Invasive Alien Species Management Plan 2016-2020, Aleipata Islands, Samoa

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INVASIVE ALIEN SPECIES MANAGEMENT PLAN

2016-2020

ALEIPATA ISLANDS, SAMOA

GEF-PAS Invasive Alien Species project/Samoa

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New Eden Samoa Environment Consultants

on behalf of the Ministry of Natural Resources and Environment, Department of Environment and Conservation

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Photo on the cover: Aerial image of the four islands of the Aleipata group: foreground to the left, the Fanuatapu islet, next to the right, still within the reef fringe, Namua island (almost at the center of the image). In the background, outside the reef, Nu'ulua (small to the left) and Nu'utele (larger to the right) (Credit: Stuart Chape).

GLOSSARY

CEPF: Critical Ecosystem Partnership Fund

CI: Conservation International

DEC: Department of Environment and Conservation

DoC: Department of Conservation, New Zealand

EDRR: Early Detection and Rapid Response

GEF: Global Environmental Facility

IAS: Invasive Alien Species

IS: Island Conservation

IUCN: International Union Conservation of Nature

MNRE: Ministry of Natural Resources and Environment

MAF: Ministry of Agriculture and Fisheries

MPA: Marine Protected Area

NUS: National University of Samoa

NZ: New Zealand

PAS: Pacific Alliance for Sustainability

PII: Pacific Invasives Initiative

SISERP: Samoa Invasive Species Emergency Response Plan

SPREP: Secretariat of the Pacific Regional Environment Programme

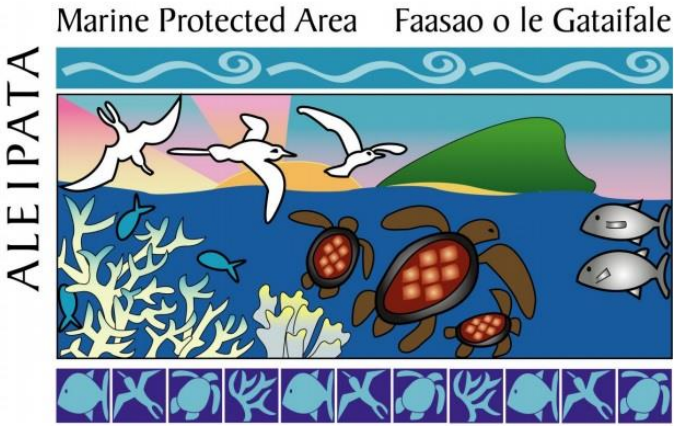
UNEP: United Nations Environment Programme

YCA: Yellow Crazy Ants

USP: University of South Pacific

1. INTRODUCTION

In 1989 the IUCN prompted the establishment of a marine protected area (MPA) programme targeting the coastal waters of eastern Upolu's tip and including the four Aleipata islands: Nu'utele and Nu'ulua (outside the barrier reef) and Namua and Fanuatapu (within the barrier reef) - see map below as a reference.



The government in collaboration with the Aleipata District (eleven villages) and IUCN developed a management plan - the last update being for the period 2008-2010 (MNRE 2008) - with the aim to guide the protection and conservation of the marine environment of the Aleipata District.

One of the Aleipata MPA management plan's guiding principle states that "**We commit Aleipata's offshore islands (N u'ulua, Nu'utele) and their wealth of biodiversity as a critical part of our Aleipata MPA**". The same plan acknowledges that "**Aleipata's islands are vitally important refuges for Samoa's natural heritage and we will continue to support these islands as an integral part of our Aleipata MPA**.

Aleipata Marine Protected Area (MPA). Area in blue: lagoon; area in brown: coral reef; area in purple: reef slope; areas in white: terrestrial habitats of Aleipata islands. Map: Conservation International.

These islands are also a vital part of our history and culture and we will also ensure conservation of the cultural heritage they contain".

The four Aleipata islands are therefore integrant part of the MPA following the concept that land and coastal ecosystems are ecologically strictly linked, especially so in small oceanic islands. The behavioural ecology of sea birds and turtles exemplify well this concept. A comprehensive and holistic approach "ridge-to-reef" is the most widely accepted conservation practice nowadays (e.g. IUCN and GEF have specific ridge-to-reef programs for Oceania).

Few locally managed no-take zones were established and run for some time. A shipyard with dry dock was established in the middle of the MPA during the 1990s and started its operation of ship renovations against the advise of CI and of an environmental impact assessment.

A trust fund was established in 2003 by Conservation International (CI) aimed at the implementation of the mentioned management plan. CI in collaboration with the Critical Ecosystem Partnership Fund (CEPF) and the Secretariat of the Pacific Regional Environment Programme (SPREP) became keen to implement the part of the management plan focusing on Nu'ulua and Nu'utele islands (priority working goal # 3.3). Therefore a project was funded by CEPF and implemented by SPREP and MNRE during period 2009-2011 (SPREP 2008, see below).

The MPA operation came to an halt soon after the tsunami of September 2009, due to problems in managing the trust fund and amidst allegations of corruption. Investigations are apparently still under way. The management plan was never updated beyond 2010. Apparently there are currently intentions to revive and update it during 2016 (MNRE/Marine Division *pers. comm.*).

Invasive Alien Species (IAS) conservation work in the Aleipata islands started in early 2000s with the identification of occurrence of IAS through several field ecological surveys (refer to Serra and Faleafaga 2015a). Priority for management action was given to Nu'utele and Nu'ulua islands because among the four Aleipata islands they are the only uninhabited ones large enough and far enough offshore to be considered as refuges for key native threatened biodiversity of Samoa.

Management priority on these two islands was given to the Pacific rat *Rattus exulans*, the Yellow crazy ant (YCA) *Anoplolepis gracilipes* and the feral pigs *Sus scrofa*. This animal focus was chosen because fortunately no relevant ecological invasion of alien flora had been detected on the two islands. In particular, the three animal species were selected as they potentially represented the hi ghest threat for the two islands' native forest ecosystems.

Outcomes of mentioned IAS surveys informed the update of the Aleipata MPA's management plan 2008-2010. Its working goal # 5.3.1 ("Offshore islands") in fact envisaged that: "**by the end of 2010 our offshore islands (Nu'utele and Nu'ulua) will have had implemented a restoration programme focusing on rat eradication, and endangered bird-life (land and sea bird) and other native wildlife conservation and overall security of these islands for heritage conservation (natural and cultural).** We will have investigated and decided upon options for nature tourism development for these islands."

As already mentioned, management action on the ground took place through a CEPF project during period 2009-2010, in the form of a SPREP/CI partnership with key support from DoC and PII (SPREP 2008) and as a mean to implement priority working goal # 5.3.1 of the MPA management plan. Main outcomes achieved by the CEPF project (Tye 2012, CI 2013) were:

- Eradication of rats from Nu'ulua (as ascertained in late 2015)
- Key lessons learned from failed attempt to eradicate rats in Nu'utele
- Improved knowledge on YCA and on occurrence of key biodiversity assets of the four Aleipata islands
- Preliminary engagement of local community and awareness on the dire need of biosecurity.

Recent IAS surveys run in late 2015, under a GEF-PAS IAS project (MNRE/SPREP/UNEP), highlighted the fact that these islands, despite having being recognized in recent times of the highest national and international relevance in terms of biodiversity conservation and despite being fully included in the Aleipata MPA, are currently still threatened by IAS occurring in Upolu. The surveys in fact ascertained that the risk of invasions by IAS (animals and plants) from Upolu is still very high due to the complete absence of any biosecurity measure.

2. AIM AND METHOD

The aim of present document is to make good use of all the knowledge and lessons learned produced so far in order to create the simplest and most cost-effective IAS management plan for the Aleipata islands that can be implemented during a short-term period: 2016-2020. This plan should align with and become integrant part of the next update of the management plan for the Aleipata MPA, apparently due to materialize by 2016. Due to the above, we adhered as much as possible to the format of the last update of the Aleipata MPA's management plan, including the short-term approach.

The method employed to compile this management plan was the following. Firstly a thorough review of available knowledge and literature about IAS in the Aleipata islands was run (Serra and Faleafaga 2015a). Secondly, IAS surveys were run in the four Aleipata islands during September-December 2015 in order to assess current status of invasions by key alien species (animals and plants) (Serra and Faleafaga 2015b). Based on this information a first draft of a short-term management plan was prepared in a way to be fully consistent with the Aleipata MPA's management plan.

A consultation with the Aleipata MPA District Committee was held on 13 November 2015 with the aim to inform them about the results of the surveys and to discuss the draft management plan. Their inputs and comments were duly recorded and integrated. The new draft was then circulated among key experts and stakeholders from MNRE, SPREP and CI in order to capture as much as possible their comments and advises.

3. VISION

The intrinsic spiritual, economic and recreational values of the Aleipata islands as a piece of unique natural heritage of Samoa and of Polynesia are preserved in the long term in the benefit of present and future generations.

4. GUIDING PRINCIPLES

The same principles adopted for the Aleipata MPA's management plan are proposed:

- We believe that Christianity and the faasamoa - our way of life and culture - underpin the success of our Aleipata MPA.
- We take responsibility for making all decisions for our Aleipata MPA.
- We commit to maintaining the life support systems of our marine environment and to conserve and wisely use the resources they contain.
- We will focus on raising awareness and the education of our people, particularly our children, to support our Aleipata MPA.
- We will find opportunities to develop businesses that are sustainable, compatible and profitable for our people and our Aleipata MPA.
- We commit to operating our Aleipata MPA in a transparent and accountable manner.
- We commit to operating our Aleipata MPA in a just manner, and to fair and equitable cost and benefit sharing.
- We will build partnerships within and outside Samoa to assist the implementation of our Aleipata's MPA Management Plan.
- We commit Aleipata's offshore islands (Nuulua, Nuutele) and their wealth of biodiversity as a critical part of our Aleipata MPA.
- We believe our Aleipata MPA Management Plan is a work in progress that like the MPA will never end. We will agree changes over time to best achieve our vision for Aleipata's MPA.
- We commit to sharing the experience of the Aleipata MPA for the betterment of Samoa and its people.

5. SUMMARY OF SHORT TERM PRIORITY GOALS 2016-2020

5.1 FUNDS - Fund raise and commit adequate funds.

5.2 BIOSECURITY - Prevent arrival of additional alien invasive species to Nu'utele, Nu'ulua and Fanuatapu islands through strict biosecurity.

5.3 PRESERVATION - Implement and enforce legal protection of forest ecosystems and associated biodiversity of the Aleipata islands (Nu'utele and Nu'ulua in first place).

5.4 RESTORATION - Restore ecosystems of Nu'utele and Nu'ulua islands through IAS active management.

6. SHORT TERM PRIORITY GOALS 2016-2020: ISSUES AND ACTIONS

6.1 FUNDS. Fund raise and commit adequate funds

Issues

Conservation and specifically IAS management require adequate funds. In order to obtain funds Samoa Government must fund raise with determination with the key assistance of international organizations available locally, like SPREP and CI. The ideal way to secure funds would be to include Aleipata IAS management within the MNRE's Biodiversity Focal Area in GEF 6 or 7.

Actions:

- Identify suitable funds
- Prepare and lodge proposals with the assistance of international organizations.

6.2 BIOSECURITY. Prevent arrival of additional alien invasive species to Nu'utele, Nu'ulua and Fanuatapu islands through strict biosecurity

Issues

Rain forests of the Aleipata islands, especially those of Nu'utele, Nu'ulua and Fanuatapu, are still healthy and pristine. Potentially dangerous invasive plants such as *Albizia, Falcataria*, *Merremia* and *Sphagneticola* have already found their way to these islands – but, fortunately, they have not invaded them yet. Three major key animal IAS are instead present and are invading or have invaded these islands. Dozens of other IAS plants and animals commonly occurring in Upolu could potentially find their way to these islands in the short term. It is clearly of paramount importance that no additional IAS reaches these islands. Implementing thorough and strict biosecurity measures is the

key. Recent work have shown that the awareness on the relevance of the issue by both Govt. staff and local community is still labile and insufficient. For instance, despite the dire need to eradicate pigs from Nu'utele was flagged as early as 2006, and despite this is not a very challenging task, this action has never materialized during the past 9 years. An Early Detection and Rapid Response (EDRR) strategy, specific for the Aleipata islands, should be discussed and agreed. This strategy should be aligned with the recently prepared national EDRR produced by MNRE (called "Samoa Invasive Species Emergency Response Plan" or SISERP). Training on biosecurity undertaken during the CEPF project should be completed, improved and upgraded by including those people who will actually implement biosecurity on the ground (for instance boatmen and fishermen).

Actions:

- ❖ Improve and upgrade awareness among local community and Government staff on the threats of IAS and the dire need of biosecurity

- ❖ Adjust recently revised SISERP in order to be fully operative in the Aleipata islands

- ❖ Improve and upgrade training of local community, MNRE and MAF/Quarantine staff on proper biosecurity methods and measures

- ❖ Identify responsibilities at MNRE, MAF/Quarantine and at local level to effectively support and implement biosecurity measures on the ground.

6.3 PRESERVATION. Implement and enforce legal protection of forest ecosystems and associated biodiversity of the Aleipata islands (Nu'utele and Nu'ulua in first place)

Issues

Recent data show that healthy and well-functioning rain forest native ecosystems are the best barrier against the invasion of alien species in oceanic small islands. Preserving the ecological integrity and functionality of rain forests is therefore the first key line of defence against IAS. The Aleipata MPA acknowledges the importance of islands' terrestrial ecosystems as confirmed by this statement included in the MPA's management plan "[…] we have agreed that eradication of rats from these islands is an important part of their restoration and also of our Aleipata MPA."

Actions:

- ❖ Develop and agree on an operational plan aimed at monitoring and enforcing the protection of the forests of Nu'utele and Nu'ulua islands and their valuable biodiversity (e.g. in relation to logging, hunting, collection of coconut crabs and turtle eggs etc.)

- ❖ Identify responsibilities, processes and budget allocations related to the implementation of the operational plan

- ❖ Implement the operational plan.

6.4 RESTORATION. Restore ecosystems of Nu'utele and Nu'ulua islands through IAS active management

Issues

In order to maximize chances of preservation of these unique native insular rain forest ecosystems in the medium- and long-term, attempts to control and/or eradicate present IAS animals and plants should be run. The dire need to eradicate pigs from Nu'utele was flagged as early as 2006 but never realized yet. An indication of current determination by MNRE/DEC to fight IAS in the Aleipata islands would be to eradicate the two IAS trees occurring in Nu'utele island as soon as possible making good use of funds, training and chemicals currently available thanks to the GEF-PAS IAS project (Mt Vaea restoration program). The recent review of the IAS Aleipata islands (Serra and Faleafaga 2015) suggests to improve knowledge of the biology and ecology of rats and YCA on Nu'utele and Nu'ulua in order to minimize risks of failures of future management attempts. The aim of this research would be to clarify and identify what are the specific ecological vulnerabilities in time and space of these two IAS occurring in the Aleipata islands. This would enable any future eradication attempt to be effective and successful. However, there is no broad consensus currently among the regional experts on the need of further research, especially in relation to rats. Some believe that priority should be given to action, although they concede that a new thorough feasibility analysis and careful planning process should be undertaken. Others maintain that this research phase is needed if a new failure, like the one happened in relation to Nu'utele in 2009, is to be prevented. The involvement of Island Conservation and key world-class experts is strongly recommended in order to run a feasibility analysis for a second rat eradication attempt in Nu'utele. Dr Ben Hoffman and the Victoria University should be instead involved for a feasibility analysis in regards to YCA management for both islands.

Actions:

- ❖ Prepare an operational plan to eradicate Tamaligi tree (one individual) and several Lopa trees in Nu'utele (Vini flats) and execute the eradication accordingly.

- ❖ Prepare an operational plan to eradicate pigs from Nu'utele involving an international expert assisted by locals and execute the eradication accordingly.

- ❖ Research biology and ecology of YCA in Nu'utele and Nu'ulua during a 1-year cycle or alternatively run a comprehensive feasibility analysis for YCA management involving key regional experts.

- ❖ Based on the research's results or the feasibility analysis, run a management program of YCA in both islands (if realistic based on available knowledge and technology).

- ❖ Run a thorough feasibility analysis for rat eradication in Nu'utele, based on the lessons learned from previous attempt (2009), and involving key regional organizations and experts.

- ❖ Based on the feasibility analysis, run an eradication attempt of rats in Nu'utele.
- ❖ Monitoring for rats in Nu'ulua at least once a year (January-March).

7. WORKPLAN 2016-2020

Actions	*Proposed timeline*	*Leadership and responsibility*	*Deliverables*	*Estimated cost*
Goal 1: **FUNDS** - FUND RAISE AND COMMIT ADEQUATE FUNDS				
1.1.Identify suitable funds	by Dec 2016	MNRE/DEC, MAF/Quarantine, SPREP, CI	Reliable and suitable funds sources identified	In-kind
1.2 Prepare and lodge proposals with the assistance of international organizations	by Apr 2017	MNRE/DEC, MAF/Quarantine, SPREP, CI	Proposals are discussed, agreed, endorsed by Govt. and lodged to donors with the assistance of international organizations locally available in Samoa such as SPREP and CI	In-kind
Goal 2: **BIOSECURITY** - PREVENT ARRIVAL OF ADDITIONAL ALIEN INVASIVE SPECIES TO NU'UTELE, NU'ULUA AND FANUATAPU ISLANDS THROUGH STRICT BIOSECURITY				
2.1 Improve and upgrade awareness among local community and Government staff on the threats of IAS and the dire need of biosecurity	by Apr 2018	MNRE/DEC, MAF/Quarantine SPREP, CI, IUCN, Birdlife, PII	Extensive awareness raised and spread across Govt. staff and local community People visiting the islands regularly (boatmen and fishermen in first place) are committed to run biosecurity checks on luggage and boats before leaving Upolu	15-20,000 USD
2.2 Adjust recently revised SISERP in order to be fully	by Apr 2018	MNRE/DEC, MAF/Quarantine, SPREP	Specific EDRR for Aleipata is agreed and approved, in	5000-10,000 USD

operative in the Aleipata islands			line with SISERP Responsibilities, processes and budget allocations to make Aleipata EDRR operative are identified	
2.3 Improve and upgrade training of local community, MNRE and MAF/Quarantine staff on proper biosecurity methods and measures	by end 2018	MNRE/DEC, MAF/Quarantine SPREP, CI, IUCN, Birdlife, PII	Capacity on biosecurity and commitment in place (Govt., local authorities, locals dealing with the islands especially boatmen and fishermen)	15-20,000 USD
2.4 Identify responsibilities at MNRE, MAF/Quarantine and at local level to effectively support and implement biosecurity measures on the ground	by end 2018	MNRE/DEC, MAF/Quarantine SPREP, CI, IUCN, Birdlife, PII	Responsibilities identified, processes in place, budget allocations ready MNRE and MAF/Quarantine support local authorities and locals dealing with the islands (boatmen and fishermen in first place) to implement biosecurity	In-kind
Goal 3: **PRESERVATION** - IMPLEMENT AND ENFORCE LEGAL PROTECTION OF FOREST ECOSYSTEMS AND ASSOCIATED BIODIVERSITY OF ALEIPATA ISLANDS (NU'UTELE AND NU'ULUA IN FIRST PLACE)				
3.1 Develop and agree on an operational plan aimed at monitoring and enforcing the protection of the forests of Nu'utele and Nu'ulua islands and their valuable biodiversity (e.g. in relation to logging,	by end 2017	MNRE/DEC, SPREP, CI, IUCN, Birdlife	Operational plan discussed, developed, agreed, endorsed by Govt. and funded – fully integrated in a comprehensive monitoring program of Aleipata MPA	In-kind

hunting, collection of coconut crabs and turtle eggs etc.)				
3.2 Identify responsibilities, processes and budget allocations related to the implementation of the operational plan	early 2018	MNRE/DEC, SPREP	Responsibilities, processes and budget allocations related to the implementation of the operational plan clearly identified	In-kind
3.3 Implement the operational plan	starting from mid 2018	MNRE/DEC, SPREP, CI, IUCN, Birdlife	Four Aleipata islands' forest ecosystems and biodiversity are fully protected and monitored Insular forest ecosystems thrive together with populations of threatened doves and pigeons, bats, coconut crabs and turtles	7000-10,000 USD annually
Goal 4: **RESTORATION** - RESTORE ECOSYSTEMS OF NU'UTELE AND NU'ULUA ISLANDS THROUGH IAS ACTIVE MANAGEMENT				
4.1 Prepare an operational plan to eradicate Tamaligi tree (one individual) and several Lopa trees in Nu'utele (Vini flats) and execute the eradication accordingly	by end 2016	MNRE/DEC, SPREP	Tamaligi tree and Lopa trees in Nu'utele are eradicated Risks of invasion by these two IAS plants are minimized in the short term	1000-2000 USD + in-kind from GEF-PAS IAS project
4.2 Prepare an operational plan to eradicate pigs from Nu'utele involving an international expert assisted by locals and execute the	by early 2017	MNRE/DEC, SPREP	A major threat and source of ecological degradation for the rainforest ecosystem of Nu'utele is eliminated	5000-8000 USD

eradication accordingly			Forest ecosystem thrives together with populations of threatened doves and pigeons, bats, coconut crabs and turtles	
4.3 Research biology and ecology of YCA in Nu'utele and Nu'ulua during a 1-year cycle or alternatively run a comprehensive feasibility analysis for YCA management involving key regional experts	by end 2018	MNRE/DEC, SPREP, CSIRO, Victoria University, NUS, USP	Dr Ben Hofmann (CSIRO) and/or Victoria University led this activity Specific vulnerabilities of YCA in the Aleipata islands are identified (specific breeding annual cycle is known) A proper YCA management program is discussed and agreed and endorsed by Govt.	20,000 USD + in-kind
4.4 Based on the research's results or the feasibility analysis, run a management program of YCA in both islands (if realistic based on available knowledge and technology)	by end 2019	MNRE/DEC, SPREP, CSIRO, Victoria University, CI	Dr Ben Hofmann (CSIRO) and/or Victoria University led this activity YCA are either controlled or eliminated from Nu'utele and Nu'ulua A major threat and source of ecological degradation for the rainforest ecosystem of Nu'utele and Nu'ulua is either controlled or eliminated Forest ecosystem of the two islands	100-200,000 USD (to be better estimated by key regional experts based on research's results)

			thrives	
4.5 Run a thorough feasibility analysis for rat eradication in Nu'utele, based on the lessons learned from previous attempt (2009), and involving key regional organizations and experts	by Apr 2017	MNRE/DEC, SPREP, IS, key regional experts	Island Conservation is outsourced; Steve Cranwell and/or Alex Wegmann led this activity Specific ecological vulnerabilities of rats in the Aleipata islands are identified, knowledge is improved. Risk of failure of next rat eradication attempt in Nu'utele is minimized	20,000 USD
4.6 Based on the feasibility analysis, run an eradication attempt of rats in Nu'utele	by end 2019	MNRE/DEC, SPREP, IS, key regional experts	Rats are eradicated from Nu'utele A major threat and source of ecological degradation for the rainforest ecosystem of Nu'utele is eliminated Forest ecosystem thrives together with populations of threatened doves and pigeons, bats, coconut crabs and turtles	200-300,000 USD (to be better estimated by key regional experts)
4.7 Monitoring for rats in Nu'ulua at least once a year (during January-March [1])	starting from Jan 2017	MNRE/DEC, SPREP, CI	Status of rats in Nu'ulua is monitored in line with the EDRR (actions # 2.2)	500-1000 USD annually

[1] This is the time of the year when the trade winds are not blowing: in these conditions the landing on Nu'ulua by boat is easier and safer.

8. PARTICIPANTS IN THE MANAGEMENT PLAN

The Aleipata Islands IAS management plan is a partnership between the Government of Samoa and all the villages of the District of Aleipata. Both partners have responsibility for the continuous implementation of this IAS plan, as part of the Aleipata MPA's management plan, which highlights a collaborative approach to the sustainable use and protection of the natural resources and environment in the District. The plan incorporates the Aleipata District villages all of which are represented by a member in the MPA District Committee.

9. REFERENCES

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ANNEX 1

REVIEW OF INVASIVE ALIEN SPECIES MANAGEMENT IN THE ALEIPATA ISLANDS, SAMOA

GEF-PAS Invasive Alien Species project/Samoa

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on behalf of the Ministry of Natural Resources and Environment (MNRE), Department of Environment and Conservation (DEC)

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Photo on the cover: Nu'utele (foreground) and Nu'ulua island (background) (Credit: G. Serra).

1. INTRODUCTION

Samoa is part of the Polynesia-Micronesia Biodiversity Hotspot (Fig. 1), one of 34 regions of the world where extraordinary levels of biodiversity and endemism are coupled with extremely high levels of threats (Mittermeier *et al.* 2004). Although 11 terrestrial and 65 marine species found in Samoa are listed as globally threatened on the 2015 IUCN Red List of Threatened Species, the number of threatened species at a national level may be significantly higher than this, perhaps in the hundreds (Conservation International *et al.* 2010).

Figure 1. Polynesia-Micronesia Biodiversity Hotspot (Map: Conservation International 2013).

The Aleipata islands are composed of 4 small islands with an aggregate area of 1.68 km² (see Fig. 2 and 3): Nu'utele (1.08 km²) and Nu'ulua (0.25 km²) islands located outside the coral reef off eastern Upolu; Namua (0.20 km²) and Fanuatapu (0.15 km²) islands located at the edge of the coral reef.

Known to be home of a high percentage of representative and threatened species of the whole Samoa national territory, they represent a key site within the Polynesia-Micronesia biodiversity hotspot. In a 1986 review of 226 islands in the South Pacific region, Nu'utele and Nu'ulua islands together rated 30th in importance for biological diversity (Vanderwoude *et al.* 2006). At least since a decade ago these islands have been recognized as having the potential to play a key role in sustaining the future of Samoa's fauna biodiversity.

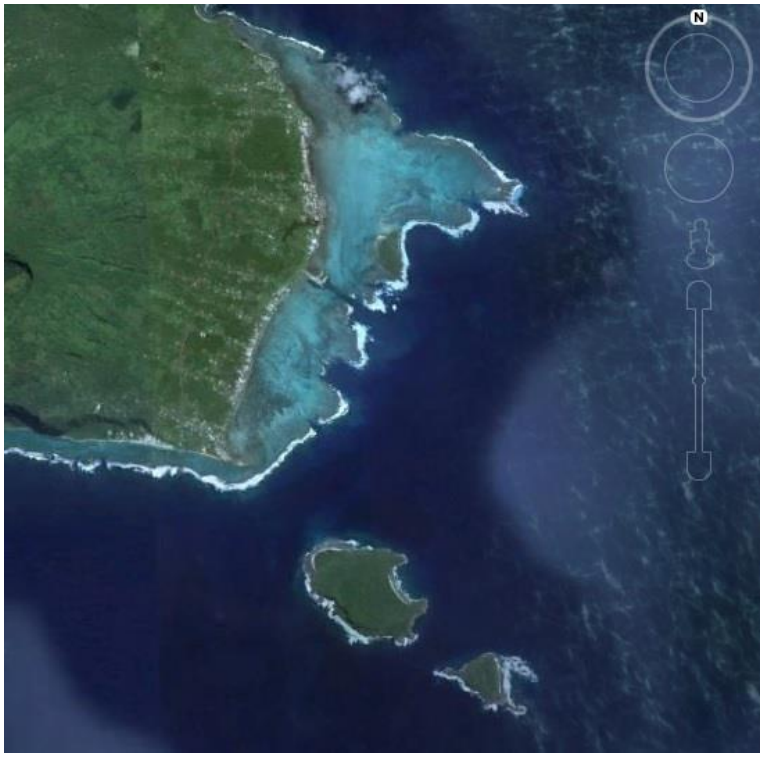


Figure 2. The four Aleipata islands face the easternmost tip of Upolu island of Samoa. North and at the edge of the reef fringe are located the smallest islands known as Fanuatapu and Namua, the latter being the closest to Upolu and the only inhabited one of the four. To the south, well outside the reef fringe, Nu'utele, the largest island of the four and Nu'ulua the most inaccessible one (Image: Google Earth).

Figure 3. Aerial image of the four islands of the Aleipata group: foreground to the left, the Fanuatapu islet, next to the right still within the reef fringe Namua island (almost at the center of the image). In the background, Nu'ulua (small to the left) and Nu'utele (bigger to the right) (Photo: Stuart Chape).

The Aleipata islands are considered to be of great regional conservation significance because they are uninhabited (with the exception of Namua), relatively pristine as forest ecosystems, hosting many species threatened throughout the greater Samoa, and still not invaded by most invasive alien species (IAS) present within Upolu main island. Due to this reason they were included in the list of the 7 Key Biodiversity Areas of Samoa (Conservation International *et al.* 2010).

In particular Nu'utele and Nu'ulua (Fig. 4), forested volcanic islands with adjacent reef and lagoons, located 1.3 Km off the far eastern end of Upolu, are major sites for the conservation of Samoa's indigenous biodiversity. The importance of these two islands is that they are uninhabited, not easy to land by boat (therefore few IAS occurring), and large and far enough to be forested and considered as potential refuges for several of the nation's native species.

Nu'utele and Nu'ulua are customarily owned and involve at least four families that are bestowed with the traditional titles, from the villages of Satitoa and Ulutogia (part of the Aleipata District).

Due to its size and the risks and challenges in relation to landing, Nu'ulua island is only occasionally visited by locals and Government staff. No families currently use the island in any traditional way and it has most likely never been inhabited. In fact, it is the only one of the four Aleipata islands not hosting any coconut grove.

Nu'utele, due to its bigger size and being more accessible by boat (although landing is not extremely easy) has a history of use including establishing plantations and hosting a leper colony during the early 20th century (between 1916 and 1918). Currently uninhabited, it is visited by members of the family who maintain two fales at Vini beach and few crops, and bring sometimes visitors (especially academics and school groups).

The other two islands of the Aleipata group are Fanuatapu (an uninhabited islet hosting a forest of limited size) and Namua hosting a touristic resort.

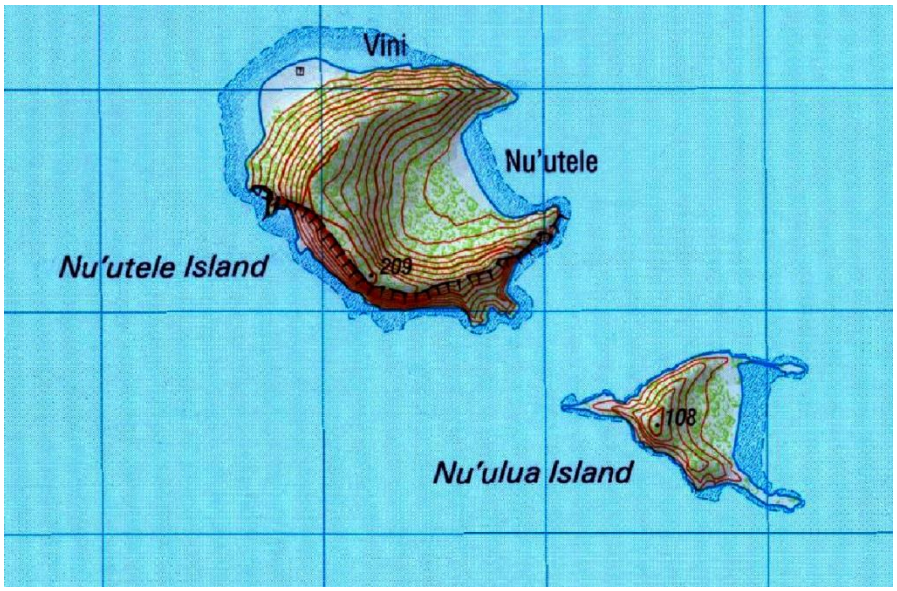


Figure 4. Topographic map of Nu'utele and Nu'ulua islands (Map: Paul Anderson/SPREP).

Due to their scarce accessibility, size and forest coverage, Nu'utele and Nu'ulua islands were selected as the target of several surveys and IAS management interventions during the past 15 years, culminated in a rat eradication attempt undertaken in August 2009.

2. AIM AND METHODOLOGY

This review is part of the requirements of a consultancy assignment, under a GEF-PAS IAS project [jointly run by MNRE/DEC and the Secretariat of the Pacific Regional Environment Program (SPREP)], aimed at assessing the present status of key IAS in the mentioned islands and at preparing a management plan. The review focuses on available reports and literature about most relevant IAS surveys and management actions undertaken in the Aleipata islands, Samoa, so far.

The review has four objectives: to review i) the current knowledge of existing biodiversity assets and threats on the mentioned islands; ii) the past and current occurrence of IAS in the islands; iii) the conservation measures in place; iv) IAS management efforts so far; v) knowledge gaps.

Relevant literature was gathered from key stakeholders and experts. Reports were examined thoroughly and further clarifications were obtained directly contacting experts involved in the past. Other key stakeholders were contacted to get insights and opinions. First draft was shared with MNRE/DEC and SPREP for comments. Following integrations of feedbacks and comments, a final version was prepared and circulated.

3. KEY BIODIVERSITY ASSETS AND THREATS

3.1 Fauna

The key fauna biodiversity assets of Nu'utele and Nu'ulua islands, holding a global relevance, can be grouped as follows:

- THREATENED TURTLE. According to MNRE/Marine Division the Critically Endangered Hawksbill Turtle *Eretmochelys imbricata* uses the beaches of these two islands as nesting sites. Reportedly the two islands support the highest number of nesting turtles in Samoa.

- THREATENED BIRDS. These two islands are among the few sites left in Samoa where the Critically Endangered and endemic Tooth-billed Pigeon *Didunculus strigirostris* can still be found. In fact, the islands offer suitable habitat for this species that is specialized in feeding on the Samoan endemic tree maota *Dysoxylum* spp. The occurrence of this bird in Nu'utele was reported last time in 2010 (Schuster 2010) - but apparently the call of this bird was also heard and detected by MNRE/DEC staff during a survey in 2013 (MNRE/DEC, *pers. comm.*). On the other hand its occurrence on this island was not recorded by surveys taken in 2005-2006 (MNRE 2006). Moreover, Nu'utele and Nu'ulua are among the two only sites in Samoa where the Friendly Ground Dove *Gallicolumba stairii*, a regionally endemic species listed as Vulnerable at global level, occurs. The two

islands actually hold the largest remaining population of this species in Samoa, a population significant in terms of the entire Western Polynesian population. The Friendly Ground Dove was the focus of a protection scheme during the rat eradication attempt carried out in 2009. Twenty six individuals were trapped and transferred to an aviary in Upolu before the eradication. The surviving twenty two individuals were released 6 weeks later. According to Alan Tye (unpublished) at least 26 were counted in 2009, after the eradication attempt, within Vini flats in Nu'utele - while David Butler estimated 92 of them in the same area in 2010. Due to the occurrence of two bird species threatened on a global scale and the presence of substantial numbers of native endemic birds and major colonies of seabirds (see below) the whole Aleipatas Marine Protected Area (see below) was enlisted as an Important Bird Area in 2010 (BirdLife, 2015).

- NATIVE ENDEMIC BIRDS. Six bird species endemic to Samoa find a haven in these islands such as the Samoan Fruit-dove *Ptilinopus fasciatus*, Samoan Whistler *Pachycephala flavifrons*, Samoan Broadbill *Myiagra albiventris*, Samoan Fantail *Rhipidura nebulosi,* Flat-billed Kingfisher *Todirhamphus recurvirostris* and Samoan Starling *Aplonis atrifusca*.

Other nationally-relevant fauna biodiversity features of the two islands are the following:

- INVERTEBRATES. The two islands in question, thanks to their uneasy boat landing, still hold good population of coconut crab *Birgus latro* that due to its size and edibility has become very rare on populated islands of Samoa. Most likely the two islands host more coconut crabs than anywhere else in Samoa. Moreover, fifteen species of land snails were collected during surveys in early 2000, 11 on Nu'utele and seven on Nu'ulua (Stinger *et al.* 2003 a and b).

- SEABIRDS. Due to the absence of resident people and their usually associated cohort of predatory tame animals (and thanks to some dramatic sheer cliffs in Nu'utele), the two islands hold the highest concentration of nesting sea birds than any other Samoa island, especially Brown Booby *Sula leucogaster*, Red-footed Booby *Sula sula*, Black Noddy *Anous minutus*, Blue Noddy *Procelsterna cerulean* and Greater Frigatebird *Fregata minor*. No burrow-nesting seabirds (petrels and shearwaters) were detected on the islands during recent surveys (Serra and Faleafaga 2015) possibly due to the presence of rats but also quite possibly due to their nocturnal and secretive habits. Apparently fishermen off the coast of Nu'utele and Nu'ulua at night hear "babies crying and people talking in the darkness".

- REPTILES. The Aleipata islands preserve ¾ of the herpetofauna of Samoa and thus unique components of the biodiversity of the islands. A total of 12 reptile species were found by Fisher *et al.* (2012), three of which are "almost endemic to Samoa". A unique assemblage of lizard species occur in these islands according to the same authors.

- MAMMALS. Two species of native bats (*Pteropus tonganus* and *Pteropus samoensis),* the latter being an endemic to Samoa and Fiji, occur in the two islands in substantial numbers. Both species are very important pollinators of forest trees.

Two surveys run in September and October 2015, under a GEF-PAS IAS project (Serra and Falefaga 2015), confirmed the occurrence of the biodiversity assets mentioned above. In particular, two possible calls of Manumea were recorded and the occurrence of Friendly Ground Dove was confirmed in both islands. Occurrence of the two species of fruit bats, of

all mentioned seabirds and native birds (with the notable exception of the Samoan Fantail) were also recorded. Three tracks of turtles were recorded on Nu'utele beach, two Hawkbill turtles were spotted on the reef in front of Vini beach, the endangered Humpback whale *Megaptera novaengliae* was observed daily around Nu'utele island (including a mother with calf), together with Spinner dolphins *Stenella longirostris*.

3.2 Flora

The two islands hold two of the few, if not unique, pristine lowland rain forest ecosystems, with almost null invasive species, still surviving in Samoa. This kind of ecosystem is threatened within the whole Pacific region. It is a quite unique ecosystem also nationally as it includes several endemic tree species. These islands support intact coastal forests, which have mostly disappeared from elsewhere in Samoa. The coastal forest of Nu'ulua is almost unique with the minimal occurrence of coconuts.

The two islands host eight plant species and two vegetation communities that are rare on the main islands of Upolu and Savai'I (Whistler 1984), known as littoral and lowland forests. Littoral vegetation is made of vines, ferns, shrubs and coconut plantations.

The uncommon and interesting species of the littoral forest are: *Thespesia populnea* (milo), *Guetarda speciosa* (puapua), *Pandanus tectorius* (fasa), *Ficus scabra* (mativao), *Tournefortia argentea* (tausuni) and *Allophyllus timoirensis*.

The flora distribution of the lowland forest vegetation along the island ridges is dominated by species such as *Syzygium clusiifolium (*asavai). Large trees like *Canarium vitiensemaali*, *Garuga floribunda* (magaui), *Cananga odorata* (mosooi), *Terminalia catappatalie* and *Inocarpus fagiferifi* are common along the eastern and western ridge slopes that are frequently visited by fruit bats. Ferns are less abundant than on Upolu: the most common are the *Asplenium nudus laugapapa* and *Phyatosorus grossus lauauta*. The *Asplenium* dominates the ground cover within Vini flats and along the western slopes.

The mentioned species is also found along the eastern slopes towards Nu'utele bay but mostly scattered and sometimes appear in large pockets. The presence of this large fern is significant as nesting place for birds like the friendly ground doves. On the summit and along the ridges the dominant species of plants are seedlings of big trees such as *Syzygium clusiifoliuma sivai*, *Diospyros samoensis*, *Diospyro selliptica*, *Planchonella garberialaa*, and *Terminalia catappatalie*.

According to Talie *et al.* (2007), the dominant tree at Vini flats is *Macaranga harveyana* (laupata) that is a common short-stature secondary tree on lowland beach areas. This is an indication of the environment disturbance caused by the two cyclones in 1990 and 1991 where the forest would have been dominated by *Terminalia catappa* (talie), *Calophyllum inophyllum* (fetau) and *Hibiscus tiliaceus* (fau).

An important information from the 2007 report is the occurrence of *Dysoxylum samoensis* (maota) that was recorded in 3 plots out of 9. Maota is an endemic tree, one of the most relevant one for pigeons and doves (the critically endangered and endemic Tooth-billed

Pigeon is specialized in feeding on this tree). Pigeons and doves carry the fruits and spread them in the forest.

Most of the vegetation is the same in the two islands, except perhaps for *Manilkara manilkara* (oani) occurring only in Nu'utele. Talie *et al.* (2007) reports no indication of negative effects on the forest of Nu'utele due to occurrence of rats and YCA. No weed species were detected nor recorded.

No information is available in the literature regarding the main threats to the biodiversity of the Aleipata islands, with the exception for the ecological invasions by alien species coming from Upolu. Based on direct experience in regards to other areas of Samoa, the other main potential threats could be the following:

- Forest logging or reclamation for plantations and crops
- Hunting, mainly of pigeons but also of other birds and bats
- Harvesting of coconut crabs.

People have never extensively farmed nor logged the islands of Nu'utele and Nu'ulua probably due to the fact that they are too small for such operations and too few profitable forest trees are present. The original ownership of these islands was under the family Sagapolu who was not interested in farming on the island.

4. INVASIVE ALIEN SPECIES

Despite growing global efforts to curtail biological invasions, the spread of invasive alien species remains an increasing conservation problem especially on oceanic islands. Boats are the key pathway for IAS introduction to Nu'utele and Nu'ulua – mostly aluminium fishing catamarans coming from Upolu.

4.1 Inventory

Fauna

1. Land snail (Gasteropoda) ***Subulina octona***, abundant in Nu'utele according to Stringer *et al.* (2000), never surveyed again since then;
2. **Yellow Crazy Ants** *Anoplolepis gracilipes* found for the first time by Smith (2003) in Nu'ulua and later by MNRE (2007) in Nu'utele; still present in both islands in September-October 2015 (Serra and Faleafaga 2015);
3. **House gecko** *Hemidactylus frenatus* (Fisher 2012), not surveyed again since then;
4. **Polynesian rat** *Rattus exulans* trapped first time in Nu'utele in 1991 (Park *et al.* 1992) and in Nu'ulua in 2004 (Parrish *et al.* 2004); still occurring in Nu'utele in September 2015 and absent from Nu'ulua in October-December 2015 (Serra and Faleafaga 2015);
5. **Pigs** *Sus scrofa* "escaped from captivity" in Nu'utele mid 2006 [Island Eradication Advisory Group (IEAG) 2006], still present in September 2015 (Serra and Faleafaga 2015).

Notable recorded absences of key IAS animals from Nu'utele and Nu'ulua that are common on Upolu were: Cockroach *Periplaneta americana*, African giant snail *Achatina fulica*, Jungle Fowl *Gallus gallus* (used to occur in Nu'utele during period 2001-2007), Common Myna

Acridotheres tristis, Jungle Myna *Acridotheres fuscus*, Red-vented Bulbul *Pycnonotus cafer* (it has been seen in 2010-11 in Nu'utele), Feral cat *Felis catus*, and dog *Canis lupus*.

It is interesting to note that the Bulbul has tried to colonize Nu'utele during the past 5-6 years (most bird species are able to cross the 1.3 Km stretch of sea separating Upolu from Nu'utele) but failed most likely because they need to associate to people in order to survive – the same as for the two species of mynas that have most likely tried the colonization of Nu'utele as well (although there is no record of this).

Flora

The vine *Merremia peltata* (fua lautetele) is present on the islands, though it is not considered seriously invasive except in disturbed areas (but these are limited in size and distribution on these two islands). The herbaceous plant *Wedelia biflora* is also present but only in open areas near beaches. A survey conducted by staff of the MNRE/DEC in 2007 found one *Albizia* tree occurring within the Vini beach area in Nu'utele (still occurring in September 2015, Serra and Faleafaga 2015).

4.2 Key species: knowledge & threats

Surveys undertaken during years 2000s identified the Polynesian rat and the YCA as the two most critical IAS threatening the biodiversity assets of the Aleipata islands. This was reflected by the Critical Ecosystem Partnership Fund (CEPF) project, a partnership between SPREP and Conservation International (CI), that was run between 2009 and 2011 (total budget ca. 220,000 USD) and that was focused mainly on the management of these two animal species (Tye 2012).

The threats to insular biodiversity produced by introduced rats are well documented (Towns *et al.* 2006, Jones *et al.* 2008). In general terms rats are a problem because they kill invertebrates, birds (especially eggs and chicks) and the seeds of native trees, preventing forest regeneration.

The Polynesian rat was probably a Polynesian introduction in the Aleipata islands or an accidental human-facilitated introduction from neighbouring Upolu in the recent past. Very little is known about the biology and ecology of this alien species in tropical islands. Rat surveys run in early 2000 showed that rats in Nu'utele have a special taste for coconut (Stinger *et al.* 2003).

This is confirmed by the fact that both in early 2000 and in September 2015 rats were found mainly among the coconut groves of the two main flats of Nu'utele (Vini and Nu'utele). The interesting fact is that rats seem not to thrive within the pristine rain forest of the slopes and the ridge of this island, consistently with results of a study about the role of *refugia* in curbing the threat of IAS in Fiji (Olson *et al.* 2006).

Many ant species that have been accidentally spread throughout the world have significant economic, environmental and social impacts in areas that they now infest. Ants in general are a problem because they attack a huge range of native plants and animals. They may destroy small seeds, attack bird nests, and kill reptiles, crabs and native insects.

One of the most notable invasive ants is the YCA. This species has a pan-tropical distribution, and is well known to have great variation in its abundance, impacts and reproductive phenology.

Field work done in the Aleipata islands showed that YCA was well distributed over the island of Nu'ulua (Vanderwoude *et al.* 2006), but is still localized to the two main disturbed areas in Nu'utele (Serra and Faleafaga 2015). The same as rats, YCA seem not to thrive within the pristine rain forest of the slopes and the ridge of this island.

The persistence of YCA on Nu'utele and Nu'ulua is of significant conservation concern. Within infested areas there were few other ants larger than YCA, as well as fewer crabs and spiders, indicating that YCA is indeed a significant conservation concern (Hoffman 2011).

YCA's spread throughout Nu'ulua is a threat to invertebrates, birds and reptiles, including turtle hatchlings, and it could lead to irreversible vegetation changes. Worker abundance and nest density were among the highest recorded in the world, being greater in May than in October (Hoffman 2011).

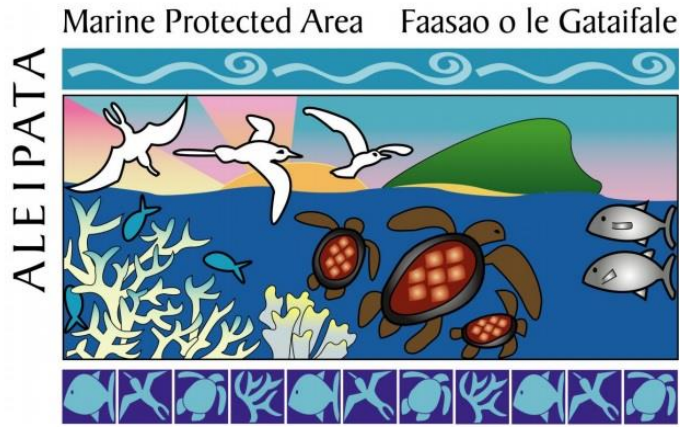
Pigs are a problem because they damage tree seedlings, dig up turtles eggs, and eat the eggs and young of ground-nesting birds. They are still occurring and breeding in Nu'utele (Serra and Faleafaga 2015), despite reiterated recommendations to eradicate them have been issued as early as 2006 (IEAG 2006).

4. CONSERVATION MEASURES

In 1989 the International Union for Conservation of Nature (IUCN) prompted the establishment of a marine protected area (MPA) including the four Aleipata islands (Fig. 5).

Figure 5. Aleipata marine protected area (MPA). Legend: area shaded in blue: lagoon; area shaded in brown: coral reef; area shaded in purple: reef slope; areas shaded in white: insular terrestrial ecosystems. Map: Conservation International *et al.* (2010).

The government in collaboration with the Aleipata District (eleven villages in total) and IUCN developed a management plan, the last update being for the period 2008-2010 (MNRE 2008), with the aim to guide the protection and conservation of the marine environment of the Aleipata District.



The four Aleipata islands are integrant part of the MPA. In fact, one of the guiding principles of the Aleipata MPA's management plan states that "We commit Aleipata's offshore islands (Nuulua, Nuutele) and their wealth of biodiversity as a critical part of our Aleipata MPA". The same plan acknowledges that "Aleipata's islands are vitally important refuges for Samoa's natural heritage and

we will continue to support these islands as an integral part of our Aleipata MPA. These islands are also a vital part of our history and culture and we will also ensure conservation of the cultural heritage they contain".

As the project progressed, the MPA Committee composed by eleven mayors, decided to bring in the support of Conservation International (CI) in order to strengthen the partnership and ensure availability of funding. A trust fund was established in 2003 by CI aimed at the implementation of the management plan. Few locally managed no-take zones were established and run for some time. CI in collaboration with CEPF and SPREP became keen to implement the part of the management plan focusing on Nu'ulua and Nu'utele islands (priority working goal # 3.3). Thus project mentioned in point 4.2 was funded and implemented.

A large shipyard with dry dock was established by the Government in the middle of the MPA during the 1990s and started its operation of ship renovations despite the advise of CI and of an environmental impact assessment. The MPA operation came to an halt soon after the tsunami of September 2009, due to problems in managing the trust fund and amidst allegations of corruption. Investigations are apparently still under way. The management plan was never updated beyond 2010. Apparently there are intentions to revive and update it during 2016 (MNRE/Marine Division *pers. comm.*).

In fact, during recent survey run between September and December 2015 (Serra and Faleafaga 2015), and during other informal visits in previous years, no apparent indications were observed on the ground that an operational marine protected area is in place in the area (e.g. no signs, no information panels for visitors, no enforcement noted).

A biosecurity training was conducted in 2009 by the Pacific Invasives Initiative (PII) as part of the mentioned CEPF project in the benefit of local communities, government staff and MPA committee members. The training was unfortunately interrupted by the tsunami. A draft biosecurity manual and visitor checklist was prepared but never printed (as it had been planned).

According to Butler *et al.* (2011) and Tye (2012) no biosecurity has ever been established following the CEPF project. This was confirmed by the recent two surveys of the four Aleipata islands by Serra and Faleafaga (2015).

5. ATTEMPTS OF MANAGING IAS

The CEPF project was conceived as the direct implementation of priority working goal #5.3.1 of the Aleipata MPA management plan ("a key step towards a long-term goal of ecological restoration and maintenance of Nu'utele and Nu'ulua islands"). The project was designed to address the threats to the rain forest ecosystems of the two islands posed by two key invasive alien species: the Polynesian rat and the YCA (SPREP 2008).

It was designed as a demonstration project with the PII and with the Pacific Invasives Learning Network facilitating the involvement of others from the region in the operation and the wide dissemination of its results.

As a step towards island restoration, the project aimed to eradicate Polynesian rat from both islands through aerial delivery of baits from a helicopter. The project originally also proposed to control or eradicate YCA by ground and aerial delivery of baits but, following expert advice, this objective was changed to obtain further information considered necessary for the design of a long-term management plan.

The local people who own and use the islands gave their support to the rat eradication as part of the Aleipata MPA project. The project thus involved working very closely with the community, through an MPA Committee involving representatives of all the villages in the District. Community members joined expeditions to the islands, were involved in the control operations and were invited to play a key role in preventing pests from reaching the islands.

SPREP signed a grant agreement with the CEPF on 1 May 2009 to deliver this project, with seven components:

1. Eradication of Polynesian rat using aerial delivery of poison
2. Protection of Friendly Ground Dove from the poisoning operation
3. Management of YCA
4. Monitoring the response of the ecosystem to rat removal
5. Work with the local community to maintain support for the project and raise awareness of the need to protect the islands
6. Establishment of a biosecurity programme for the islands
7. Dissemination of results.

The full final report (Tye 2012), including detailed outcomes and lessons learned, is available online: https://www.sprep.org/publications/restoration-of-nuutele-and-nuulua-islands-aleipata-group-samoa-through-the-management-of-introduced-rats-and-ants

Rat eradication attempt

Rat eradication of Nu'utele and Nu'ulua was one of the first helicopter-delivered rat eradication attempts on islands of Oceania, and surely the first attempted in Polynesia.

The eradication operation carried out at Nu'utele during the second half of August 2009, through 3 subsequent aerial spreading of rat toxin (brodifacoum), unfortunately did not succeed, as shown by several rat surveys undertaken during following years (Butler 2011a and b; Serra and Faleafaga 2015). On the other hand, based on several rat surveys run between 2009 and 2015 (Fisher *et al.* 2012; MNRE 2012; Serra and Faleafaga 2015), it seems now clear that the eradication attempt in Nu'ulua was successful.

The reasons of the failure of rat eradicaion in Nu'utele unfortunately will never be known: rat tail samples collected for DNA analysis (pre-treatment and post treatment ones) were lost within New Zealand in 2011 while transiting internally via a courier package.

Recently the feasibility of a late DNA analysis based on the comparison of current rat samples from Aleipata islands *versus* those from Upolu (in the irreversible absence of the pre-treatment samples from the islands) was excluded by Dr Rachel Fewster from the

Department of Statistics of the University of Auckland (email communication exchange posted in Annex 1).

Therefore only hypothesis can be mentioned in relation to the eradication failure of Nu'utele island. Below table is an attempt to list all the most likely proxy and root causes of the failure that were found mentioned in the available reports and literature.

Proxy causes	***Reference***
Coverage of ground with toxin dropped by helicopter was not complete due to: i) technical problems with the spreader bucket and with the GPS devices; ii) pilot inexperience; iii) occurrence of rain soon after the spreading.	IEAG (2006), Wylie (2009), Butler *et al.* (2011)
Incorrect lapse between drops ("11 dd lapsed between the first and the second drop, while Alan Saunders had advised at least 14 dd").	Watkin (2012)
Challenges with weather forecasts: forecasts of limited reliability, intrinsic unpredictability of rainfall in the tropics. E.g. 6.25 mm of rain fell during the first night following the first drop; 2009 dry season turned out to be wetter than usual due to El Ninho.	Wylie (2009), Butler *et al.* (2011), Tye (2012)
Rats on Nu'utele have plenty of food all year round (coconuts), recent evidence collected that they breed also during the dry season (second half of August, i.e. same timing of treatment in 2009); unclear (to be tested) whether all rats would prefer the toxic bait to their abundant natural food.	Keitt *et al.* (2014); Serra and Faleafaga (2015) Ulf Beichle (*pers. comm.*)
Possible re-invasion of rats via the tsunami that took place in September 2009, only few weeks after the eradication.	Butler *et al.* (2011), Tye (2012)
Biosecurity measures not applied thoroughly, neither before nor after the eradication attempt.	Butler *et al.* (2011), Tye (2012)
Root causes	***Reference***
Late confirmation of funding from the donor (project approved on 27 April 2009, funds received on 2 June 2009, first drop scheduled for early August 2009) which implicated tight timeframes: for instance, technical recommendations from IEAG/DOC (2006) such as the use of two buckets, two DGPS and a test of equipment before the operation could not be applied.	IEAG (2009), Wylie (2009), Butler *et al.* 2011, CI (2013)
Capacity loss due to staff turnover at MNRE (three changes to the project manager within MNRE during the ten weeks before the first drop); challenges with MNRE support.	Butler *et al.* 2011, Tye (2012), CI (2013)
Management issues: unclear roles, insufficient focus and time of some roles, SPREP part-time management, "problematic project management structure", 5 people responsible for managing MNRE's	IEAG (2009), Butler *et al.* 2011

inputs to the project etc.: all this translated into challenges in maintaining project momentum and ensure tasks were completed on schedule.	
Some level of disconnect between the respective roles of the project including SPREP, MNRE and the local communities.	Watkin (2012)
Risks associated with rat eradication at tropical latitudes (*versus* those at temperate latitudes, e.g. in NZ) were not emphasized sufficiently with stakeholders and the donor prior to the operation; expectations were possibly unrealistically too high.	Keitt *et al.* (2014)
Biosecurity not in place at the time of eradication despite IEAG/DOC had clearly recommended it to be "in place and functioning well before pests are removed" (recommended twice, once in 2006 and then in 2009, "urgently"); recommended also by Wylie 2009.	IEAG (2006, 2009), Wylie (2009), CI (2013)
Possible insufficient biological and ecological knowledge about Polynesian rats occurring in Samoa/Aleipata islands.	Ulf Beichle (*pers. comm*); Keitt *et al.* (2014)

Despite the rats were found on Nu'utele following the eradication attempt, the project apparently resulted in a release of forest regeneration and of populations of some animals, and the long-term effects of this was to be positive for the island ecosystem (Butler *et al.* 2011, Tye 2012).

MNRE accepted to include follow-up activities for some components of this project in its workplan financed under the GEF-funded PAS IAS project, namely further monitoring of rats and further investigation on YCA's biology and ecology.

YCA surveys

YCA surveys led by Dr Ben Hoffman on Nu'utele in October 2010 and March 2011 (Hoffman 2011) revealed insights on the distribution and expansion since the previous time they were surveyed in 2006, on the reproductive phenology, on the annual cycle of abundance and on the annual nest density cycle. Impact on co-existing fauna was also assessed together with interactions with phytophagus insects and extrafloral nectar.

Part of the study on YCA (the monthly ant monitoring) was planned to be carried out by MNRE staff, but this never materialized. The conclusion from data analysis was that before a management plan is written and implemented, further and improved knowledge is required about suitable bait-toxin mixes, on side-effects to native fauna and especially on ant breeding cycle in the Aleipata islands and in Samoa.

Following the recommendations made by Ben Hoffman to undertake targeted research on YCA in Aleipata islands/Samoa, the GEF-PAS IAS project (Samoa component) included an activity termed "research on YCA in Aleipatas" with an allocation of 20,000 USD. This activity however was recently revised by the Samoa National Invasives Technical Team and turned into a more general one: review of past IAS management efforts (as an outcome the present

review document), new IAS surveys in the Aleipata islands and preparation of a IAS management plan for the Aleipata islands.

Pigs

IEAG (2006 and 2009), in addition to other experts, strongly recommended feral pigs to be removed from Nu'utele as a matter of priority. A pig shooting exercise was carried out in 2007 according to Talie *et al.* (2007). But pigs are still present and breeding in Nu'utele as recently documented by Serra and Faleafaga (2015). The damage to native biodiversity and the rain forest ecosystem during period 2009-2015 can be estimated as substantial. Their removal is a relatively easy task – certainly it is compared to removing rats and YCA. The mere fact that this has not happened so far may be an indication of lack of awareness about the threat of IAS on part of competent authorities and local communities.

Biosecurity

The CEPF project planning phase evaluated the probabilities of rats reaching the islands by various means, and considered that they were low enough to recommend eradication, but that improving biosecurity was advised. The occurrence of a tsunami soon after the eradication attempt was not taken into account as a likely event to occur – and yet it happened right few weeks after the eradication attempt, ironically during the undertaking of the biosecurity training held in New Zealand.

The project included a set of activities to improve biosecurity for the islands. MNRE staff and the local communities of Aleipata District were trained in biosecurity and given the means to implement improved measures. This included training, the development, production and use of biosecurity protocols and guides, and the implementation of a long-term monitoring and rapid response system.

The biosecurity training led by PII was scheduled for September 2009 in Auckland, and local community representatives and MNRE members were attending the course when the tsunami struck Samoa. The Samoan participants had to abandon the course and return to their families, and this workshop was eventually completed in Samoa in March 2010. A biosecurity manual and visitors' guide (MNRE & Aleipata Islands MPA Committee 2012, MNRE *et al.* 2012) were developed by SPREP and PII, and submitted to MNRE for publication and distribution.

A system to inspect boats, equipment and supplies taken by people visiting the islands was established by the MPA Committee and they undertook inspections through most of 2010. However, the system lapsed in 2011. Lines of bait stations with wax baits and traps were set up on Vini Beach in January 2010 and on Nu'utele Beach in March 2010. Such devices have not yet been set up on Nu'ulua owing to problems of access.

Nu'ulua can only be reached if seas are relatively calm and the consequent low rate of visitation by boats is one of its key defences against re-invasion by rats. It has not been possible for MNRE to establish regular monitoring or a rapid-response system for the islands. This should be a major concern for any future eradication plans, whether of rats or any other pest on the islands.

According to Tye (2012), “the community-managed biosecurity system for the islands was not maintained. Biosecurity is no better than before the project, and further pest incursions to the islands may be expected. A monitoring and rapid-response system, to be operated by MNRE, has not been established.” Serra and Faleafaga (2015) confirmed the absence of any biosecurity measure in place in relation to the four Aleipata islands.

A Samoa Invasive Species Emergency Response Plan (SISERP) was prepared in 2015 under the GEF-PAS IAS project. This document defines the guidelines for an emergency response to the threat of a new potential invasive species at a national level.

Additional remarks

The main challenges to sustainability of CEPF project were the inconsistent support provided by government and local community partners to different aspects of the project (Tye 2012). However, the project clearly fell within the priorities of Samoa’s National Invasive Species Action Plan (NISAP), and follow-up activities have been included by MNRE in its plans under the GEF-PAS Invasive Species project which began in 2012, including further monitoring on the islands and revision of Samoa’s Emergency Response Plan to cover incursions more effectively.

The final report of the CEPF project (Tye 2012) recommended the following:

- Rat survey in Nu’ulua (plan included in the GEF-PAS IAS project)
- DNA analysis to get conclusion on new rat management plan (plan included in the GEF-PAS IAS project)
- Pigs and fowl eradication (assumed to be led by MNRE and local communities with zero investment as these are edible animals)
- Monitoring Friendly Ground Doves and other birds, together with vegetation, reptiles and invertebrates
- YCA research (recommended by Dr Hoffman, originally included in the GEF-PAS IAS project)
- MNRE continues to work closely with the MPA Committee and Aleipata District communities, to ensure the maintenance and enhancement of the biodiversity values of the islands
- The community-managed biosecurity system is provided continuous support from MNRE if it is to become and remain functional
- Publication of the biosecurity manual for Aleipata islands and the visitos’ checklist (not done so far)
- The biosecurity guidelines included in the biosecurity manual should also be adhered to and enforced by MNRE
- A long-term surveillance programme is established on Nu’ulua and Nu’utele, to detect new pest incursions and a rapid-response system needs to be developed to deal with incursions detected (outline plans for these being included in the biosecurity manual).

6. IDENTIFICATION OF KNOWLEDGE GAPS

Lack of biological and ecological knowledge of IAS is recognized as a major factor contributing to eradication failures. Management must be informed by a site-specific understanding of the invasion system.

Polynesian rats are known to survive well on remote Pacific islands making the best out of what is available, and especially foraging on coconuts. In order to increase the chances of success of any future second rat eradication attempt in Nu'utele, it would seem sensible trying to improve the knowledge about the distribution, the breeding cycle and the diet of the rats on that island thoroughly during the course of 12 months at least.

Particularly, it seems crucial to get a better understanding of whether there is any annual low point of productivity on these islands or not. Also the issue of bait palatability at tropical latitudes and how to best address the challenge of the unpredictability of rainfall events should be investigated further.

Although there have been many attempts at eradicating exotic ant incursions, few efforts have been successful, and a lack of specific biological and ecological knowledge is believed to have been a major contributing factor.

In situ knowledge of the biology and ecology of a species is vital to create effective management protocols. This is particularly important for YCA because globally there is great variation in its abundance, impacts and seasonal phenology, and its reproductive strategy is particularly problematic and unresolved (Drescher et al. 2007; Gruber *et al., in press*).

Due to this, during CEPF project, leading researcher Dr Ben Hoffman recommended to not attempt any action of control and eradication of YCA until some key knowledge gaps are addressed.

Targeted site-specific research was recommended. Investigation of the yearly breeding cycle in Samoa and the side-effects of treatment on other species (especially crabs) were indicated as priority gaps of knowledge to be filled.

The timing of male reproduction appears to be consistent with places elsewhere in the world, but queen reproduction was found to be outside of the known reproductive period for this species in the region, indicating that the timing of treatment regimes used elsewhere are not appropriate for Samoa.

For example, baiting during periods when queen brood are in pupal stage will not achieve eradication because these pupae will not be affected by the treatments and will emerge to initiate new colonies. A lack of site-specific information can also hinder effective assessment of treatment success (Hoffman 2012).

6. ACKNOWLEDGEMENTS

We acknowledge and thank the Ministry of Natural Resources and Environment, Division of Environment and Conservation for their assistance, especially Mr Taupau Maturo and Mr Niualuga.Evaimalo.

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APPENDIX 1

ENQUIRING ON THE FEASIBILITY OF A LATE DNA ANALYSIS

-----Messaggio originale-----
Da: Rachel Fewster [mailto:r.fewster@auckland.ac.nz]
Inviato: Thursday, 17 September 2015 11:37 p.m.
A: g. serra
Cc: faleafaga tipamaa; maturo.paniani@mnre.gov.ws; Rachel Fewster
Oggetto: RE: DNA analysis rat samples Aleipatas islands, Samoa

Dear Gianluca,
Can I just confirm a few details: you're trying to find the source of rats that have been on the Aleipata Islands since 2009, specifically whether they are descended from the pre-eradication rats or whether they are migrants from the main island Upolu. You can collect contemporary samples from Aleipata Islands and from Upolu, but you won't have any samples from pre-eradication Aleipata Islands, in other words the "survivor" population?

Which species of rat is it?

If I've got this right, I'm a bit concerned that you might not be able to address the question adequately without having the pre-eradication Aleipata Islands samples. The problem is that the pre-eradication Aleipata Islands would quite likely have been a genetic subset of the Upolu rats. If so, then we can only really distinguish rats in one direction: we'd be able to say that a Upolu rat couldn't have come from the pre-eradication Aleipata Islands (because it has genes that have been lost from the Aleipata Islands), but we wouldn't be able to say that an Aleipata Islands rat couldn't have come from Upolu because all its genes are there available on Upolu.

This would mean that any present day rat on the Aleipata Islands could genetically have come from Upolu, regardless of whether it is descended from Aleipata Islands survivors or whether it came over from Upolu after the eradication. So you could go to a lot of expense and not really get any answer from the results.

The only situation where you would get a result is if the pre-eradication Aleipata Islands rats were very different from Upolu, for example if they had originated from a different source when the islands were first colonised. Additionally, you would also need that the truth was a failed eradication and that the present-day rats are survivors from this very different population. Then we could tell genetically that the present-day rats are very different from the Upolu rats and we could deduce that the only explanation is if the pre-eradication Aleipata Islands rats were also different from Upolu, and this would imply that the present-day rats are descendants of these rats, in other words survivors.

However I think this scenario is rather unlikely, unfortunately. It's more likely that Upolu and Aleipata Islands were genetically similar before the eradication, and that we would need the pre-eradication samples to be able to distinguish the source of the present-day rats. I am a bit worried that the genetic analysis won't be worth the money it will cost, assuming that I've got it right that there aren't any pre-eradication samples available.

To answer your specific questions:

- Samples of size 30 from every source population are ideal: for example from Upolu and from pre-eradication Aleipata Islands. It doesn't matter how many samples you get from post-eradication Aleipata Islands if the aim is to say whether these rats could, or could not, be drawn from Upolu. We'd treat every post-eradication rat as a separate analysis. But if you do want to go ahead regardless of the problems above, I'd suggest you should try to get at least 15 rats from Aleipata Islands and preferably a few more.

- 70-90% ethanol is ideal for preparation. It's best if you can keep the samples in the fridge after preserving in ethanol. The other thing to note is not to stuff too much tail into a single bottle. Only a tiny amount of tail (2-4cm) is needed for genetic analysis. It's much more important that there is enough ethanol to permeate the tail tissue completely, so it's better to use a smaller amount of tail and not overfill the bottles.

- We now send all rat samples to EcoGene for processing: they are a commercial lab and their current prices are (I think) about $100 NZ per rat: I'll look out the correct pricing and let you know. So it isn't cheap: it would be maybe $5000 NZ to process the samples you need for a good analysis. I'd just suggest that you weigh up this expense against the other objectives of the project and consider whether the funds might be better spent elsewhere in this particular situation.

Of course it would be good to sample the the Aleipata Islands population now if there is a plan to eradicate it again and you want to store samples for a future DNA analysis in case of a future invasion. It's the pre-eradication samples that are the all-important ones, unfortunately. Anything else can be dealt with at a later date, but you can only take the pre-erad samples while the population is still extant.

I hope this is helpful. I'll look out those prices now.

Best wishes,
Rachel

Rachel Fewster (r.fewster@auckland.ac.nz) Department of Statistics, University of Auckland, Private Bag 92019, Auckland, New Zealand.
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http://www.stat.auckland.ac.nz/~fewster/

_____

From: g. serra [abunug@gianlucaserra.com]
Sent: Thursday, 17 September 2015 2:48 p.m.
To: Rachel Fewster
Cc: faleafaga tipamaa; maturo.paniani@mnre.gov.ws
Subject: DNA analysis rat samples Aleipatas islands, Samoa

Hello Rachel, I have just been given your contact by Bill Nagle.

[…]

Among several other tasks a very important one would be to get sufficient rat tail samples in order to try to understand the reason for the failure of the eradication attempt that was run in 2009 (CEPF project).

As you may recall, all the samples collected at that time (pre-treatment tails, post-treatment tails and main island/Upolu tails) were mysteriously lost between Nelson and Auckland. So that critical DNA analysis could never be run.

Could you kindly give us the contact of somebody from Auckland University that you consider would be keen to run this new DNA analysis?

Most likely we will start the survey next Monday (sorry for the short notice, I have been struggling to find your contact).

In particular, we would like to get instructions on the sample size needed in order to make a meaningful DNA analysis. We assume we will collect as many samples as possible from the Aleipatas and then others from the main island of Upolu.

We were told to use ethanol 70-90% in order to store these samples: kindly confirm this is correct.

I would greatly appreciate your feedback on this matter.

Thank you very much.

Best regards (also from Bill)

Gianluca

ANNEX 2

INVASIVE ALIEN SPECIES SURVEY

ALEIPATA ISLANDS, SAMOA

SEPTEMBER-DECEMBER 2015

GEF-PAS Invasive Alien Species project/Samoa

Gianluca Serra and Faleafaga Toni Tipama'a
New Eden Samoa Environment Consultants

on behalf of the Ministry of Natural Resources and Environment (MNRE), Department of Environment and Conservation (DEC)

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Photo on the cover: Nu'utele island (Credit: G. Serra).

1. INTRODUCTION

Samoa is part of the Polynesia-Micronesia Biodiversity Hotspot, one of 34 regions of the world where extraordinary levels of biodiversity and endemism are coupled with extremely high levels of threat (Mittermeier *et al.* 2004).

The four Aleipata islands (Photo 1), holding a high percentage of representative and threatened species of Samoa, certainly represent a key site in the Polynesia-Micronesia biodiversity hotspot. In a 1986 review of 226 islands in the South Pacific region, these islands together rated 30th in importance for biological diversity (Vanderwoude *et al.* 2006). They were also more recently included in the list of the 7 Key Biodiversity Areas of Samoa (Conservation International *et al.* 2010).

Photo 1. Aerial image of the four islands of the Aleipata group: foreground on the left, Fanuatapu islet; next to the right, Namua island (almost at the center of the image). In the background, Nu'ulua (small to the left) and Nu'utele (larger to the right) (Photo: Stuart Chape).

Nu'utele and Nu'ulua islands, belonging to the Aleipata islands group, are the only uninhabited islands of the group large enough and far enough offshore to be considered as refuges for key native threatened biodiversity of Samoa (Butler *et al.* 2011). These two islands still hold highly pristine and sizable lowland rain forests (an ecosystem highly threatened all over the Western Pacific region) with almost null IAS occurrence.

In addition of being a refuge for several native and endemic bird species, these forests are home to the largest population in Samoa of a regionally threatened dove (Friendly Ground Dove *Alopecoenas stairi*) and to the elusive and critically endangered Tooth-billed Pigeon *Didunculus strigirostris*. The two islands host also the largest sea bird colonies in Samoa and the best nesting grounds nationally for the Hawksbill Turtle *Eretmochelys imbricata.*

The other two islands of the Aleipata group, Namua and Fanuatapu, are smaller in size and more easily accessible from Upolu, as they are located within the coral fringe (see Photo 1). Namua is forested and hosts a quite popular touristic resort. Fanuatapu, the smalle~~r~~st of the 4 islands (just a rocky islet), is uninhabited, covered by limited short-standing vegetation, and bearing a lighthouse.

Due to their size, forest coverage and remoteness, conservation work in the Aleipata islands during the past 15 years have focused on Nu'utele and Nu'ulua, and it culminated in a Critical Ecosystem Partnership Fund (CEPF) project that was implemented during period 2009-2010 [a partnership between the Secretariat of the Pacific Regional Environment Program (SPREP) and Conservation International; total budget ca. 220,000 USD; Tye 2012]).

This project identified and recognized Polynesian rats *Rattus exulans*, Yellow crazy ant (YCA) *Anoplolepis gracilipes* and feral pigs *Sus scrofa* as the priority threats to the native biodiversity assets of these two islands (pigs only for Nu'utele). A review of past and recent Alien Species (IAS) management efforts in the Aleipata islands was recently compiled (Serra and Tipama'a 2016).

Three IAS field surveys of the Aleipata islands were organized by Maturo Paniani, national coordinator of GEF-PAS IAS project (a project run by MNRE/DEC in cooperation with SPRPE/United Nations Environment Program), during days 21-25 September, 26-30 October and 18 December 2015, as part of implementation of two activities of the workplan for Samoa (activities # 5 and 6).

Aim of the surveys was to survey current status of IAS on the four islands with a special focus on rats, YCA, pigs and weeds, and with a focus on the two larger islands, Nu'utele and Nu'ulua.

2. METHODOLOGY

2.1 NU'UTELE

Rats

Nine transect lines were established across Nu'utele island on days 22 and 23 September 2015 with the aim to cover most of its representative habitats, for a total of 100 rat trap stations (Maps 1a and 1b). Stations were spaced regularly, every ca. 50 m, and were marked with a coloured flagging tape. The transects covering the two slopes and the top ridge were in total ca. 3 km long. The parallel trap lines across Vini flats (ca. 0.7 km) and across Nu'utele flats (ca. 0.7 km) were similar and equivalent to those described by Butler (2010). The total transect coverage was therefore ca. 4.4 km.

At each station the following procedure was followed (as advised by Greg Sherley, *pers. comm.*): 1 snap trap with roasted coconut as bait was set up in parallel with 1 sticky (glue) trap with same bait. They were set up high on the ground at chest height on trees, to avoid interference by crabs. They were set up in the afternoon. At the end of each night the traps were checked, data and DNA rat samples were taken and baits replaced as needed (standard template of data log used is attached in Annex 1 as a reference). Sixty rat stations were run for three consecutive nights (22-25 Sept) while 40 were run for two nights (23-25 Sept).

Map 1a. Distribution of 100 rat trap stations across Nu'utele island as they were established during days 22 and 23 September 2015. Each station was made up of a snap trap and a sticky trap, both featuring roasted coconut as bait (Image: Google Earth).

Map 1b. Zooming of Fig. 1a (Image: Google Earth).

A spotlight night search was run on the first night soon after the arrival in Nu'utele aimed at detecting as many rats as possible, comprehensively covering the so called Vini flats and partially the adjacent slope.

Any sign for rat occurrence was searched during day and night (e.g. fallen fruits with fresh signs of chewing, fresh tracks and scats etc.). Identification of rats was made based on specific reference developed by Kiwicare.co.nz (http://www.kiwicare.co.nz/help/advice-pests-post/index.cfm/2011/09/identification-of-rats-and-mice/). Identification was based on the use of 6 different and independent parameters simultaneously, such as the ratio of tail /body length, the length and colouration of hind feet, the hair colouration of belly, shape of muzzle and the body fur colour. Samples of tails for DNA analysis were stored in ethanol -95%, as advised on the website of the Pacific Invasives Initiative.

Yellow Crazy Ants

As advised by Dr Ben Hoffman (*pers. comm.*; Hoffman, 2011) a visual search of the top soil and base of trees was undertaken to map the current distribution of occurrence of Yellow Crazy Ants (YCA). A team of 3 people walked for 20 m in parallel looking for presence of the ants on the top soil. The aim being to record and define the boundaries of infestation with a GPS.

Once YCA were detected a count of abundance was carried out by counting the number of ants on a 10x10cm laminated card positioned on the top soil over a fixed period of 30 sec. In the presence of nests abundance was not calculated as it was assumed to be maximum.

The detection and abundance assessment procedures were run once at each rat trap stations mentioned above and perpendicularly outside the transects for a length of 50 m, where access was possible.

Most of above survey work was done during the first expedition (22-25 September 2015) but a back-up survey was run one day during the second expedition as well (24 October 2015).

Other fauna (IAS and native)

Occurrence of pigs across the island was estimated while surveying rats and YCA. Active direct visual spotting and search for signs (e.g. scats and excavated soil) was employed. While surveying for rats and ants, high vigilance was maintained in order to detect any other IAS fauna through direct visual detection, hearing of specific calls and based on signs and scats.

In particular, special focus was held for Feral cat *Felis catus*, Jungle Fowl *Gallus gallus*, Common Myna *Acridotheres tristis*, Jungle Myna *Acridotheres fuscus*, Bulbul *Pycnonotus cafer* and Giant African Snail *Achatina fulica (*IAS Samoa database*)*.

Occurrence of key biodiversity species was attempted visually and based on calls, opportunistically, while running rat and YCA work. With a special emphasis on rare species such as the Friendly Ground Dove, the Samoan White Eye *Zosterops samoensis*, the Tooth-billed Pigeon and burrow-nesting sea bird-s during night surveying (petrels and shearwaters).

An estimate of numbers of individuals of the Friendly Ground Dove was attempted on 24 September and on 28 October 2015 as described in Butler (2010 and 2011). Sand beaches were checked for tracks of nesting turtles and surrounding ocean scanned for marine life.

Flora (IAS and native)

The forest team measured 200 meter intervals from the start of the trail at Vini flats to Nu'utele flats (please refer to Maps. 1a and b: plots were located on the same track used for rat sampling, but spaced 200 m instead than 50 m). Selected trees were measured within the 20x20m plots for checking tree growth and photo points were taken at intervals that were identified in the past surveys by Foliga *et al.* 2007. The surveyors plotted out the areas on the map (using the GPS coordinates given) and marked it with flagging tape. They then measured the diameter at breast height for key species present (those that had been identified in the report) and conduct comparison for tree growth and tree volume.

Identification of new growing tree and forest species were recorded, including, fruits, flowers and birds feeding on these trees. The distance was measured and recorded, to contrast the growth patterns of forest to the elevation of the island. A reconnaissance survey was conducted along the baseline, recording the different forest species present, with special focus on IAS trees. This assisted with calculating the vegetation types and forest trees, from lower elevation, mid-slope and upper elevation of the island.

IAS weeds were surveyed at Vini and Nu'utele flats covering as much ground as possible.

2.2 NU'ULUA

The access by boat to Nu'ulua was confirmed to be highly difficult and risky especially with the trade winds on (the trade winds season runs from March-April to November). Two boats were involved: a local fishing aluminium catamaran and an aluminium dinghy from MNRE/Marine Division. Sea and wind forecasts were not consulted beforehand. First landing was achieved on the morning of 27 October despite the rough sea and strong wind. The return to the fishing boat 4 hours later, with low tide, was even more complicated and riskier.

Forty-three sticky traps were laid down on that same day covering a good portion of the island's surface and most habitat types (Map 2). Roasted coconut as bait was used as for Nu'utele. The same rat trapping design adopted in Nu'utele could not be replicated in Nu'ulua because the snap traps had not been included in the luggage brought from Apia (as it was discovered on landing in Nu'ulua). While laying the sticky traps, occurrence and abundance of YCA was assessed, using method explained for Nu'utele (see point 2.2), together with occurrence of key fauna and flora (IAS and native).

Two days later, on 29 October 2015 (with better sea conditions), all trap stations were checked for rat signs. Thirty traps (those whose baits had not been disturbed by crabs) were left in place. A survey to check the 30 traps was organized for 5 December 2015, aimed at increasing the number of trap-nights, but it had to be cancelled at the last minute due to the suddenly worsened sea conditions (i.e. big swells coming from north and south).

Another one-day survey was organized on 18 December and successfully implemented with the aim to check the 30 sticky traps left on 29 October (Young, 2015).

Map 2. Locations of forty-three sticky rat traps laid down across Nu'ulua on 26 October 2015 and associated sites of YCA assessment (Image: Google Earth).

2.3 NAMUA

On 29 October 2015 IAS surveys (fauna and flora) were run on Namua using the track shown in Map 3. YCA were searched using method explained for Nu'utele (point 2.2.). Visual detections of rats and birds were attempted. The owner of the resort Mr Ieti, from the family to which the island belong to, was interviewed on the same day.

Map 3. In blue, the track followed on 29 October 2015 across Namua island. Red cross: location of roost of fruit bats *Pteropus tonganus* (Image: Google Earth).

2.4 FANUATAPU

Twenty rat sticky traps were laid down on 28 October 2015 on Fanuatapu with the aim to cover as much ground as possible and all the available habitats (Maps 4a and b). Traps were checked two days later for rat signs, on 30 October 2015, when YCA were also searched using the same transect.

Map 4a. Islet of Fanuatapu (Image: Google Earth).

Map 4b. Locations of twenty rat sticky traps laid down across Fanuatapu on 28 October 2015 (Image: Google Earth).

2.5 BIOSECURITY

Informal biosecurity assessments were run at the time of boarding on the boats taking the various teams to the islands on the surveys run in September and October (for a total of 2 independent landings in each of the four islands, N=8). Attention was paid to ascertain whether MNRE staff or the locals would call for biosecurity checks of the luggage and of the equipment before boarding on the boat or at the time of landing on the islands.

2.6 TEAMS

Survey 21-25 September 2015

- Joe, Finni, Kim, Va'a, Fou from Terrestrial Team (MNRE/DEC)
- Paulo from Parks and Forestry (MNRE/DEC)
- Tasi and Pule, two local labourers from Lalomanu village district
- Faleafaga Toni Tipama'a (flora expert)
- Gianluca Serra (fauna expert).

MNRE staff were trained during the implementation of the field work. In particular Joe, Finni. Kim and Va'a assisted the fauna surveys and were trained in rat and YCA surveying while Tasi and Pule assisted the flora surveys and were trained in forest surveying.

Survey 26-30 October 2015

- Va'a from Terrestrial Team (MNRE/DEC)
- Kuata and Pule, two local labourers from Lalomanu village district
- Maturo Tapau (national coordinator GEF-PAS IAS project)
- Faleafaga Toni Tipama'a (flora expert)
- Gianluca Serra (fauna expert).

Survey 18 December 2015

- Va'a and Ta'alili from Terrestrial Team (MNRE/DEC)
- Maturo Tapau (national coordinator GEF-PAS IAS project)
- Stuart Young (biologist and ecologist).

2.7 SCHEDULES

Total duration of first survey had been originally planned to be 7 days from Monday to Sunday, but it was shortened to 5 days due to a series of logistical and organizational constraints.

21.9: Drive Apia-Lalomanu, boat to Nu'utele; arrival in Nu'utele ca. 15:00; camp established; G. Serra visited seabird cliff on W side of Vini beach at sunset on low tide; Joe and Kim checked the trail to the ridge before sunset; G. Serra led Paulo and Va'a in a 2-hour rat night search on Vini flats using spotlights.

22.9: G. Serra, Joe, Va'a, Kim and Finni established rat trap stations along the Vini slope to top ridge (10 stations), along the north and western ridge (20 stations), on the western slope to Nuutele bay (10 stations) and across Nu'utele flats (20 stations) . At same time occurrence of YCA and other IAS fauna were surveyed and recorded. Toni, Paulo and

two locals survey forest plots on the Vini slope towards the ridge, along the north and western ridge and along a path going down to Nu'utele flats; weeds were surveyed on Nu'utele flats.

23.9: Kim and Finni established another 14 rat trap stations along the path going down to Nu'utele bay (the one that was marked the day before by Toni) and checked the rat trap stations of previous day; Toni established 26 rat trap stations across Vini flats while surveying for IAS plants and weeds. Gianluca, Va'a and Joe estimated area of infestations of YCA on the ridge and checked the rat trap stations of previous day.

24.9: all together checking for rat traps (+ collection of rat DNA samples), searching for Friendly Ground Doves on Vini flats and searching for YCA (estimate of infestation areas).

25.9: split up in four teams to check and recover all rat trap stations and collect rat DNA samples; camp undone; boat to Lalomanu; drive back to Apia.

Second survey had been originally planned to last 5 days from Monday to Friday, but in the end the first day was spent in Apia due to organizational delays:

26.10: preparations in Apia including shopping, reached Namua after sunset.

27.10: first survey in Nu'ulua (rat traps laid down + YCA surveys)

28.10: first survey in Fanuatapu (rat traps laid down) + backup survey of YCA on Nu'utele

29.10: second survey to Nu'ulua (rat traps checked) + Namua IAS surveys

30.10: second survey in Fanuatapu (rat traps checked) + YCA surveys.

Third survey aimed at Nu'ulua only was run on 18 December from early morning to afternoon.

3. RESULTS

3.1 NU'UTELE

Fauna

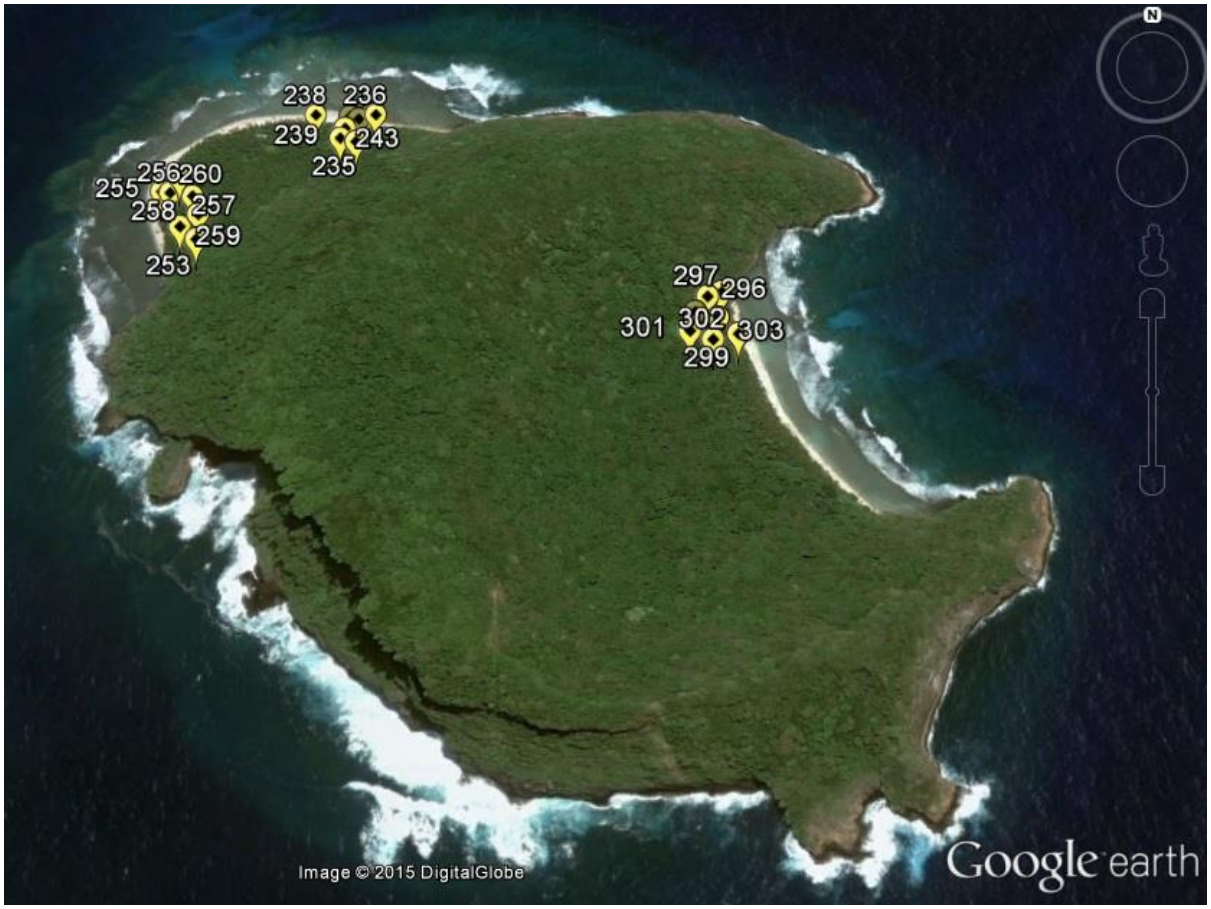
Rat trapping total effort was: 60 trap stations deployed for 3 nights = 180 trap nights; plus 40 trap stations deployed for 2 nights = 80 trap nights. In total therefore the trapping effort was 260 trap nights using two different types of traps. As a result, a total of 8 rats were caught in snap traps and one on a sticky trap (Map 5). Their tails were cut and stored for DNA analysis. Moreover, 4 instances of rat hair caught in the sticky traps were detected and recorded at four different trap stations (Map 5). Therefore, in total, we obtained 13 detections of rats through 260 trap nights.

Map 5. Rat detections in Nu'utele. Red tags: rats caught in snap traps (1 baby in sticky trap); Pink tags: rats hair found in sticky traps (Image: Google Earth).

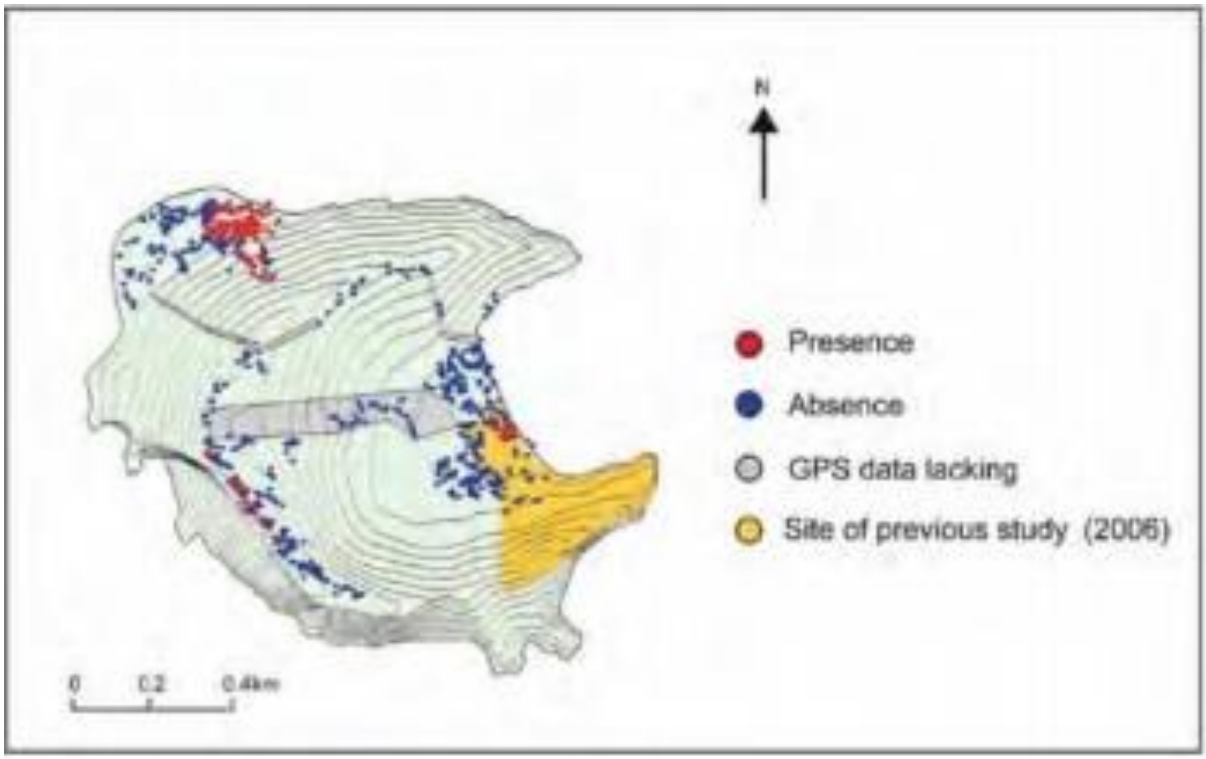
All rats were identified as Polynesian rat. They were all adults except for a very young one caught on a sticky trap (head-body length= 50-60 mm). A total of six rats were detected at night using the spot light across Vini flats.

YCA were detected on Vini and Nu'utele flats only. Locations of their occurrence within Vini and Nu'utele flats is shown in Map 6a. Several nests were found on the ground below stones, inside old and empty coconut shells and at the base of trees on Vini flats. Assessment of abundance was not undertaken in Nu'utele due to lack of time. YCA were not detected along the transect starting at Vini flats and reaching the top ridge, or ~~and also~~ along the two transects going down from the top ridge to Nu'utele flats.

We also did not detect their occurrence along the top ridge itself. On the top ridge several nests of *Camponotus* spp. ants were detected within dead log and branches. Interestingly, this species had not been detected on previous surveys by Hoffman (2011) (Hoffman, *pers. comm.*). Confusion ID between YCA and *Camponotus* spp. (that is also yellow in colouration) was avoided thanks to: i) samples collected and photographs taken, ii) *a posteriori* remote kind assistance by Dr Hoffman and iii) a back-up survey run on Nu'utele's top ridge on 28 October. As a term of reference, distribution of occurrence of YCA during previous surveys run by Dr Hoffman in 2009-2010 is shown in Map 6b.



Map 6a. Locations of YCA detections within Nu'utele island in September 2015 (Image: Google Earth).



Map 6b. Areas infested by YCA in 2009-10 (Map: Hoffman, 2011).

Photo 2. Polynesian rat caught in snap trap in Vini flats with YCA exploring the muzzle (Photo: Fou).

Photo 3. Coconut crab found on Vini flats during day-time (Photo: Toni).

Pigs were visually detected on several occasions during the day and evidence of their presence recorded (Map 7). In particular, a quite large female with piglets was seen at least in one instance.

Map 7. Locations of detections of pigs. Yellow tags: direct visual detections; Purple tags: signs of pig activity and occurrence (Image: Google Earth).

Notable recorded absence of key IAS animals that are common in Upolu were: Cockroach *Periplaneta americana*, Giant African Snail, Jungle Fowl, Common Myna, Jungle Myna, Red-vented Bulbul, Feral cat, and dog *Canis lupus*. Apparently the Jungle Fowl had survived the rat eradication in 2009 (A. Tye, *pers. comm.*) but it vanished in the following years due to unknown reasons (possibly eradicated by locals).

Birds detected and identified during the survey are listed in Annex 3. An estimated 5-6 Friendly Ground Doves were detected during a half an hour early morning count on the eastern side of Vini flats on 24 September 2015 (i.e. about a third of the total Vini flats area was covered). Six-seven individuals of the same species were detected between 7.15 and 8.15 on 28 October 2015 (2 definite males) within the whole extension of Vini flats – no rings were seen.

Substantial numbers of sea birds are confirmed to be nesting across the forest of Nu'utele and especially at its NW/W large sheer cliff. Dominant species were the Red-footed and Brown Booby *Sula sula* and *S. leucogaster*, Brown Noddy *Anous stolidus* and White Terns *Gygis alba*. Ca. 100 Brown Noddies were counted in association to a small vertical rocky cliff east of Vini beach during the October expedition. Few Black Noddies *Anous minutus* were recorded as well. Greater Frigatebird *Fregata minor* were seen passing by especially in the evening most likely directed to Nu'ulua. At least one Lesser Frigatebird *Fregata ariel* was intercepted and identified.

Possible detection of call of Manumea (Tooth-billed Pigeon) took place twice on Nu'utele: i) on 25 September, early morning, at the beginning of the trail starting from Vini flats and heading up to the top ridge: the "coo" call was heard twice with a time lapse of 7-8 sec; ii) on 28 October, coo call was heard repeated for 13 times in a row with frequency 10-15 sec. during first 10 repetitions (while time lapse increased to 20-25 sec. during the last three repetitions).

This latter call was heard within the patch of 15-20 maota trees *Dysoxylum samoensis*, the principal source of food for this critically endangered bird, in the middle of Vini flats (no fruits observed). Several fruiting maota were instead detected on Vini flats and also scattered elsewhere within the forest during the first expedition to Nu'utele, in September.

Notable bird absences recorded, consistently with previous surveys (Parrish and Sherley 2012): Masked Booby *Sula dactylatra* (seen at other times at sea within Aleipata islands range during previous years; reported to breed only on Rose Atoll, American Samoa, Biechle, *pers. comm.*), Samoan Fruit-dove *Ptilinopus fasciatus* (most common dove in Samoa, usually present in forested areas with many fruiting trees), Blue-crowned Lory *Vini australis,* Samoan Fantail *Rhipidura nebulosi* (common in the undergrowth of forests and at the edge of forests but "rare on islands" according to Parrish and Sherley 2012), Red-headed Parrotfinch *Erythrura cyaneovirensis,* Cardinal Honeyeater *Myzomela cardinalis*, Mao *Gymnomyza samoensis* (usually occurring in mature forests)

We did not detect also the White-throated Pigeon *Columba vitiensis* (usually common in forested areas) or the Samoan Triller *Lalage sharpie* that were detected during previous surveys (Parrish and Sherley 2012). Butterflies detected and identified are listed in Annex 4: they were all seen at the camp base on 24 September 2015 except for the Samoan vagrant that was also seen in the forest (in October).

Samoan fruitbat (*Pteropus samoensis*), endemic to Samoa and Fiji, was commonly and daily observed soaring over the forest during the day. Detections of *Pteropus tonganus* were made at dusk and night, involving individuals flying from Upolu. A freshwater prawn was detected on a small pond of a drying creek at one edge of Nu'utele flats in September.

Three separated tracks of turtles were observed in the sand on Nu'utele beach at the upper intertidal shore level on 22 September 2015. They were not too far apart (less than 80 m), so it could have been the same individual. Species identification was not possible. According to MNRE/Marine division staff only the critically endangered Hawksbill Turtle is nesting on Nu'utele beaches. A~~n~~ Hawksbill Turtle was in fact spotted and identified on 22 September over the reef in front of Vini beach and the same observation at an equivalent site was replicated on 28 October 2015.

Endangered Humpback whale *Megaptera novaeangliae* was observed once on each of the five days around Nu'utele during the September survey, both within the outer and the inner side (between Nu'utele and Upolu) around the island. A calf with mother and another accompanying adult was observed on 23 September, surrounded by at least 15 dolphins (most likely Long-snouted spinner dolphins *Stenella longirostris*). A mother and calf were seen again between Nu'utele and Upolu on the evening of 28 October 2015. A pod of unidentified dolphins was observed on 22 September and also on 27 October between Nu'utele and Upolu.

Flora

Flora surveys resulted in no detection of IAS forest tree species nor IAS weeds, with the exceptions of one Lopa tree *Adenanthera pavonina* (listed under the Invasives Index List for Samoa – but still no broad consensus on its inclusion) and one individual of Tamaligi palagi (*Albizia* sp.) on Vini flats. This is the same individual detected by Foliga *et al.* (2007). The team conducted a ring barking process to kill this tamaligi tree (Photo 4).

Photo 4. Barking of tamaligi tree (Photo: Fou).

The forest of Nu'utele seemed pretty dry being the end of the dry season. The forest vegetation of the island was found to be in good healthy state. Good undergrowth of native species was detected. Trees of *Diosporus spp.* (aoauli), *Syzygium clusiifolium* (asivai), *Stercilua fanahio* (fagaio) and *Dysoxylum* spp. (maota) were found fruiting.

A checklist of key forest tree species detected through the plots is reported in Annex 5.

Photo 5. Fruits of *Syzygium clusiifolium* (asivai) (Photo: Toni).

3.2 NU'ULUA

Thirteen out of 43 sticky traps were found to be missing the bait during the check run on 29 October. These 13 traps did not have any rat hair but instead presented signs compatible with crab movements. These traps had been probably not placed sufficiently high and vertically on trees to avoid crab interference. The other 30 traps instead still had the bait

intact and did not have any sign of rat movement nor hair (30 traps x 2 nights = 60 trap nights). Only 20 of the 30 traps left were detected and recovered on 18 December (a cyclone touched lightly Samoa at the end of November) and were found devoid of any hair nor sign of rat. Assuming, conservatively, that the baits lasted at least another 10 days following the visit of 29 October (they have probably lasted more than this), total effort achieved was 20 traps x 10 nights = 200 trap nights. Overall, we obtained 260 trap nights in Nu'ulua using only one type of rat trap.

YCA were detected at 22 out of 43 stations (Map 8) with abundance ranging from 9 to 45 ants / 30 sec (on top of these estimates, five nests were detected). A Blue moon butterfly was observed. Seven Friendly Ground Doves were detected in 1 and a half hour spent in the forest on 29 October 2015 (four on the slope and on the top ridge and three within the flats).

Nu'ulua appears to host important numbers of breeding Brown Noddy, Greater Frigatebird and White Tern (on top of appreciable numbers of Red-footed and Brown Boobies). Frigatebirds and red-footed boobies were seen at nest on top of trees on the top ridge of this island. Ca. 80-100 Ffrigatebirds were seen soaring over the island on 27 October 2015, while ca. 50 Brown Noddies used the north-eastern rocky point of the island as a perch/roost on the same day.

A ca. 10-foot shark was seen while sailing towards the above mentioned rocky point, on the outer side of the island, in deep waters, ca. 80 m from the shore. A young coconut crab was detected on Nu'ulua flats during the day.

No IAS trees, commonly found in Upolu, were detected on Nu'ulua, such as the Tamaligi *Albizia* spp., *Latana Lantana* spp. and Faapisi (African tulip *Spathodea campanulata*). No sign of *Merremia* spp. and no sign of weeds was found. The native forest of Nu'ulua was found intact. The dominant tree on Nuulua is Pu'a vai *Hernandia nymphaeifolia*, and the same trees found fruiting in Nu'utele were also found fruiting in Nu'ulua. The matalafi *Psychotria* spp., Mati *Ficus tinctoria* and Fetau *Inocarpus* spp. were also found fruiting. The only common vine growing on the island is the Mile-a-minute *Milkania micrantha.*

Map 8. Locations of detections of YCA along the transect used for the rat trap stations across Nu'ulua, as assessed on 27 October 2015 (Map: Google Earth).

3.3. NAMUA

A Polynesian or black rat was observed in the late afternoon at mid-way of the top ridge trail not far from where the fruit bat roost is located (Map 3). At least one cat and two dogs occur at the resort by the beach. No YCA were found across the transect indicated in Map 3. Other key IAS apparently absent from this island are the Giant African ~~giant s~~Snail, the two myna species and the Bulbul.

Mr Ieti, the owner of the resort, confirmed the presence of rats on the island. He stated that neither F~~f~~eral cats are present in the forest nor G~~g~~iant African ~~s~~Snails, nor mynas nor bulbuls. He mentioned the presence of cockroaches and of the Rhinoceros beetle *Oryctes rhinoceros* on island.

Namua hosts a roost of *Pteropus tonganus* (see Map 3, red cross) counting several hundred individuals at the very least. They depart at sunset directed toward Upolu to return at dawn. Twelve turtles and one ray were observed while sailing on a dinghy boat through the lagoon of Namua during a period of 30 minutes at mid tide on 29 October 2015.

Namua island's forest appears partially invaded by Tamaligi and *Merremia* spp. vine. The inhabited and cultivated fringe of the island holds taro, bananas, yams, breadfruit, coconuts, flowering plants and exotic plants and very little native trees. This island also has *Lantana* spp. an ornamental plant listed in the Samoa IAS index.

3.4 FANUATAPU

No hair of rat was detected on any of the 20 sticky traps set in Fanuatapu following two nights (for a total of 40 trap nights). No YCA was detected along the transect. A flock of ca. 80 Brown Noddies was observed soaring above the islet (together with few individuals of

both species of boobies). One large tern (probably a Crested Tern *Sterna bergii*) was spotted flying over this island on 30 October. A local surf guide mentioned that the waters in front of this islet, ocean side, are known to host sharks, in particular hammerheads.

Coconut grows on the island together with some patches of Taemanu (Wild banana) trees along the 150 steps to the lighthouse. Dominant trees on the island are Pu'a vai and Fau *Hibiscus tiliaceus*. No IAS weeds have been detected on the island.

3.5 TRAINING

MNRE staff involved in the three surveys received a substantial in-service training on rat and YCA surveying and on forest surveying.

3.6 BIOSECURITY ASSESSMENT

The call for biosecurity check of the vessel, luggage and equipment at the time of boat boarding while directed to the four islands of Aleipata was never heard/mentioned neither by the Government staff involved nor by the local people or the boat man during 8 different and independent occasions (N= 8).

This critical issue was mentioned at the time of landing on the islands by the experts involved and late biosecurity searches and checks were then run on the luggage, supplies and boat. As a result, several ants were found on the dinghy boat that landed on Nu'ulua on 27 October 2015 (they were killed one by one): most likely they had accessed the boat while it was kept at the MNRE parking place in Apia.

4. DISCUSSION

The surveys confirmed the persistence of the Polynesian rat on Nu'utele ~~island~~Island consistently with findings by Butler *et al.* 2011 and its absence in Nu'ulua consistently with findings by Fisher *et al.* (2012) and MNRE (2012).

The failure of the rat eradication attempt run in Nu'utele in August 2009 is therefore confirmed 6 years later. The disproportionate distribution of detections of rats in Vini and Nu'utele flats (77% over the total, N= 13) seems an indication of the rodent's attraction for the coconut grove habitat *versus* the native forest habitat, consistently with what found by Olson *et al.* (2006).

In fact, the high rate of capture of rats within Vini's coconut grove is also consistent with results by Stringer *et al.* (2003a, b), who accounted 87% of their total rat captures within the same habitat (N= 24). These authors, by using peanut butter *versus* roasted coconut baits during two different surveys in early 2000s, concluded that the Polynesian rat in Nu'utele prefers the coconut bait, differently from what had been observed for the same species in New Zealand. It has been actually suggested by several authors that Polynesian rats survive manly on coconuts in uninhabited oceanic islands (Biechle, *pers. comm.*).

According to Aaron Shiels (APHIS/USDA, *pers. comm.*) the young rat captured on a sticky trap at Vini flats was an estimated 4-5 weeks old. This means that it was most likely born at some point between 17 and 24 August ~~-~~2015. This is an evidence that rats ~~in~~ on Nu'utele

breed in the second half of (a very) dry season. So the spread of rat toxin in 2009 may well have taken place right when rats were giving birth.

The rat trapping/survey design adopted for Nu'utele worked well with 13 detections out of 260 traps nights, and by using two easy and locally available trap types. This is important in terms of chances of replicability by MNRE staff in the future. Four MNRE staff (Joe, Finni, Kim and Va'a) should be able to replicate a thorough rat survey using this simple design in the future.

By setting traps on tree trunks at chest high, interference by crabs was avoid in Nu'utele (only a couple of crab interferences were recorded out of 260 trap nights). The same cannot be said about the survey in Nu'ulua, taken place a month later under high time pressure (due to the need to leave the island before the low tide came in). Due to this temporal constraint, traps were laid down paying less attention to the issue of the need to avoid the crab interference. On top of this a higher density of crabs in Nu'ulua *versus* Nu'utele may also occur. As a result 13 out of 43 baits were reached and removed by crabs in Nu'ulua.

The rat survey design in Nu'utele was prepared based on:

- past rat surveys in the Aleipata islands (Stringer *et al.* 2000 and 2003; Butler 2010; Butler 2011; Fisher *et al.* 2012) and the New Zealand's Department Of Conservation's reference Broome *et al.* (2014);

- advises and recommendations by Dr Greg Sherley and Mr Niualuga Evaimalo (Head of Terrestrial Division of MNRE/DEC), both involved in rat surveys on those same islands in the recent past.

As a term of reference, below are reported key details of past rat trapping efforts:

1) Stringer *et al.* (2003) - Nu'utele: 85 trap nights (two types of traps); Nu'ulua: 40 trap nights (two types);
2) Fisher *et al.* (2012) - Nu'utele: 375 trap nights (1 trap type); Nu'ulua: 44 trap nights (1 trap type);
3) Butler (2010) - Nu'utele: 316 trap nights (4 trap types).

For a full perspective and details on past rat trapping efforts refer to Annex 2.

Unfortunately, the trapping design used in Nu'utele, involving two trap types, could not be replicated in Nu'ulua one month later due to organization and logistical shortcomings. The outcome of this trapping attempt, using sticky traps only, should be evaluated in the light of the outcomes of previous 4 independent trapping surveys run following the 2009 eradication attempt:

1) August 2009: 44 sticky traps, well covering the whole island area, deployed for 1 night (44 trap nights): no rats detected (Fisher *et al.* 2012).

2) December 2009: 44 sticky traps, well covering the whole island area, deployed for 1 night (44 trap nights): no rats detected (Fisher *et al.* 2012).

3) August 2010: 44 sticky traps, well covering the whole island area, deployed for 1 night (44 trap nights): no rats detected (Fisher *et al.* 2012).

4) April 2012: 19 snap traps, covering mostly the flats of Nu'utele, deployed for 2 nights (38 trap nights): no rats detected (MNRE 2012).

The rat survey run in Nu'ulua between October and December 2015, with its total trapping effort of at least 260 trap nights (a conservative figure), represents the biggest effort of trapping run so far, following the eradication attempt of August 2009. The consistency of the outcomes of the five independent surveys run after the eradication attempt (including the most recent one), between 2009 and 2015, taken all together (two types of traps employed in total), appears as a quite robust evidence that the eradication operation in Nu'ulua had been successful.

As a reference, ca. 100 trap nights of sticky traps only, deployed within the eastern slopes of Nu'utele and within Nu'utele bay in September 2015, were sufficient to detect four rats. Moreover, David Butler caught one Pacific rat with a snap trap in 2004 in Nu'ulua over only one night, presumably using the same bait we used (Parrish *et al.* 2004). Based on the above mentioned two facts, if rats still occurred in Nu'ulua, 260 trap nights of sticky traps using roasted coconut as a bait should have been sufficient to detect at least one rat.

The occurrence of YCA on both Nu'utele and Nu'ulua was confirmed. The full invasion of Nu'ulua by YCA is confirmed (Vanderwoude *et al.* 2006). In Nu'utele YCA seem still limited to Vini and Nu'utele flats, while they are absent from the other sectors of the island that were sampled.

They seem to have expanded their distribution on both flats of Nu'utele. On the other hand they seem to not occur anymore on the top ridge as they used to do in 2009-10 (Hoffman 2011). Overall, 8 years after their first detection by MNRE, the invasion of Nu'utele by YCA seems "on hold". This outcome would be worth to be confirmed by a more focused survey covering more ground and time in Nu'utele.

Interestingly, both rats and YCA in Nu'utele seems still both confined to Vini and Nu'utele flats: an indication that a pretty large and pristine stretch of native forest like that of Nu'utele is a fully fun ctional ecosystem offering limited opportunity for invasion by alien species, consistently with results by Olson *et al.* (2006) on rats and mongooses in Fiji. On the other hand, a small stretch of native forest like the one in Nu'ulua may be more vulnerable to invasions.

Sadly, the widespread occurrence of feral pigs in Nu'utele is also confirmed. They seem to be still in low density but worryingly they appear to be thriving and even breeding.

Present survey confirms that rats and YCA are absent from Fanuatapu (consistently with Fisher *et al.* 2012). It also confirms the occurrence of rats in Namua (Fisher *et al.* 2012). We did not find any YCA on this latter island, partially consistently to what found by Fisher *et al.* (2012) ("YCA are very rare on this island"). Probably they have vanished from this island since the time of the survey by Fisher *et al.* (2012).

The land bird community recorded in Nu'utele at this specific time of the year was consistent with communities found in equivalent ecosystems in Upolu, except for the notable rarity of Samoa Fruit-dove and for the apparent absence of White-throated Pigeon, Many-coloured Fruit-dove, Samoan Fantail, Red-headed Parrotfinch and Samoan Triller.

The parrotfinch was also not detected in Nu'utele during bird surveys in 2000-2001 and in 2010-2011, while the fantail was found to be "very rare" (Butler 2010 and 2011; Parrish and Sherley 2012). The absence of doves and the pigeon during present surveys may be linked to the very dry season found during the first survey (end of September), despite many trees were found to be fruiting.

The non-detection of other 3 forest bird species that are normally found in Upolu (Mao and to a lesser extent Blue-crowned Lory and Cardinal Honeyeater) is consistent with previous bird surveys mentioned (Butler 2010 and 2011; Parrish and Sherley 2012). Indications that the mysterious and extremely elusive, critically endangered, Manumea may still occur in Nu'utele seems confirmed by present surveys, consistently with the presence of its favourite fruiting tree (maota).

The Friendly Ground Dove counts at Vini flats (Nu'utele) during September and October surveys seemed consistent with figures reported by Butler (2011). It may be worth conducting a more detailed check in the short-term: the methodology used by previous surveys (e.g. Butler 2011) should be replicated in order to attempt to assess the trend of this valuable population over time.

Although counts were not undertaken, the current population sizes of sea birds (frigatebirds, noddies and boobies) seem consistent and equivalent with those mentioned by Butler (2011). A major colony of breeding frigatebirds is confirmed for Nu'ulua, consistently with previous surveys (Parrish and Sherley 2012). Flocks of dozens of Polynesian starlings *Aplonis tabuensis* were seen arriving at sunset to Nu'utele, coming from Upolu, on 24 September and also on 28 October.

Also some Pacific Pigeons *Ducula pacifica* were seen doing the same, one bird at a time, both in Nu'utele and in Namua. These observations together seem to confirm the important role as roosting site played by Nu'utele for forest birds occurring in Upolu (Parrish and Sherley 2012).

Overall, recorded avian diversity in Nu'utele and Nu'ulua (28 native species in total) and its conservation relevance (6 endemic species to Samoa and 2-1 globally threatened) is equivalent and consistent to what found in early 2000s by Parrish and Sherley (2012: 23-26 native species, 6-5 endemic, 2-1 globally threatened).

These two islands together should be considered as a key bird sanctuary of Samoa. And also a turtle sanctuary: present survey confirmed presence of critically endangered Hawksbill Turtle in the waters surrounding Nu'utele and on its beaches. The ocean surrounding these two islands seem still rich of marine life (whale, dolphins, sharks) confirming the ecotourism vocation of the Aleipata MPA.

Based on past reports, it is interesting to note that the Bulbul has probably made few attempts to colonize Nu'utele during the past 5-6 years (as mentioned above, most bird species are able to cross the 1.3 Km stretch of sea separating Upolu from Nu'utele) but failed most likely because they need to associate to people in order to survive. Same applies for the two species of mynas that have most likely tried the colonization of Nu'utele as well (although there is no record of this).

Nu'utele, Nu'ulua and Fanuatapu are still quite devoid of IAS flora (both trees and weeds). Abundance of good undergrowth of native species observed seems to show little disturbance from IAS animals in Nu'utele. No evident signs of negative effects of YCA on the forest were observed.

Comparison of the results of the previous forest survey by MNRE in Nu'utele (Foliga *et al.* 2007) with the present survey shows no detection of IAS plants in the mid-slope to upland slope of the island. Only one IAS tree individual detected in the lower-slope of the island (tamaligi), and no weed species detected. In particular, *Merremia* and *Wedelia* detected in 2007 were not detected during current survey.

Selected forest trees in the plots surveyed in 2007 in Nu'utele were re-measured in this survey and found to have grown in girth/size and height since then. The abundance of undergrowth seedlings evidence a remarkable forest regeneration.

Unfortunately, present surveys confirm that the complete lack of biosecurity is still threatening the biodiversity and ecosystems of these islands. Addressing this key threat, by reviving the interest and participation of the local community, seems currently the priority number one for the Aleipata islands, together with the eradication of pigs from Nu'utele [that had been recommended the first time in 2006 (IEAG 2006)].

5. ACKNOWLEDGEMENTS

We acknowledge and thank the Ministry of Natural Resources and Environment (MNRE), Division of Environment and Conservation (DEC) for their assistance, especially Mr Taupau Maturo and Mr Niualuga.Evaimalo. Thanks to Stuart Young, who acted as a volunteer in the field, and to U. Biechle., B. Hoffman, G. Sherley and J. Atherton for their valuable advises, insights and comments on the preliminary draft.

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ANNEX 1

TEMPLATE DATA LOG FOR RAT TRAPPING

ISLAND:

DATE: **DATA COLLECTOR:**

Station #	Waypoint	Status snap trap	Status sticky trap	Photograph taken (Y/N and ref. #)	Sample taken (Y/N and ref. #)	Notes

ANNEX 2

PREVIOUS RAT SURVEYS IN NU'UTELE AND NU'ULUA

Survey/author/date	*Island*	*Coverage*	*N. trap nights*	*N. and type of traps*	*Type of bait*	*N. rats caught*
Stringer et al. 2000	Nu'utele	Cross island trail (every 50 m)	102 or 36.5 snap traps + 44 tunnel nights?	Snap + tunnels	Roasted coconut and peanut butter	1
	Nu'ulua	Circle trail (described by Fisher 2012), every 7-10 m	120	Snap	Roasted coconut and peanut butter	0
Stringer et al. 2003	Nu'utele	Cross island trail (every 50 m) + 3 lines on Vini beach	85	Snap + tunnels	Roasted coconut	24 (21 on Vini)
	Nu'ulua	Circle trail (described by Fisher 2012)	40	Snap	Roasted coconut	0
Foliga et al. 2007 (September)	Nu'utele	Cross island trail from Vini to Nuutele beach	90	Snap and wax (both worked the same)	?	13
Fisher Jun 2009, Dec 2009, Aug 2010	Nu'utele	Ridge, Vini and Nuutele beach	375	Glue	?	26, 0, 0
	Nu'ulua	Nuulua beach and ridge	44x3	Glue	?	
Butler 2010 (March)	Nu'utele	Vini and Nu'utele Beaches, up the hill from Vini beach and on three lines from the top of the hill to Nu'utele Beach (down the centre along the bird transect, and around cliffs on each side	316	Snap + tunnels +wax tags + tomahawk	Roasted coconut	0
Butler 2011	Nu'utele	Similar to above	?	?	?	10
MNRE/Stowers et al. 2013	Nu'utele	Trail from Vini to ridge	26	Snap	Roasted coconut	0

ANNEX 3

BIRD CHECKLIST

#	*Species common and scientific names*	*Notes**
1	White-tailed Tropicbird *Phaethon lepturus*	Seen once
2	Brown Booby *Sula leucogaster*	Common and breeding
3	Red-footed Booby *Sula sula*	Common and breeding, chicks seen both in September and October
4	Great Frigatebird *Fregata minor*	Breeding in Nu'ulua. Seen a congregation of 80-100 individuals soaring over the island on 27 October
5	Lesser Frigatebird *Fregata ariel*	Identified at least one time from Nu'utele
6	Reef Heron *Egretta sacra*	Seen once
7	Banded Rail *Gallirallus philippensis*	Heard once in Nu'utele in September and seen by Toni in Nu'ulua in October
8	Far Eastern Curlew *Numenius madagascariensis*	Seen twice on the beach of Nu'ulua in October
9	Pacific Golden Plover *Pluvialis fulva*	Seen one individual on the rocky intertidal
10	Wandering Tattler *Heteroscelus incanus*	
11	Ruddy Turnstone *Arenaria interpres*	Several seen on the intertidal rocks in Nu'ulua
12	Blue Noddy *Procelsterna cerulean*	Probably breeding
13	Brown Noddy *Anous stolidus*	Common and probably breeding
14	Black Noddy *Anous minutus*	Uncommon
15	White Tern *Gygis alba*	Common and probably breeding
16	Friendly Ground Dove *Alopecoenas stairi*	Listed as Vulnerable by the IUCN Red List. Counted 5-6 during 30 min search on Vini flats in September (a third of flats was covered), and 6-7 in October across all Vini flats. They were seen also along the slope

		from Vini to the top ridge and on Nu'utele flats.
17	Pacific Pigeon *Ducula pacifica*	Common
18	Tooth-billed Pigeon *Didunculus strigirostris*	Possibly heard twice in both September and October. Endemic to Samoa, listed as Critically Endangered by the IUCN Red List
19	Samoan Fruit-dove, *Ptilinopus fasciatus*	Only heard once
20	White-rumped Swiftlet *Aerodramus spodiopygius*	Common and most probably breeding
21	Flat-billed Kingfisher *Todirhamphus recurvirostris*	Common, endemic to Samoa
22	Polynesian Starling *Aplonis tabuensis*	Common
23	Samoan Starling *Aplonis atrifusca*	Abundant, endemic to Samoa
24	Scarlet Robin *Petroica multicolor*	Probably heard few times
25	Samoan Broadbill *Myiagra albiventris*	Endemic to Samoa. Heard and seen few times, indication of breeding in October
26	Polynesian Triller *Lalage maculosa*	
27	Samoan Whistler *Pachycephala flavifrons*	Heard and seen several times, endemic to Samoa
28	Wattled Honeyeater *Foulehaio carunculata*	Abundant, most common bird in both islands

(*) If not mentioned explicitly, identification was definite. Possible additional sightings and identifications mentioned by team staff (unconfirmed) are the following: Samoan Fantail and Samoan Triller.

ANNEX 4

DIURNAL BUTTERFLY CHECKLIST

#	*Species common and scientific names*	*Notes*
1	Grass yellow *Eurema hecabe sulphurata*	
2	Monarch *Danaus plexippus*	
3	Blue moon *Hypolimnas bolinas pallescens*	
4	Samoan eggfly *Hypolimnas errabunda*	Endemic to Samoa
5	Common vagrant *Vagrans egista bowdenia*	
6	Samoan cerulean *Jamides argentina*	

ANNEX 5

CHECKLIST OF KEY FOREST TREES

Local Name	*Scientific name*	Plot # /Distance	Elevation (m asl)	Number of trees	Comments
Fuafua	*Kleinhovia hospita*	075/0	44	5	very common tree in the lower slopes
Tavai	*Rhus taitensis*			2	Common tree from lower slopes to the upland slopes
Atone	*Myristica inutilis*			7	
'Au'auli	*Diospyros samoensis*			3	Fruiting during surveys
Maota	*Dysoxylum maota*			7	Fruiting trees during the survey. Good food source for pigeons and doves.
Magaui	*Garuga floribunda*			2	
Pu'a vai	*Hernandia grandis*			4	
Futu	*Barringtonia asiatica*			10	fruiting
Niu	*Cocos nucifera*			1	
Matalafi	*Psychotria insularum*			5	Fruiting scrub, red berries
Leva	*Cerbera manghas*			2	
Atone	*Myristica inutilis*	076/200	54	10	
Futu	*Barringtonia*			10	

	asiatica				
Fuafua	*Kleinhovia hospita*			5	
Magaui	*Garuga floribunda*			5	
Maota	*Dysoxylum samoense*			3	
Lopa	*Adenanthera pavonina*	077/400	71	10	Suspect an invasive tree under the Samoa Invasive Species index
Fuafua	*Kleinhovia hospita*			2	
Auauli	*Diospyros samoensis*			5	
Talie	*Terminalia catappa*			3	
Pani	*Manilkara manilkara*	078/600	61	2	
Filimoto	*Flacourtia rukam*			2	
Laupapata	*Marcaranga harveyana*			15	Dominant species
Fasa	*Pandanus tectorius*			1	
Alaa	*Planchonella garberi*			2	
Lautivao	*Cordyline samoensis*			3	
Futu	*Barringtonia asiatica*			2	
Matalafi	*Psychotria insularum*			2	Fruiting shrub, red berries

Lopa				2	
Fetau	*Calophyllum inophyllum*	079/800	63	4	
Fao	*Neiosperma oppositifolium*			10	
Ifi	*Inocarpus fagifer*			11	
Nonu	*Morinda citrifolia*			5	
Tavai	*Rhus taitensis*			10	
Asi vai	*Syzygium clusiifolium*			1	
Tagitagi	*Polyscias sp*			4	
Fau	*Hibiscus tiliaceus*			3	Flowering trees in the forest
Olamea	*Aidia cochinchinensis*			2	
Anume	*Diospyros samoensis*			1	
Fanaio	*Sterculia fanaiho*			1	Fruitibg trees in Nuutele forest

Tavai	*Rhus taitensis*	080/1000		2	
Atone	*Myristica inutilis*			2	
‘Au’auli	*Diospyros samoensis*			3	
Maota	*Dysoxylum maota*			1	
Tamanu	*Calophyllum neo-ebudicum*			1	
Pu’a vai	*Hernandia*			4	

	grandis				
Futu	*Barringtonia asiatica*			5	
Niu	*Cocos nucifera*			1	
Matalafi	*Psychotria insularum*			5	
Magaui	*Garuga floribunda*			1	
Ifi	*Inocarpus fagifer*			2	
Fau	*Kleinhovia hospita*			5	dominant tree
		081/1200	29		
Lama				3	
Futu	*Barringtonia asiatica*			1	
Fuafua	*Kleinhovia hospita*			5	
Ifi	*Inocarpus fagifer*			5	
maota	*Dysosxylum samoense*			3	
Atone	*Myristica fatua*			2	
		082/1400	24		
Fuafua	*Kleinhovia hospita*			2	
Auauli	*Diospyros elliptica*			5	
Talie	*Terminalia catappa*			3	
		083/1600	-14		

Niu	*Cocos nucifera*			2	Nuutele flat area, dominant tree
Pua vai	*Pisonia grandis*			5	
Auauli	*Diospyros elliptica*			15	Dominant tree in the plot
Fasa	*Pandanus tectorius*			1	
Fau	*Hibiscus tiliaceus*			2	
		084/1800	-34		
Milo	*Hernandia grandis*			2	
Matalafi	*Psychotria insularum*			2	
Lopa				2	
Masame	*Diospyros samoensis*			3	
Fetau	*Calophyllum inophyllum*			2	
Futu	*Barringtonia asiatica*			4	
Ifi	*Inocarpus fagifer*			1	
		085/2000	-34		
‘Auauli	*Disopyros eliptica*			2	
Tavai	*Rhus taitensis*			1	
Asi vai	*Pisonia grandis*			1	
Tagitagi	*Polyscias sp*			2	
		086/2200	-29		

Pani	*Manilkara manilkara*			2	Very hard and good wood for axe handles.
Magaui	*Garuga floribunda*			1	
Fagaio	*Sterculia fanaiho*			2	
Tavai	*Rhus taitensis*			1	
Atone	*Myristica fatua*			2	
‘Au’auli	*Diospyros*			3	
Maota	*Dysosxylum samoense*			1	
Tamanu	*Calophyllum neo-ebudicum*			1	
Milo	*Hernandia nymphaeifolia*			1	
		087/2400	-43		
Matalafi	*Pyschotria insularum*			5	Common tree schrub in the plot
Gasu	*Palaquium stehlinii*			1	
Ifi	*Inocapus fagifer*			2	
Fau	*Hibiscus tiliaceus*			5	Common tree in this plot
Auauli	*Diospyros elliptica*			4	
Masame	*Diospyros samoensis*			2	
		088/2600	-24		
Pani	*Manilkara manilkara*			2	
Auauli	*Diospyros*			3	

	elliptica				
Fau	*Hibiscus tiliaceus*			2	
Toi	*Alphitonia zizyphoides*			1	