four new native species were found—*Hibiscus tiliaceus*, *Portulaca lutea*, *Ipomoea pes-caprae*, and *Syringodium isoetifolium*. With a little bit of searching, these species are likely to turn up on the other two atolls as well, not to mention other new species. In fact, *Ipomoea pes-caprae* showed up on all three atolls this year, which is unusual. Also found during the fieldwork were twelve new weedy species—*Wedelia trilobata* (wedelia), *Kalanchoë pinnata* (life plant), *Cleome viscosa*, *Acalypha indica*, *Chamaesyce hypericifolia*, *Chamaesyce hyssopifolia*, *Chamaesyce thymifolia*, *Physalis angulata* (wild cape-gooseberry), *Solanum americanum* (black nightshade), *Stachytarpheta cayennensis* (blue rat's-tail), *Cyperus compressus*, and *Chloris barbata* (inflated fingergrass). This is an increase of 32% from what was previously known from the archipelago.

It is likely that some of the weeds recorded in the past are no longer found in Tokelau. They may have established a tenuous hold when they first arrived, but eventually disappeared. During the present study on Atafu, three weeds previously recorded from the island—*Ruellia prostrata*, *Peperomia pellucida*, and *Kyllinga nemoralis*—were not found. These have either disappeared, or were so uncommon as to escape the gaze of the alert botanist. During the work on Atafu, only three weedy species were found on the outer motus—*Laportea ruderalis* (not seen on the main motu), *Lepidium virginicum*, and *Phyllanthus amarus*. This is a good sign that most of the motus are generally free of weeds. What is not a good sign is the introduction of twelve new weedy species in the last 28 years. What is interesting is that of the twelve new weed records, four of them belong to the same family, and three of them to the same genus (*Chamaesyce*). *Chamaesyce*, with hundreds of species, includes many easily dispersed species that become weeds in relatively dry soils like those in Tokelau. None of the weeds recorded during the present fieldwork were seen to be invasive.

Three species, *Achyranthes velutina*, *Hedyotis romanzoffiensis*, and *Solanum viride*, are recommended for inclusion on a Red List for threatened and endangered species of Tokelau. The first two are native, the third is a cultural plant.

The author would like to make several recommendations for future research involving the plants of Tokelau.

1. Further Botanical Surveys.

Relatively few plant collections have been made on Nukunonu, and the author has never collected there. It, along with Fakaʻofo, should be visited and more collections made in order to make the flora more comprehensive.

2. Completion of a Flora of Tokelau.

A complete flora of Tokelau has never been done. The present report includes a checklist, but this is just an abbreviated version of a flora that is useless to the non-botanist in identifying native plants. While the flora should be published, it is nowadays more desirable to develop an electronic flora that is more easily accessible and can be more easily updated than a printed copy. Such an online flora has been done or places like Hawaiʻi and the Marquesas, and is being planned for Samoa. The completed flora should be put up on the existing website, floraoftokelau.com, along with photos, to increase its usefulness.

3. Red-Listing of Tokelauan Plant Species.

The work in this report is only preliminary. Three plant species rare in Tokelau, *Achyranthes velutina*, *Hedyotis romanzoffiensis*, and *Solanum viride*, are recommended here for inclusion in the IUCN Red List of Tokelauan plants. To facilitate this, a panel of experts should collaborate and determine if the three qualify. Profiles for the three are presented in Appendix 3.

4. The Collection of Live Material of the Rare Species.

Live material of the three plants that are recommended for red-listing should be made. Perhaps even more importantly, live material (cuttings) of the cultivars of Pandanus tectorius (screwpine) should be made. These are disappearing from Tokelau because of changing life styles and agricultural needs. Only a few of them were pointed out to the present author during his work on Atafu.

5. Establishment of a Botanical Garden.

A botanical garden should be set up in Tokelau to grow rare native plants and cultigens. Probably the best place would be on the large motu of Fenua Fala on Fakaʻofo. However, it is also advisable to grow the plants in Samoa, which as more land and resources. This particularly applies to the cultivars of screwpine. It is also advisable to set up an exchange of plants with regional or global botanical gardens under the Botanical Gardens Conservation International (BGCI) program to make sure that the native species and cultigens do not disappear. Botanical gardens like the National Tropical Botanical Garden and the Lyon Arboretum in Hawaiʻi have established programs.

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10. APPENDICES (3)

Appendix 1. Checklist and distribution of native and naturalized plants of Tokelau.

Species Name	FAMILY A[1]	F[2]	N[3]	*Tokelauan*	
				FERNS AND FERN ALLIES	
	ASPLENIACEAE				
Asplenium nidus L.				*laumea*	
	A	F	N		
	NEPHROLEPIDACEAE				
Nephrolepis hirsutula (Forst. f.) Presl				*lau maile kimoa*	
	A	F	N		
	POLYPODIACEAE				
Phymatosorus grossus (Langsd. & Fisch.) Brownlie				*lau maile*	A
	F	N			
Psilotum nudum (L.) Beauv.				*fale 'o te kimoa*	
	A	F	N		
	PTERIDACEAE				
Pteris tripartita Sw.				----------	
	--	F	--		
	VITTARIACEAE				
Vittaria elongata Sw.				----------	
	--	--	N		
				DICOTS	
	ACANTHACEAE				
Ruellia prostrata Poiret				----------	
	A	--	--		
	AMARANTHACEAE				

Achyranthes velutina Hooker & Arnott *tamatama*

A F N

APOCYNACEAE

Catharanthus roseus (L.) G. Don ----------

A F N

Neisosperma oppositifolium (Lam.) Fosb. & Sachet *fao* --

F N

ASTERACEAE

Eleutheranthera ruderalis (Sw.) Sch.-Bip. ----------

A F N

Mikania micrantha Kunth ----------

A F --

Synedrella nodiflora (L.) Gaertn. ----------

A F N

Vernonia cinerea (L.) Less. ----------

A F N

Wedelia trilobata (L.) Hitchc.[4] ----------

A F N

BARRINGTONIACEAE

Barringtonia asiatica (L.) Kurz *futu*

A F? N

BORAGINACEAE

Cordia subcordata Lam. *kanava*

A F N

Tournefortia argentea L. f. *tauhunu*

A F N

BRASSICACEAE

Lepidium virginicum L. ----------

A F N

Rorippa sarmentosa (DC.) Macbride ----------

-- F --

CAPPARACEAE

Cleome viscosa L.[4] ----------

A -- --

CARICACEAE

Carica papaya L. *ehi*

A F N

Species FAMILY *Tokelauan*

Name A[1] F[2] N[3]

CASSYTHACEAE

Cassytha filiformis L. *fetai*

A F N

COMBRETACEAE

Terminalia samoensis Rech. *talie*

-- F --

CONVOLVULACEAE

Ipomoea macrantha Roemer & Schultes *fue*

A F N

Ipomoea pes-caprae (L.) R. Br.[4] ---------

A F N

CRASSULACEAE

Kalanchoë pinnata (Lam.) Pers.[4] *pagi*?

-- -- N

EUPHORBIACEAE

Acalypha indica L.[4] ----------

A -- --

Acalypha lanceolata Willd. ----------

-- F --

Chamaesyce hirta (L.) Millsp. ----------

A F N

Chamaesyce hypericifolia (L.) Millsp.[4] ----------

A F --

Chamaesyce hyssopifolia (L.) Small[4] ----------

A F --

Chamaesyce prostrata (Aiton) Small ----------

A F --

Chamaesyce thymifolia (L.) Millsp.[4] ----------

-- F --

Euphorbia cyathophora Murray *hei ‘a Matatia?*

-- F N

Phyllanthus amarus Schumacher & Thonning ----------

A F N

FABACEAE

Mimosa pudica L. ----------

-- F --

GOODENIACEAE

Scaevola taccada (Gaertn.) Roxb. *gahu*

A F N

HERNANDIACEAE

Hernandia nymphaeifolia (Presl) Kubitzki *puka, puka ama* A

F N

LYTHRACEAE

Pemphis acidula Forst. *gagie*

A F N

MALVACEAE

Hibiscus tiliaceus L.[4] *fau*

A -- --

MORACEAE

Ficus tinctoria Forst. f. mati

A F N

NYCTAGINACEAE

Boerhavia tetrandra Forst. *nuna*

A F N

Pisonia grandis R. Br. *puka kakai*

A F N

ONAGRACEAE

Ludwigia octovalvis (Jacq.) Raven *mahiku* (F)

-- F --

PIPERACEAE

Peperomia pellucida (L.) Kunth ----------

A F --

PORTULACACEAE

Portulaca lutea Sol. ex Forst. f.[4] *katuli*

A -- --

Portulaca oleracea L. *katuli*

A F --

Portulaca samoensis Von Poll. *katuli*

-- F N

Species *Name*	FAMILY A[1] F[2] N[3]			*Tokelauan*

RUBIACEAE

Guettarda speciosa L. *puapua*

A F N

Hedyotis romanzoffiensis (Cham. & Schlecht.) Fosb. *kautokiaveka* A

F N

Morinda citrifolia L. *nonu*

A F N

Spermacoce assurgens Ruiz & Pavón ----------

A F N

SOLANACEAE

Physalis angulata L.[4] ----------

A F --

Solanum americanum Mill.[4] ----------

-- F --

Solanum viride Forst. f. ex Spring. polo

-- F N

TILIACEAE

Triumfetta procumbens Forst. f. *totolo*

A F N

URTICACEAE

Laportea ruderalis (Forst. f.) Chew *ateate* A

F N

Pilea microphylla (L.) Liebm. ----------
-- F --
Pipturus argenteus (Forst. f.) Wedd. fau
A F N
Procris pedunculata (Forst.) Wedd. *gahe vao* A
F N

VERBENACEAE

Stachytarpheta cayennensis (L.C. Rich.) M. Vahl [4] *mautofu*
A -- --

MONOCOTS

ARECACEAE

Cocos nucifera L. *niu*
A F N

CYMODOCEACEAE

Syringodium isoetifolium (Aschers.) Dandy[4] --------- --
-- N

CYPERACEAE

Cyperus compressus L.[4] ----------
-- F --
Cyperus rotundus L. *mumuta*
-- F --
Eleocharis geniculata (L.) R. & S. ----------
-- F --
Fimbristylis cymosa R. Br. *tuihē*
A F N
Kyllinga brevifolia Rottb. ` ----------
-- F --
Mariscus javanicus (Houtt.) Merr. & Metcalfe ----------
-- F --

PANDANACEAE

Pandanus tectorius Parkinson *fala*
A F N

POACEAE

Brachiaria subquadripara (Trin.) Hitchcock ----------
-- F --
Cenchrus echinatus L. *vao tuitui*
-- F N
Chloris barbata (L.) Sw.[4] ----------
A -- --
Digitaria horizontalis Willd. ----------
-- F --
Digitaria radicosa (Presl) Miq. ----------
-- F --
Digitaria setigera Roth ex Roem. & Schultes ----------
-- F N

Eleusine indica (L.) Gaertn. ----------
A F N
Eragrostis tenella (L.) Beauv. ex Roem. & Schultes --------- A F N

Species *Name*	FAMILY A[1]	F[2]	N[3]	*Tokelauan*
POACEAE (cont'd.)				
Lepturus repens (Forst. f.) R. Br.				*mutia*
	A	F	N	
Paspalum conjugatum Bergius				*vao lima*
	--	F	--	
Paspalum vaginatum Sw.				----------
	--	F	--	
Pennisetum purpureum Schumacher				----------
	--	F	--	
Sporobolus diander (Retz.) Beauv.				----------
	A	--	--	
Stenotaphrum secundatum (Walter) Kuntze				----------
	--	F	--	
TACCACEAE				
Tacca leontopetaloides (L.) Kuntze				*māhoā*
	A	F	N	

---

[1]Atafu. [2]Faka'ofo. [3]Nukunonu. [4]Indicates a new record for Tokelau.
Species in bold are native.

All Species (86)
56 75 50
Alien Adventive (50)
29 42 20
Native Species (36)
27 33 30

Appendix 2. Parham's (1971) vegetation description of Nukunonu (edited by the author).

(1) PLANTS OF THE FORESHORE:

The unprotected sandy or 'shingly' beach between high-tide level and the frontage of the beach-crest is, at the present time at least, practically devoid of vegetation. This is probably due to the unstable condition of this exposed zone. On the upper slope occasional plants of the creeping sand-binder *Triumfetta procumbens*, the grass *Lepturus repens*, and the sedge *Fimbristylis cymosa* may occur as pioneers on a recently-formed beach or as remnants on the older beach which has been eroded by the action of waves.

(2) PLANTS OF THE BEACH-CREST:

Also exposed to wind and salt-spray and with its lower margin occasionally inundated briefly at spring-tides, the beach-crest rises gradually, and sometimes abruptly, to a height of 3–5 m above the high-tide mark, with a more stable beach frontage of coral sand, rubble or exposed coral limestone ("hard-pan"), and may extend 10–20 m inland. This zone supports several plant communities comprising a distinct association of trees and shrubs, with their seedlings and a few herbaceous plants in the ground cover. These, briefly described below, are: (a) the *Scaevola taccada* facies, (b) the *Pemphis acidula* facies, (c) the *Messerschmidia argentea* [*Tournefortia argenteus*] facies, characteristic of the exposed sea-side frontage of the habitat; and (d) the *Pandanus/Guettarda speciosa* facies, which last is a mixed community extending a short distance inland, with many more species represented.

(a) THE SCAEVOLA TACCADA FRINGING-SCRUB COMMUNITY:

This forms a windbreak, up to 3 m. high, on the seaward face of the beach-crest, on sand, or broken coral rubble immediately above spring-tide level. Often the lower branch tips and roots of the plants in this community are inundated at high tide.

(b) THE PEMPHIS ACIDULA SCRUB FACIES

This is a typical beach community occurring on both ocean and lagoon beaches, always on the hard-pan coral in open exposed sites; sometimes on "rocks" offshore, but above the reach of normal high tides. In the Tokelau group this plant is a tall straggling shrub or small tree, up to 4 m or more high, and the stands are usually without vegetative ground cover. On Long motu, Nukunonu, a large clump was noted growing on a hard-pan area on the inland side of the beach-crest. It seems possible that this unusual site is the remnant of the original foreshore isolated from the beach by the accretion of sand.

(c) THE MESSERSCHMIDIA [TOURNEFORTIA] ARGENTEA FACIES:

This is also common on the beach frontage close to and often overhanging the high-tide level. Here *Tournefortia argentea* grows to a height of about 4 m with a spreading canopy; and associated with it are the wild screwpine *Pandanus tectorius,* the grass *Lepturus repens,* and seedlings of *Scaevola taccada.* The exposed beach communities described above comprise a discontinuous strip of vegetation on the seaward frontage of the beach-crest community.

(d) THE PANDANUS/GUETTARDA SPECIOSA FACIES.

Generally having a canopy rising well above that of the preceding communities, this vegetation comprises several layers. Palms and palm-like trees, the coconut and wild screwpine, the trees *Guettarda speciosa, Cordia subcordata*, *Hernandia peltata,* and the tall shrub *Morinda citrifolia,* are all common in the upper story to 6–8 m high, but rarely are seen the *Neisosperma oppositifolium* and *Calophyllum inophyllum.* Also the beach shrubs *Scaevola taccada* and *Tournefortia argentea* not uncommonly occur, together with the fig *Ficus tinctoria,* and seedlings of several of the trees as a shrubby understory. The strand shrub *Hedyotis romanzoffiensis* was found only on Tuatiga and Vini motu. The parasitic climbing vine *Cassytha filiformis* and the liana *Ipomoea macrantha* are conspicuous on trees and shrubs, the former also on the low-growing *Boerhavia*

tetrandra, which with the grass *Lepturus*, the creeping *Triumfetta*, and the erect shrubby *Achyranthes velutina* favors the more open sites in the community. The ferns *Phymatosorus grossus,* and less commonly, *Nephrolepis hirsutula,* occur as terrestrial species.

In general reference to the coastal vegetation of the Tokelau group, attention may be drawn to its status in relation to typical tropical shore formations as defined by van Steenis (1958): "the [vegetation] of the sandy beach in a broad sense consists of two parts, (1) the mostly herbaceous, largely creeping flora on the seaward face, the *pes-caprae* formation and (2) behind it, the largely ligneous *Barringtonia* fringe-forest. These two formations can occur one without the other, the first only on accreting coasts where sand accumulates, and the second on the sand-ridge [beach crest]. In certain associations no morning glory (*Ipomoea*) is present and, if there is excess of sand. *Barringtonia* need not always be present." Since at the present time, neither *Ipomoea pes-caprae* nor *Barringtonia asiatica* are known to occur in the Tokelau Islands in a wild state, the Tokelau coastal communities correspond in only a limited sense with facies of these two widespread tropical shore formations. This may be a temporary situation owing either to the present unstable nature of the beaches and coastal fringes which have been eroded by heavy seas in recent years, or to the felling of *Barringtonia asiatica* and other trees by the inhabitants.

(3) PLANTS OF THE CENTRAL ZONE:

Occupying the protected central zone of the islets, this "inland" vegetation is comparatively luxuriant in number of species, their abundance, and dense growth at various levels. Here, sheltered above by the continuous palm-leaf canopy and protected on the sides from salt-laden winds by the beach-crest communities, a micro-climate of the tropical rain-forest prevails, the soil and water relations are good, and there is a heavy accumulation of fallen leaves, branches and logs in all stages of decomposition. The ground cover of ferns, occurring both in terrestrial form and as epiphytes on fallen logs and branches, and other shade-tolerant plants is a conspicuous feature; and fungi, mosses and lichens are common. The high-climbing liana *Ipomoea macrantha* is frequent on all atolls. An example of the capacity for rapid regeneration of vegetation in this zone was observed by Dr Wodzicki on a motu at Atafu, where a "scorched-earth" programme carried out four years previously by a Health Officer, as a demonstration of a so-called "practical means of controlling rats," had been succeeded by a striking regrowth of the natural plant cover (Wodzicki, 1968). The structure of this community may be briefly described: Dominant or overstory trees: *Cocos nucifera;* 10–20 m high with an individual canopy spread to 10 m, grows closely' together on most motu (up to 300 to 750 palms per hectare), with crowns of 10–15 fronds each, overlapping on all sides to provide a varying degree of shade from the light and heat of the sun. Secondary trees comprising the understory include: *Cordia subcordata;* common on the outskirts, with a wide-spreading crown of dense foliage; *Pisonia grandis*; widely-branching, in limited stands (facies), with less dense foliage; *Guettarda speciosa*; in the forest as a tall tree with spreading, large-leaved crown. *Pandanus* spp.; palm-like stilt-rooted trees, with a dense crown of drooping serrated leaves, 2–3 m long, often with the dead leaves hanging in a tuft below. Seedling trees and tall shrubs: seedlings of all the above species, often crowded and reaching a height of 4–6 m are common, along with the taller shrubs, *Morninda*, *Ficus*, and *Solanum viride* scattered throughout. Low shrubs, often overcrowded in the ground cover dominated by the luxuriant growth of terrestrial ferns, are frequent to common: *Procris*

pedunculata, Pipturus argenteus, and seedlings of other species. The terrestrial ferns are the dominant feature of the ground cover, especially *Asplenium nidus* with entire fronds up to 1.5–2 m long and 15 or more cm wide; *Phymatosorus grossus* is very common, with fronds 6–9 dm long. Both these species also occur as epiphytes on the trunks of coconut palms, *Pandanus,* and other trees. The fern *Nephrolepis hirsutula* occurs in the same habitats; but *Psilotum nudum* and *Vittaria rigida* are found only as epiphytes on the fibrous base of *Asplenium nidus.* The *Vittaria* is here recorded for the first time from the Tokelau group; and the *Psilotum* only once before.

THE ADVENTIVE PLANTS:

Apart from the thirteen species introduced and cultivated for food or ornamentals, the number of adventive plants collected on Nukunonu, or collected and observed on Atafu or Faka'ofo, is small. These are all found almost exclusively in the village *malae* or neighborhood or in gardens. All are widespread and frequent weeds of such habitats. The grasses *Eleusine indica, Eragrostis tenella, Digitaria setigera* and *Cenchrus echinatus,* are all common in open more or less dry, sandy areas everywhere in the tropics; the composites *Vernonia cinerea, Eleutheranthera ruderalis* and *Synedrella nodiflora* are equally widespread in warm climates, as also are the spurges, *Chamaesyce hirta, Chamaesyce prostrata* and *Phyllanthus amarus.*

The adventives comprise a minor element in the local vegetation of artificially developed habitats associated with human activities; and in the same situations are found two interesting plants which cannot but be regarded as indigenous, but which do not occur in any of the communities already described. These are the rare sand-grass *Lepturus acutiglumis,* and the nettle *Laportea ruderalis.* Of the former species, but three plants have been collected from a clump of the adventive grass, *Eleusine indica,* growing on the village motu; and of the latter, one specimen from that same locality and one from Vaitupu on Long Motu. Common in the undergrowth of the coconut forest is the Polynesian arrowroot, *Tacca leontopetaloides*. The plant, widespread in Polynesia usually in sandy areas behind the beach, is sometimes cultivated for the starch-rich tubers, but it is generally regarded as an indigenous plant.

Appendix 3. Plant Species Recommended for Red listing for Tokelau.

AMARANTHACEAE

Achyranthes velutina Hooker & Arnott

Bot. Beechey Voy. 68. 1842; Parham in N. Z. Jour. Bot. **9:** 596. 1971; Whistler in Atoll Res. Bull. **262:** 8. 1983; Whistler in Econ. Bot. **42:** 165. 1988.

Achyranthes of Pickering in USEE: 238. 1876.

TOKELAU NAME: *tamatama, lau tamatama*
ENGLISH NAME: none

Indigenous to Tokelau, ranging from Tokelau eastward to the Tuamotus and northward to Micronesia. This subshrub is restricted to atolls and makatea islands, where it occurs in sunny, sandy, coral rubble, or limestone areas, and is probably uncommon or rare on most of islands on which it occurs. In Tokelau it is uncommon or rare on all four islands. It was not found on

Atafu during the 2011 survey there, and it appeared that no one knew the name anymore. Some authors consider this to be just an atoll variety (var. *velutina*) of *Achyranthes aspera* L. The two are very difficult to distinguish, but *Achyranthes velutina* is much more canescent. The leaves, heated over a fire, were formerly applied to superincision (the technical term for the Polynesian form of circumcision) wounds, a practice also reported from Tonga and Samoa. Also called *vao tuitui*, by people who do not know its real name. This species should be considered to be rare in Tokelau, and should be red listed to reflect this.

Erect woody herb or subshrub up to 2 m in height, with densely white-pubescent stems. **Leaves** simple, opposite; blade obovate to nearly round, mostly 3–15 cm long, acute to attenuate at the base, acute to acuminate and mucronate at the tip; surfaces densely white-pubescent; margins entire; petiole 5–15 mm long. **Inflorescence** a narrow terminal spike 5–45 cm long, with a densely woolly rachis, bearing spikelet-like flowers. **Calyx** of 3 hard, lanceolate, green, lanceolate tepals 5–8 mm long, with 3 shorter spine-tipped bracts below; sessile. **Corolla** absent. **Ovary** superior, 2-celled, with a capitate stigma on a short style. **Stamens** 5, free, included. **Fruit** an ovoid, 1-seeded utricle, falling enclosed within the calyx.

Distinguishable by its herbaceous or subshrub habit; white-pubescent foliage; opposite simple leaves; tiny green flowers; and sharp-tipped, grass-like fruits in terminal spikes.

ATAFU: *Woodward 180*, *181*, *182*; *Whistler 5755*. **FAKA'OFO**: (USEE); *Bryan 68*; *Woodward 69*, *70*, *71*; *Whistler 4649*, *4659*. **NUKUNONU**: *Wodzicki 12*. **SWAINS**: *Whistler 3420*.

RUBIACEAE

Hedyotis romanzoffiensis (Cham. & Schlecht.) Fosb.

Occ. Pap. Bishop Mus. **13:** 248. 1937; Parham in N. Z. Jour. Bot. **9:** 599. 1971; Whistler in Atoll Res. Bull. **262:** 14. 1983; Whistler in Econ. Bot. **42:** 165. 1988.

Petesia? of Pickering in USEE: 236, 238. 1876.

TOKELAU NAME: *kautokiaveka*
COMMON NAME: none

Indigenous to Tokelau, ranging from Tuvalu to the Tuamotus, and northward to Christmas Island. It is uncommon to rare on the four Tokelau islands in open, sunny places. It was not located on Atafu during the 2011 survey, even in the place where it was formerly collected and known by the locals to have occurred. Its fruits are sometimes gathered and used in making leis. This plant should be red-listed because of its rarity in Tokelau and elsewhere in the Pacific islands.

Subshrub up to 1.3 m or more in height, with glabrous stems and interpetiolar stipules. **Leaves** simple, opposite, blade obovate, 2–7 cm long, attenuate at the base, broadly acute to rounded at the tip; surfaces glabrous; margins entire; petiole 0.2–1.5 cm long. **Inflorescence** of solitary flowers, or 2- or 3-flowered cymes 0.5–3 cm long. **Calyx** urn-shaped, 3–5 mm long, 4- or 5-lobed at the tip; pedicel 2–10 mm long. **Corolla** sympetalous, salverform, white, tube ca. 5 mm long, limb of 4 ovate lobes 4–5 mm long. **Ovary** inferior, style 2-lobed. **Stamens** 4 epipetalous, partly exserted. **Fruit** a fleshy, obovoid drupe-like berry 1–1.5 cm long, white turning purple.

Distinguishable by its small woody herb habit; opposite leaves; interpetiolar stipules; white sympetalous flowers in short inflorescences; and a white fleshy fruit.

ATAFU: *Wodzicki s.n.* (2); *Whistler 4615, 5750*. **FAKA'OFO**: (USEE). **NUKUNONU**: *Wodzicki 42, 63, 93*. **SWAINS**: (USEE); Lister s.n.; (Whistler, n.s.).

SOLANACEAE

Solanum viride Forst. f. ex Spreng.

In Biehler, Pl. Nov. Herb. Spreng. **14:** 1807; Parham in N. Z. Jour. Bot. **9:** 599. 1971; Whistler in Econ. Bot. **42:** 170. 1988.

Solanum uporo Dunal in DC. Prodr. **13 (1):** 138. 1852; Whistler in Atoll Res. Bull. **262:** 15. 1983.

TOKELAU NAME: *polo, fua polopolo*
COMMON NAME: cannibal cherry

Probably an intentional Polynesian introduction to Tokelau, ranging from Melanesia to eastern Polynesia. It is unclear what the native range for this species is, since it is more common in cultivation than in the wild, and appears to have gone extinct, or nearly so, in some of the islands in its reported range. In Tokelau it is rare in sunny open places on three of the islands (not reported from Atafu). The fruit was probably once cultivated as a minor tomato-like fruit, and possibly for medicine and for decoration (fruit leis). This plant should be red-listed because of its rarity in Tokelau and elsewhere in the Pacific islands.

Shrub up to 2 m in height with nearly glabrous to pubescent stems. **Leaves** simple, alternate; blade ovate, mostly 8–18 cm long, unequal and usually decurrent at the base, acute at the tip; surfaces glabrous to pubescent with simple and branched hairs; margins subentire to shallowly lobed; petiole 1–3 cm long. **Inflorescence** of axillary and terminal, several-flowered cymes. **Calyx** synsepalous, 2–7 mm long, 5-lobed, on a pedicel 4–20 mm long (1–5 cm long in fruit). **Corolla** sympetalous, rotate, white or yellowish white, often pubescent on the outside, divided to near the base into 5 lobes 5–12 mm long. **Ovary** superior, with a short style and capitate stigma. **Stamens** 5, epipetalous, yellow. **Fruit** a subglobose or ellipsoid berry mostly 1–2 cm in diameter, glossy red. **Flowering** and fruiting probably occur throughout the year.

Distinguishable by its subshrub habit; alternate, mostly glabrous, ovate leaves; several-flowered clusters of white rotate flowers with yellow stamens; and red fruit much like a cherry tomato.

FAKA'OFO: *Whistler 4650*. **NUKUNONU**: *Wodzicki 2, 8, 29, 86, 108*. **SWAINS**: *Bryan 69*; *Schultz 8*.

Appendix 9 - Preliminary report on the biodiversity survey of arachnids on Nukunonu

Dr Amber S. Beavis

A comprehensive biodiversity survey of arachnids (spiders, schizomids and pseudoscorpions) was conducted on Nukunonu from 6th July – 6th August 2011, by Dr Amber S. Beavis and Mr Tom Sapienza. Identifications of the specimens collected during this survey are currently underway, however, some early statements can be made regarding the arachnid assemblages recorded during the survey as follows:

1. Work by Dr B. M. Marples in the 1950s detected the presence of one endemic spider species, *Apiacera minuta*, which is known only to exist in the Tokelau islands. This species of spider from the family Ochyroceratidae was collected from Nukunonu in some numbers. Further examination of these specimens is required to confirm whether this species is, in fact, endemic to Tokelau.
2. Representatives of upwards of 9 spider families, 1 pseudoscorpion family and 1 schizomid family were collected. Spiders collected included wolf spiders (Lycosidae), jumping spiders (Salticidae) and huntsman spiders (Sparassidae). These spider groups are known to be widespread across Polynesia and much of the Pacific.
3. Of particular interest is whether spiders from the family Desidae were collected on Tokelau. An endemic species of Desidae is known from Swain's Island. We are interested in determining whether this species was found on Tokelau. This spider inhabits the intertidal zone, and it is worth noting that a number of spiders were collected from amongst coral rubble that superficially resembled desid spiders.

Dr Beavis is a researcher at the Western Australian Museum in Perth and is currently identifying all specimens collected from Tokelau. A full report will be forthcoming as soon as all IDs have been performed.