BASELINE SURVEY

of the

VAIPU SWAMP FOREST

EDITORS

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Cover photo: Top left corner: Vaipu Swamp Forest, Right: Niu Vao, (*Clinostigma warburgii*) © Elizabeth Kerstin-Yoshida
Left: Uunu (*Sarcopygme pacifica*) © Arthur Whistler
Middle: Tolaiula, Scarlet Robin (*Petroica multicolor*) © Chikara Yoshida

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This report was launched on the 4th of April 2023, during commemoration of World Wetlands Day, International Day of Forests, World Water Day and National Sanitation Day, as a joint event by the Ministry of Natural Resources and Environment.

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Vaipu Swamp Forest © Elizabeth Kerstin-Yoshida

Executive Summary

A baseline biodiversity and hydrology survey of the Vaipu Swamp Forest (VSF) in Eastern Upolu was conducted from the 27th to 30th March 2017 and the 3rd to 11th April 2017 by the Ministry of Natural Resources and Environment. The Vaipu swamp is the largest remaining mixed upland swamp in Samoa with an unusual wetland habitat and a number or rare and endemic species. The purpose of the study was to identify the biological and hydrological status of the swamp and to provide critical data to determine and prioritize actions to conserve the site.

The baseline survey confirmed the conservation values of the swamp and its priority for onservation as part of the Eastern Upolu Craters Key Biodiversity Area (CI, MNRE and SPREP 2010). Biodiversity recorded in the 280 hectare swamp includes the following:

- 30 tree species, including the endangered bush palm, *Clinostigma warburgii*
- 25 bird species plus an uncorroborated observation of the Tooth-billed Pigeon (*Didunculus strigirostris*)
- 10 land snail species, including three endemic snails *Eua expansa, Samoana canalis* and *Succinea putamen*
- 7 skinks, half of Samoa's skink fauna
- 4 fish, including the endemic *Kuhlia rupestris*
- 4 ant species, mostly introduced
- 3 butterflies
- 2 flying fox species

The water quality results for the Vaipu swamp for each of the components tested are within the World Health Organization standards. The water flow for the Vaipu swamp is perennial and according to the MNRE's Water Resource Division database, the river flowing through the swamp has maintained an average flow height of between 0.6 m and 0.9 m since 2009.

In addition to the swamp's biological and hydrological values, the swamp is also of historical interest as adjacent to the swamp are the remains of the ancient village of Vaigafa and nearby at Mauga o alii are historical sites including a star mound.

The main threats to the site are from stray cattle, invasive species and hunting, and potentially the development for a hydro power scheme in the future. It is highly recommended that efforts to ensure the long term conservation of the site are undertaken with local landowning communities. The objective of these discussons should be the development of a site management plan to safeguard the values of the swamp.

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We thank James Atherton (Consultant) for doing the technical edit and finalization of the report. We also thank the landowning communities of Va'a of Fonoti and Lotofaga districts for providing permission for surveys on village land, as well as the Electric Power Corporation for providing access to the site.

1. BACKGROUND INFORMATION

The Vaipu Swamp, also called the Fusiluaga swamp, is a large area of swamp forest covering approximately 280 hectares in a poorly drained basin on one of the upper tributaries of the Salani River (also called the Fagatoloa river), in eastern Upolu (see Figure 1). Holloway and Floyd (1975) recommended that the site be protected as a nature reserve, and this was supported by Dahl (1980) and again by Schuster *et al* (1997). The site was listed as the third highest conservation priority in Samoa by Pearsall and Whistler (1991) in their "Terrestrial Ecosystem Mapping for Western Samoa". The swamp is included in the Eastern Upolu Craters Key Biodiversity Area (CI, MNRE and SPREP 2010). Until the current study the area had never been properly surveyed and is in urgent need of more detailed study. The swamp has great potential for eco-tourism, although at present it is seldom visited except by pigeon hunters.

The Vaipu swamp is located at the interface of old Fagaloa volcanics (perhaps 3 million years old) to the north and Salani volcanics (around 750,000 years old), to the south. It is in an area of high rainfall, over 4,500 mm per annum, with limited seasonal variation (NIWA 2014). The swamp is fed by the Vaipu stream, and lies below the site of the former Punataemo'o swamp forest which was submerged by the Afulilo hydro-electric scheme in 1993. The basic alluvium and colluvium soils in the central part of the basin are saturated with freshwater, and there is some open water in the northeast.

The swamp forest is a very important water catchment area for the Salani river system. The forest comprises a mixture of typical swamp forest species and lowland rain forest species, with *Barringtonia samoensis, Calophyllum neo-ebudicum, Cananga odorata, Canarium harveyi, Canthium merrillii, Clidemia hirta, Cyathea* spp., *Dysoxylum samoense, Elaeocarpus tonganus, Fagraea berteroana, Ficus tinctoria, Hernandia moerenhoutiana, Hibiscus tiliaceus, Macaranga stipulosa, Myristica fatua, M. hypargyraea, Neonauclea forsteri, Pisonia* sp., *Planchonella torricellensis, Pometia pinnata, Rhus taitensis, Scirpodendron ghaeri, Syzygium samarangense and Terminalia richii* (Pearsall & Whistler, 1991). The screwpine *Pandanus turritus* and various endemic woody trees such as *Aglaia samoense, Clintostigma samoense* and *Sterculia fanaiho* have also been recorded. The swamp forest lies adjacent to disturbed lowland rainforest, secondary forest and some small taro plantation areas and cattle ranches.

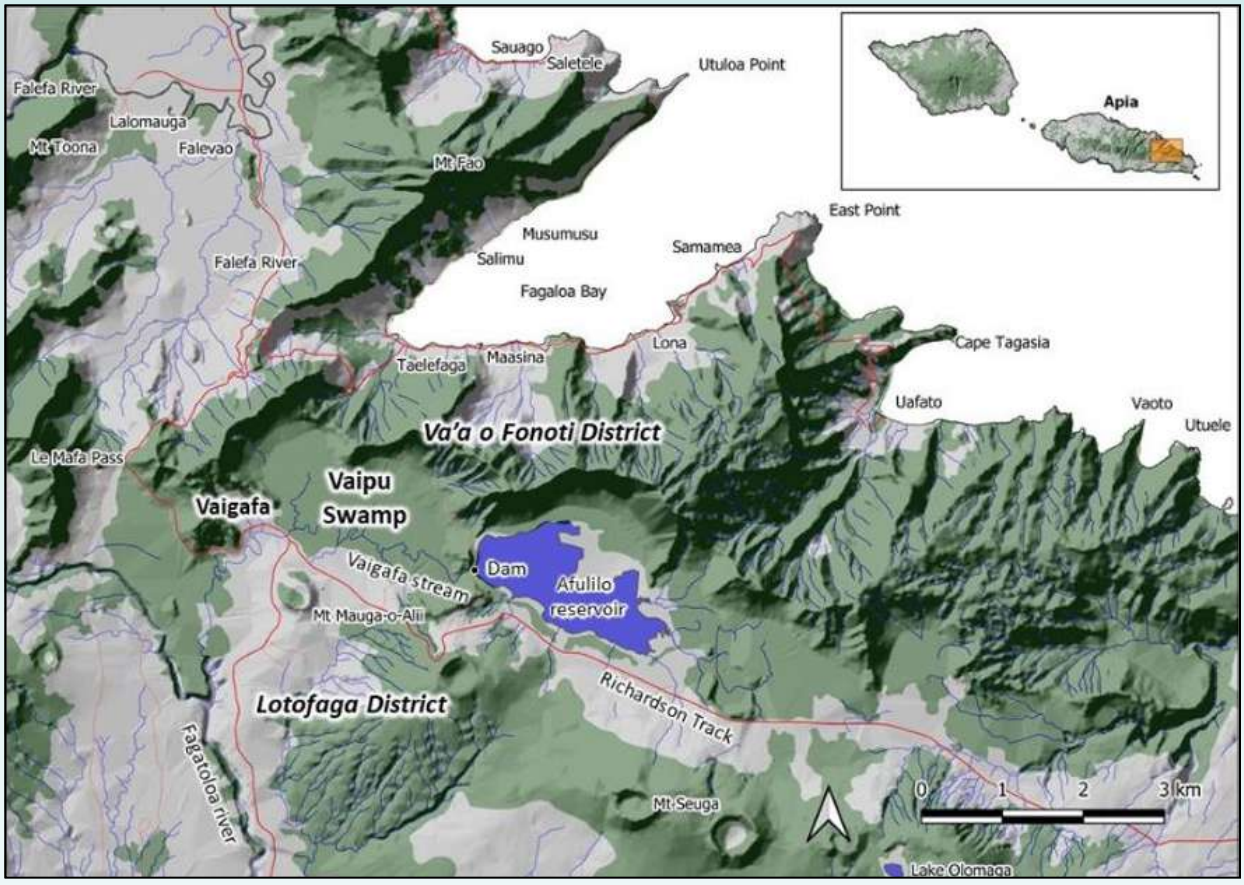
The Vaipu swamp contains a rare type of upland swamp forest (mixed upland species swamp forest) with a number of endemic tree species. Wildlife recorded at the site includes Pacific Boa (*Candoia bibroni*), two species of flying fox (*Pteropus* sp.), Pacific Black Duck (*Anas superciliosa*), Mao (*Gymnomyza samoensis*) and possibly Spotless Crake (*Porzana tabuensis*). The endangered Tooth-billed Pigeon (*Didunculus trigirostris*) is known to occur in the area.

The area has some archaeological significance, with an ancient settlement at the western end of the wetland at a location called Vaigafa. Vaigafa was believed to have been occupied by Paramount Chiefs for generations and was a site of pigeon snaring, a sport of the chiefs (Green and Davidson 1974). There are also other nearby historical sites including a star mound and burial sites at Mauga o Ali'i (refer to Figure 1).

The wetland and surrounding areas are now under the customary ownership of Va'a o Fonoti district to the north but historically had close links with the village of Lotofaga to the south. The Afulilo hydro-electric power scheme was developed in the upper catchment area in the early 1990s and opened in 1993. The wetland is threatened by development of plantations and expansion of the road network in the area. Pigeon hunting causes some disturbance, and there may be a small amount of logging. The cyclones of 1990 and 1991 caused significant damage to the forest. Development of the Afulilo hydro-electric power project in the water catchment area resulted in the destruction of the neighboring Punataemo'o Swamp Forest; any further expansion of this project could have a detrimental effect on Vaipu Swamp Forest.

For the purpose of this proposal, the Vaipu Swamp Forest have been defined according to the Ramsar Convention definition of wetlands.

Figure 1. Site Location Map



1.1. RATIONALE FOR SELECTING WETLANDS

Wetlands have three characteristics that make them an important target for biological survey and ongoing monitoring. Firstly, wetlands are an integral and highly productive part of the natural environment and play an important role in maintaining biodiversity. Many ecosystem services are delivered by wetlands, including;

- climate regulation;
- water regulation (hydrological flows);
- water purification and waste treatment;
- erosion regulation
- maintenance of water tables;
- groundwater recharge;
- natural hazard regulation (flood mitigation, storm protection);
- pollination (by providing habitat for pollinators);
- drought refuge for fauna and flora;
- soil formation; and
- nutrient cycling and retention.

Wetlands are complex systems that are often poorly understood. Numerous interactions between climate, topography, groundwater, surface water, substrates and biota create a myriad of unique wetland types.

Finally, wetlands are also amongst the most threatened ecosystems worldwide, with at least 64% of the world's wetlands having disappeared since 1990 (Ramsar 2018) due largely to practices such as draining, infilling, pollution and overexploitation of their resources. The unfortunate result of the combination of these three factors is that highly valuable aquatic ecosystems are being degraded or lost, even before their values can be documented or understood.

1.2. OBJECTIVES OF THE SURVEY

The overall goal of the 2017 baseline survey was to "*enhance knowledge of the status of the wetland ecosystems of the Vaipu Swamp Forest and improve management by establishing immediate and long-term plans for its conservation*".

The project objectives were to:

1. Survey the biota, hydrology and testing of water quality characteristics to provide baseline description of ecological character of the Vaipu Swamp Forest.
2. Assess the likely impacts on the ecological character of the site.
3. Develop a standard monitoring procedure to allow early detection of changes in the ecological character of the site.
4. Strengthen community involvement and participation in protected area assessment and management.
5. Improve knowledge of MNRE staff in surveying skills and techniques.
6. Develop a survey report for Vaipu Swamp Forest.
7. Develop a Management Plan to manage and protect the values of the Vaipu swamp.

2. REPORT on BIOTA of VAIPU SWAMP FOREST

2.1. PLANTS AND VEGETATION

The vegetation of the Vaipu Swamp Forests has been poorly surveyed. A study conducted in 1991 only focused on the east end below Afulilo Falls, and at the west end of the Salani River where it passes under the Lemafa Pass road (Pearsall & Whistler 1991). However, a comprehensive vegetation study was conducted from the 27th to 30th March and the 3rd to 11th April 2017 by the Ministry of Natural Resources and Environment. The purpose of the study was to identify the status of flora at the Vaipu Swamp Forests and to contribute towards the conservation and management of the Vaipu Swamp Forests by providing critical biodiversity data to assist in determining and prioritizing specific areas that require conservation action. Results obtained have confirmed that the Vaipu swamp forest has a high species diversity with many of the tree species being endemic.

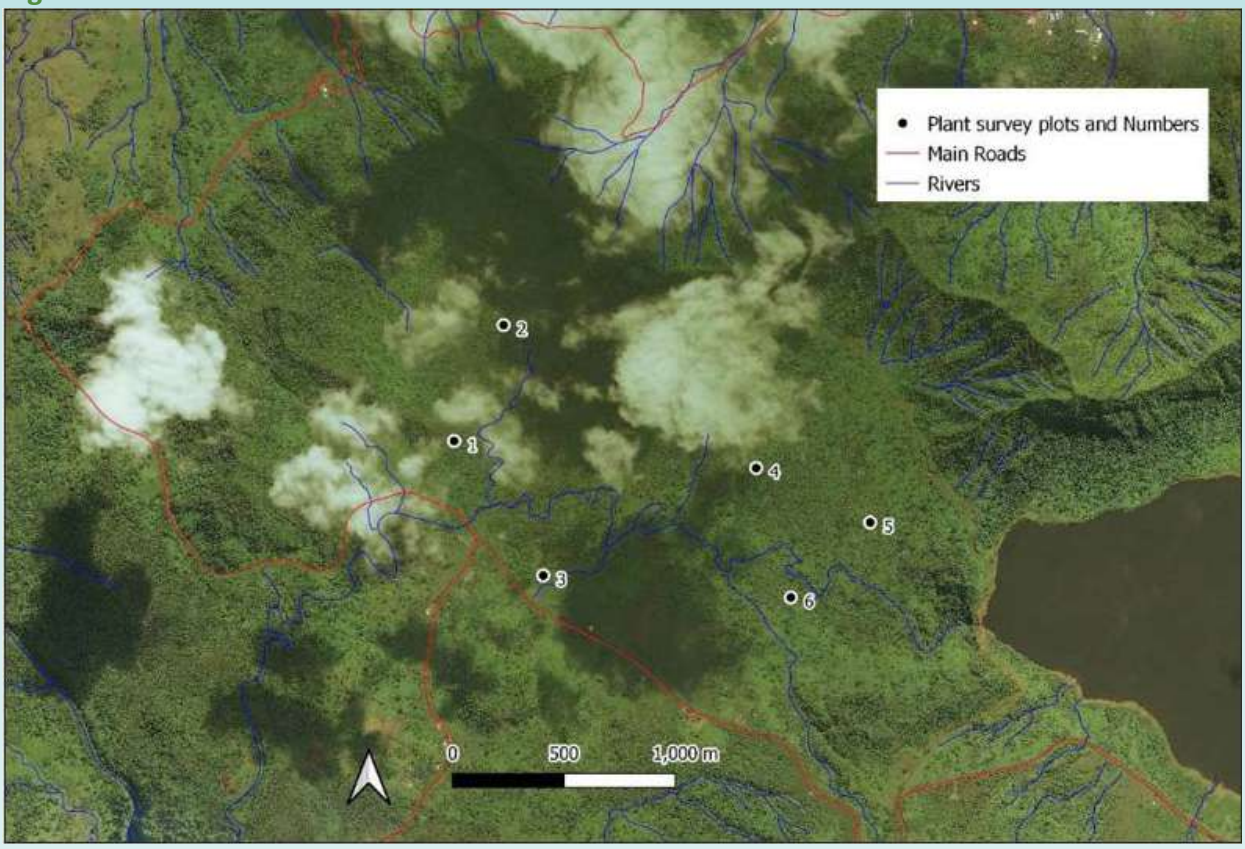
METHODOLOGY

The original plan of the plant and vegetation survey envisioned seven (7) transects randomly pre-selected within the Vaipu Swamp Forests using satellite images. This was undertaken through a mapping exercises conducted between staff of the Mapping Section of the Technical Services Division and the Forestry Division prior to the survey. All vegetation transects were sited to be representative of the vegetation communities present at the area. A stratified sampling method was used to ensure the presence of two (2) key subgroups/strata within the survey area and to reduce sampling error. The entire swamp forests was divided into two subgroups or strata: forest density and open area, then randomly selected the survey plots proportionally from the different strata. However, due to the complete disruption of the original canopy structures (emergent climax trees, upper canopy and understory) and the presence of invading weeds such as Merremia peltata, the team was able to survey only six (6) transects, concentrated in compartments with the best forest stands as indicated in Figure 2 (see Annex 1.1 for GPS coordinates). Each transect was divided into two (2) sections;

1. Rectangular transects were established in size of 20m by 25m (500m^2). All trees more than 5 cm in Diameter at Breast Height (DBH) were measured in both height and DBH.
2. 5m by 5 m (25m^2) square transects were set up within each rectangular plot to assess the understory or plant species that are less than 5 cm DBH. All the plant species were recorded with coverage degree and height. Several trees were measured with heights to draw a DBH-Height curve.

DBH-Height curves were drawn for every plot however, the curve from other tree heights was estimated. Basal Area (Area of cross section of breast height) were calculated from DBH to represent dominance (refer to Annex 1 for more details).

Figure 2. Location of Botanical Plots



RESULTS

Upon completion of the vegetation survey, a total of 337 stems from 30 tree species were identified and measured in the rectangular transects as summarized in Table 1 and shown in full in Annex 1.2. The assessment confirmed that *Barringtonia samoensis, Calophyllum neo-ebudicum, Cananga odorata, Cyathea lunulata, Fagraea berteroana, Hibiscus tiliaceus, Inocarpus fagifer, Neonauclea forsteri* and *Pandanus turritus* were the dominant tree species in the plots present within the rectangular transect. In addition, there were 21 plant species recorded and dentified present within the square transects including 12 tree species, 4 vines and 5 grasses (see Annex 1.3). The main dominant species are *Sciripendron ghaeri, Clidemia hirta, Nephrolepis hirsutula* and *Faradaya amicorum*. The overall coverage degree of the understory is not so high. It was also witnessed during the survey that plants including *Fagraea berreroana, Pandanus turritus, Sarcopygme pacifica, Terminalia richii* and *Meryta macrophylla* were commonly present outside of survey plot area. Two tree species from the fifty four identified are endemic to Samoa.

The largest tree recorded in the survey was a *Rhus taitensis* with a 140 cm DBH in plot No.3. Very few other big trees were found. Only 3.3 trees greater than 30 cm DBH were found in each plot and only 1.7 trees per plot trees were more than 40 cm DBH. Consequently the volume of forest is low at 69 - 194m^3/ha, or an average 118 m^3/ha (this figure excludes the huge *Rhus*). *Inocarpus fagifer* and *Pandanus turritus* were recorded as dominant tree species growing and adapted to wet areas with standing water.

Table 1. Trees recorded in the Vaipu Swamp Forests

Scientific name	Samoan name	Frequency	Endemic
Alphitonia zizyphoides	Toi	Occasional	No
Barringtonia samoensis	Falaga	Very common	No
Calophyllum neo-ebudicum	Tamanu	Common	No
Cananga odorata	Mosooi	Common	No
Clinostigma warburgii	Niu vao	Occasional	No
Cyathea lunulata	Olioli	Very common	No
Elaeocarpus floridanus	Aamatie	Occasional	No
Endiandra elaeocarpa	Endiandra	Occasional	No
Fagraea berreroana	Pualulu	Common	No
Flacourtia rukam	Filimoto	Occasional	No
Glochidion ramiflorum	Masame	Occasional	No
Hernadia moerenhoutiana	Pipi	Occasional	No
Hibiscus tiliaceus	Fau	Abundant	No
Inocarpus fagifer	Ifi	Abundant	No
Macaranga stipulosa	Lau fatu	Occasional	No
Manilkara dissecta	Pani	Occasional	Yes
Myristica hypargyraea	Atone ulu	Occasional	No
Myristica inutilis	Atone	Occasional	No
Neonauclea forsteri	Afa	Common	No
Palaquium stehlinii	Gasu	Occasional	No
Pandanus turritus	Fasa	Common	No
Planchonella garberi	Alaa	Occasional	No
Planchonella samoensis	Mamalava	Occasional	No
Pometia pinnata	Tava	Occasional	No
Psydrax merrillii	Olasina	Occasional	No
Rhus taitensis	Tavai	Occasional	No
Sarcopygme pacifica	Uunu	Occasional	Yes
Sterculia fanaiho	Fagaio	Occasional	No
Syzygium inophylloides	Asi toa	Occasional	No
Syzygium samarangense	Nonu vao	Occasional	No

2.2. FRESHWATER FAUNA

Freshwater and associated biodiversity are being threatened globally by anthropogenic influences despite their clear role in providing essential ecosystem services. The first of an anticipated series of freshwater surveys for Samoa was conducted in 2008 which sampled 15 m by 20 m sections of Samoan freshwater bodies (Jenkins *et al* 2008). Unfortunately, the Vaipu Swamp Forest was not part of this study and its freshwater biodiversity was never been surveyed and remained unknown. However, fish species recorded downstream from the swamp in the same river system near the Fuipisia falls included the Mozambique Tilapia (*Oreochromis mossambicus*) and the Shortfin Molly (*Poecilia mexicana*) (Jenkins *et al* 2008).

This report is beginning to address this gap in knowledge by presenting results of a survey conducted in March/April 2017 targeted two freshwater organisms being fishes and macro-crustaceans.

METHODOLOGY

Prior to the implementation phase of the field survey, a series of maps were developed that indicated all active rivers and streams within the Vaipu Swamp Forest to assist with siting of sampling locations to get a representative spread of sample sites. One hundred metre long line transects were used to collect fishes and macro-crustaceans in each sampling location, sampled from downstream section of the site working upstream as per the methodology used by Jenkins *et al* 2008. A variety of techniques and equipment were used to sample each location including:

1. An electro-fisher was the most preferable sampling tool but was unfortunately only available to the survey team for one (1) day. It uses direct current electricity flowing between a submerged cathode and anode which affects the movement of fauna so they can swim towards the anode where they can be caught for identification in as little as two minutes before they return to their natural state and are released.
2. Mesh and pole seine net was a primary sampling tool used throughout the freshwater survey. Nets were used to scoop along vegetated stream and river banks by being thrusted under submerged vegetation while vegetation was also disturbed on the bank dislodging fauna into the net. Nets were also used to scoop the bottom of the stream and moved forward along the substrate for a few seconds. Fauna collected were then raised and placed in a water-filled plastic bucket. These nets were most commonly used in conjunction with the electro-fisher (Jenkins *et al* 2008).

The majority of fauna collected were released except a few which were kept in liquid preservative. Specimens stored directly in 96% ethanol caused morphological disturbance through shrinkage, hardening and distortion and witnessed rapid colour loss however the accurate preservation of color patterns was documented. Additionally, the 96% concentration ethanol was diluted with 600 ml of water for preservation of other specimen such as fish.

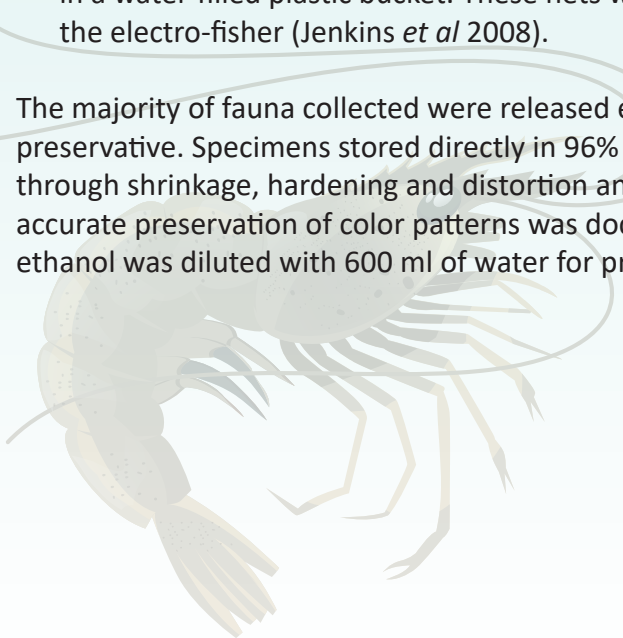


Figure 3. Colour change in shrimps stored in 96% concentration ethanol

Figure 4. Young eggs of female shrimp

RESULTS

A summary of the fish and macrocrustacea recorded in the Vaipu swamp forests are shown in table 2. The full freshwater survey report is shown in Annex 1.4.

Species	Scientific name	Common name	Samoan name	Endemic
Fishes	*Gambusia affinis*	Mosquitofish		
	Kuhlia rupestris	Jungle perch	Sesele	Yes
	Eleotris fusca	Dusky sleeper	Apofu	
	Oreochromis niloticus	Tilapia	Tilapia	
Crustaceans	*Macrobrachium rosenbergii*	Giant river prawn	Ula vai	Yes
	Caridina cf. cantonensis sp	Blue tiger shrimp	Ula vai	

Table 2. Fish and crustaceans recorded in the Vaipu Swamp Forests

2.3. BIRDS AND FLYING FOXES

METHODOLOGY

Bird counts were conducted at stations between 200 m to 400 m apart along the approximate 2.7 km transect (See Figure 5 with locations in Annex 1.5). Each station was surveyed two to four times depending on location and accessibility. There is no major difference in the vegetation cover in the area although any interesting findings would be key to this survey. For each survey the team conducted repeated sampling at each station from 6.30 am – 9.30 am, and again from 3.00 pm – 6.00 pm. The team also made general observations outside of survey hours.

During the surveys they made note of the date and time, weather, habitat characteristics, trees that are fruiting at this time of the year and observer name. They also noted any bird nests, signs of disturbance to habitats such as logging, hunting or predatory attacks to birds such as by rats or feral cats. Surveys were completely halted if there was rain as this affects the observations and counting.
For most of the survey area, the thick vegetation and the thick mud and streams below were impediments impacting the survey implementation. Consequently, the team made records of presence and absence for species detection only, while also making note of those species that are commonly present overall. Bird surveys were conducted in the same areas as other taxa included in this report.

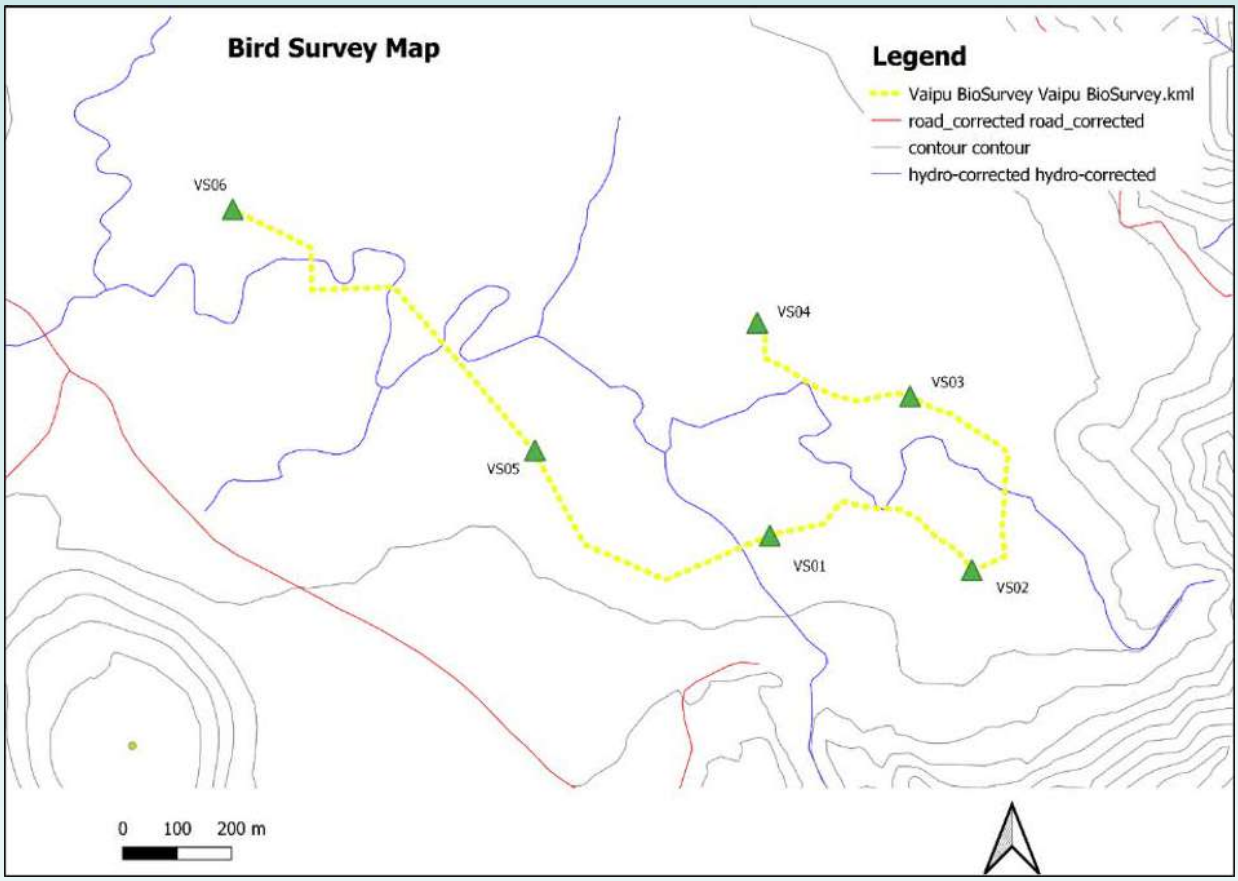


Figure 5. Location of Bird Transects

RESULTS

Bird and flying fox results are shown in tables 3 and 4. There were 27 bird species identified of which 6 are endemic to Samoa. Both flying foxes species native to Samoa (*Peropus tonganus* and *Pteropus samoensis*) were also recorded.
Acridotheres fuscus (Jungle Myna) and *Pycnonotus cafer* (Red-vented Bulbul) were recorded but at low numbers and no roost sites were observed.

There was little difference in the avifauna diversity reported for Vaipu since the 1999 survey from the results that were found in 2017. However, since the team did not conduct a thorough quantitative survey, there was insufficient sampling data to do a quantitative analysis of species abundance. There is a possibility of more bird species being found in the area but the wet weather throughout the survey constrained their identification. There was a good representation of native fruiting trees recorded as food source for birds but only a few were recorded fruiting including *Barringtonia samoensis, Calophyllum neo-ebudicum, Cananga odorata* and *Clinostigma waburgii*. Maota (*Dxsoylum* spp), a well known fruiting tee for pigeons, was also recorded but was not fruiting at the time. *Anas superciliosa* (Pacific black duck) was not seen in the survey area however this species is commonly found in the Afulilo dam pond within 1 km from the survey area. In the Upland ecosystem survey report (Schuster *et al* 1999), *Didunculus strigirostris* (Manumea) was recorded in the highest numbers in the Vaipu swamp area compared to all other areas surveyed at the time. After almost two decades, Manumea was only recorded as an uncorroborated record from two accounts heard on two different days during the survey. This result is disappointing and indicates how Critically Endangered and rare Manumea has become.

Table 3. Birds recorded in the Vaipu Swamp Forests

No	Common Name	Scientific Name	Samoan Name	Status
1	Samoan whistler	*Pachycephala flavifrons*	Vasavasa	Endemic
2	Samoan triller	*Lalage sharpei*	Miti	Endemic
3	Crimson crowned fruit dove	*Ptilinopus porphyraceus*	Manutagi	Endemic
4	Samoan starling	*Aplonis atrifusca*	Fuia	Endemic
5	Samoan fantail	*Rhipidura nebulosa*	Se'u	Endemic
6	Flat billed kingfisher	*Todirhamphus recurvirostris*	Ti'otala	Native
7	Pacific scarlet robin	*Petroica multicolor*	Tolai'ula	Native
8	Cardinal honeyeater	*Myzomela cardinalis*	Segasegamau'u	Native
9	White rumped swiftlet	*Aerodramus spodiopygius*	Pe'ape'a	Native
10	Polynesian triller	*Lalage maculosa*	Miti tai	Native
11	Wattled honeyeater	*Foulehaio carunculata*	Iao	Native
12	Polynesian starling	*Aplonis tabuensis*	Fuia vao	Native
13	Blue crowned lory	*Vini australis*	Segavao	Native
14	Many-coloured fruit dove	*Ptilinopus perousii*	Manuma	Native
15	Pacific Imperial pigeon	*Ducula pacifica*	Lupe	Native
16	White throated pigeon	*Columba vitiensis*	Fiaui	Native
17	Banded rail	*Gallirallus philippensis*	Ve'a	Native
18	Purple swamphen	*Porphyrio porphyrio*	Manuali'i	Native
19	Jungle myna	*Acridotheres fuscus*	Maina fanua	Introduced/Invasive
20	Red-vented bulbul	*Pycnonotus cafer*	Manupalagi	Introduced/Invasive
21	Barn owl	*Tyto alba*	Lulu	Native
22	Pacific black duck	*Anas superciliosa*	Toloa	Native
23	Brown noddy	*Anous stolidus*	Gogo	Native
24	White tern	*Gygis alba*	Manusina	Native
25	White-tailed tropicbird	*Phaethon lepturus*	Tava'e	Native

MAMMALS

The team did not find any main roost locations for flying fox within the survey area or around the vicinity of Vaipu swamp forest. Observations of the two species were quite frequent but in low numbers. Occasionally they would fly out independently or a few were seen roosting in the *Terminalia richii* (Malili) trees.

Common name	Scientific name	Status
Samoan flying fox	*Pteropus samoensis*	native
Tongan flying fox	*Pteropus tonganus*	native

Table 4. Native mammals recorded in the Vaipu swamp forest

SEABIRDS

Three species of seabird were recorded: *Anous solidus* (Brown Noddy), *Gygis alba* (White Tern) and *Phaethon leturus* (White-tailed Tropicbird). Accounts of these birds were mostly during flight and the birds tend to fly northward towards the Uafato coast. The team could not detect if there are any nests in the survey area.

2.4. LAND SNAILS

METHODOLOGY

The land snail fauna of the Vaipu swamp area has never been studied in detail before. The team attempted to collect a baseline from this study was limited by the technical capacity of the team studying land snails. In light of our interest to collect land snails during this work, the team made reference to previous research on land snail fauna of Samoa by Cowie and Robinson (2003), and used the chapter by Brook in Atherton and Jefferies (2012), for standard methods.

As there was no formal equipment available for collection so the team manually searched for snails by hand. The team searched for snails in leaf litter and under logs and decaying material, under and on tree leaves and even on tree trunks. Dead specimens found were taken for initial identification at the office; photographs of live specimens were photographed and released back on site. The team used the online snail identification guide on the land snails of Samoa by Cowie (http://pbs.bishopmuseum.org/samoasnail/). The final list and photographs of specimens was sent to the key land snail experts in the Pacific region, namely Professor Robert Cowie and Dr Fred Brook for their review and validation of species found.

RESULTS

Land snail results are shown in Annex 1.6. A total of 11 land snail specimens from 10 species were collected and recorded from the survey sites including the invasive Giant African Snail, *Achatina fulica*. There is high endemicity for land snails in Samoa with 72 species known, including 58 native snails, 10 introduced snails and 4 with an unknown origin (Cowie and Robinson 2003).
Most of the specimens collected from the litter were empty shells and the majority were of native snails including three endemic species - *Eua expansa, Samoana canalis* and *Succinea putamen*. The smaller endemic tree snails were mostly collected alive on small tree leaves either on top or underside. The team expected a higher a number of land snails from Vaipu however the basic methodology used for collection did not allow for all species to be located.

2.5. REPTILES

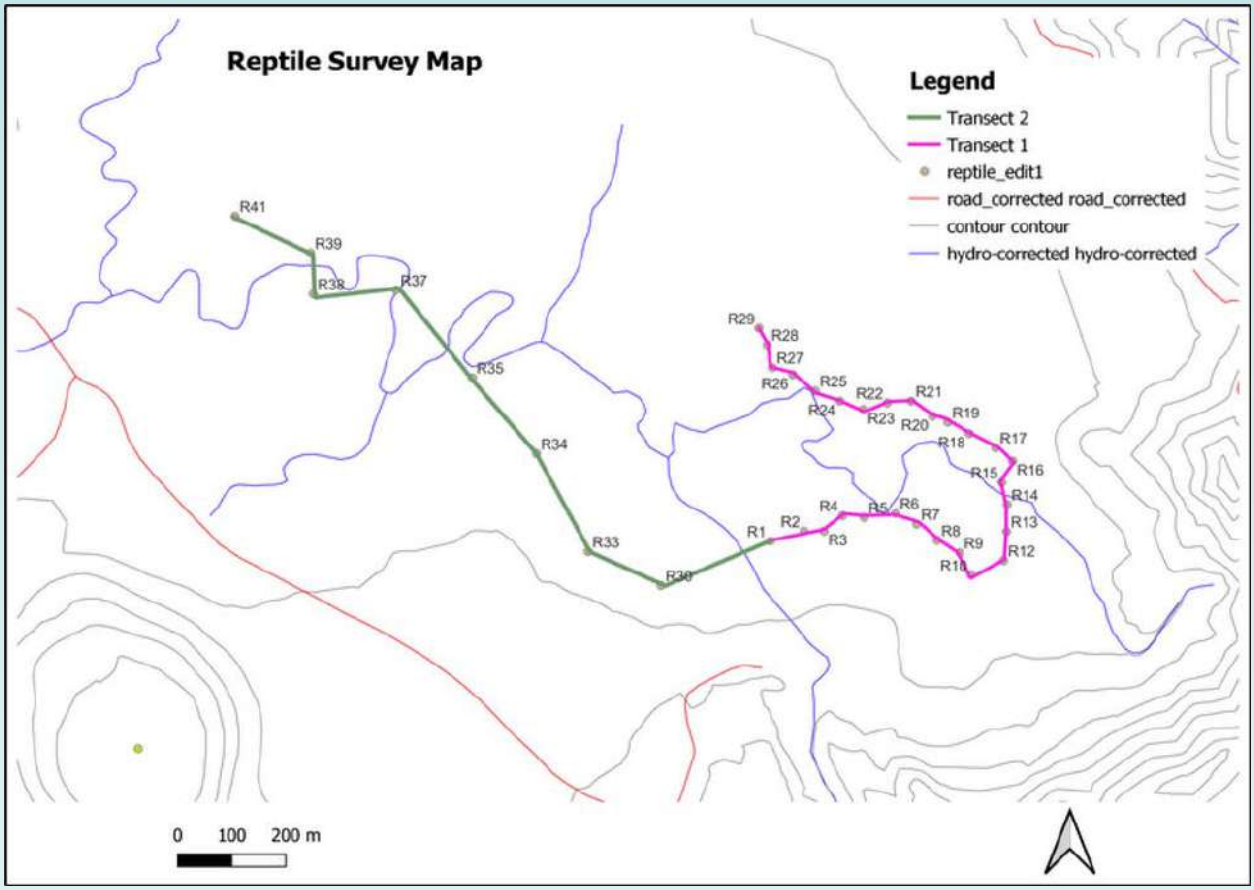
METHODOLOGY

A total of 144 glue traps were used in 48 stations between 50 m - 100 m apart in the project area (Figure 6). Two methods were used to collect reptile information: daytime and night time visual encounters and the use of glue board sticky traps. Annex 1.7 gives information on reptile trapping sites and conditions.
Conducting reptile surveys is highly weather dependent because wet conditions are not suitable for glue traps to work successfully. During the two days of survey the weather was changeable with at least 40% cloud cover but most time were suitable for the use of sticky traps.

On day one, the team set up the survey stations in transect 1 at least 30 m apart. However, due to the high humidity and the wet and damp surfaces even on tree trunks, the traps were mostly damaged with very little success in trapping skinks. On day 2, the team changed the strategy to increase the sampling size to at least 100 m between stations, covering transect 2. This gave them the resources where chances of trapping success were limited. For each station, the team laid out 3 glue traps, one on the tree, the second on a firm log and the third on the ground. Deciding where to put the traps is important and because of the high humidity in the survey area, it is crucial to find a space with the sun light penetrates through the vegetation and to look for open areas with some trees and logs around to attach the traps to.

The traps were left out for at least an hour to increase the chance of trapping any skinks in the area. In areas that are directly under the sun, it is recommended that traps are checked within 15 minutes. Any skinks trapped on the glue traps in the sun for more than 15 minutes are at high risk of dying in the hot sun or being attacked by birds. Timing and weather conditions are critical in monitoring the activities at the stations. In addition to trapping, a daytime visual count is also conducted between stations. This includes looking for snakes under tree logs or inside tree trunks with large holes in them. During the night time after dinner, the team set out night visual counts for geckos using head lamps to search on the trees, logs, leaves or low on the ground. A portable counter machine was used to record the number of individuals seen while also making note of the species present.

Figure 6. Location of Reptile Surveys



RESULTS

A total of 39 skinks were captured representing 7 of the 14 skink species found in Samoa. From our daily observations we recorded 5 skinks, 2 gecko species and 1 juvenile Pacific Boa (*Candoia bibroni*). These include *Emoia tongana* (Green skink), *Lipinia noctua* (Moth skink), *Emoia impar* (Blue- tail skink), *Emoia cyanura* (Azure-tail skink) and *Emoia nigra* (Black skink). *Emoia samoensis,* the Samoan skink endemic to Samoa and Tonga, was not observed or captured on the traps or recorded from our visual encounters. With favourable conditions *Indotyphlops braminus* (Brahminy blind snake), was surprisingly not recorded. Only two gecko species were recorded, *Gehyra oceanica* (Oceanic gecko) and *Lepidodactylus lugubris* (Morning gecko).

2.6. BUTTERFLIES AND MOTHS

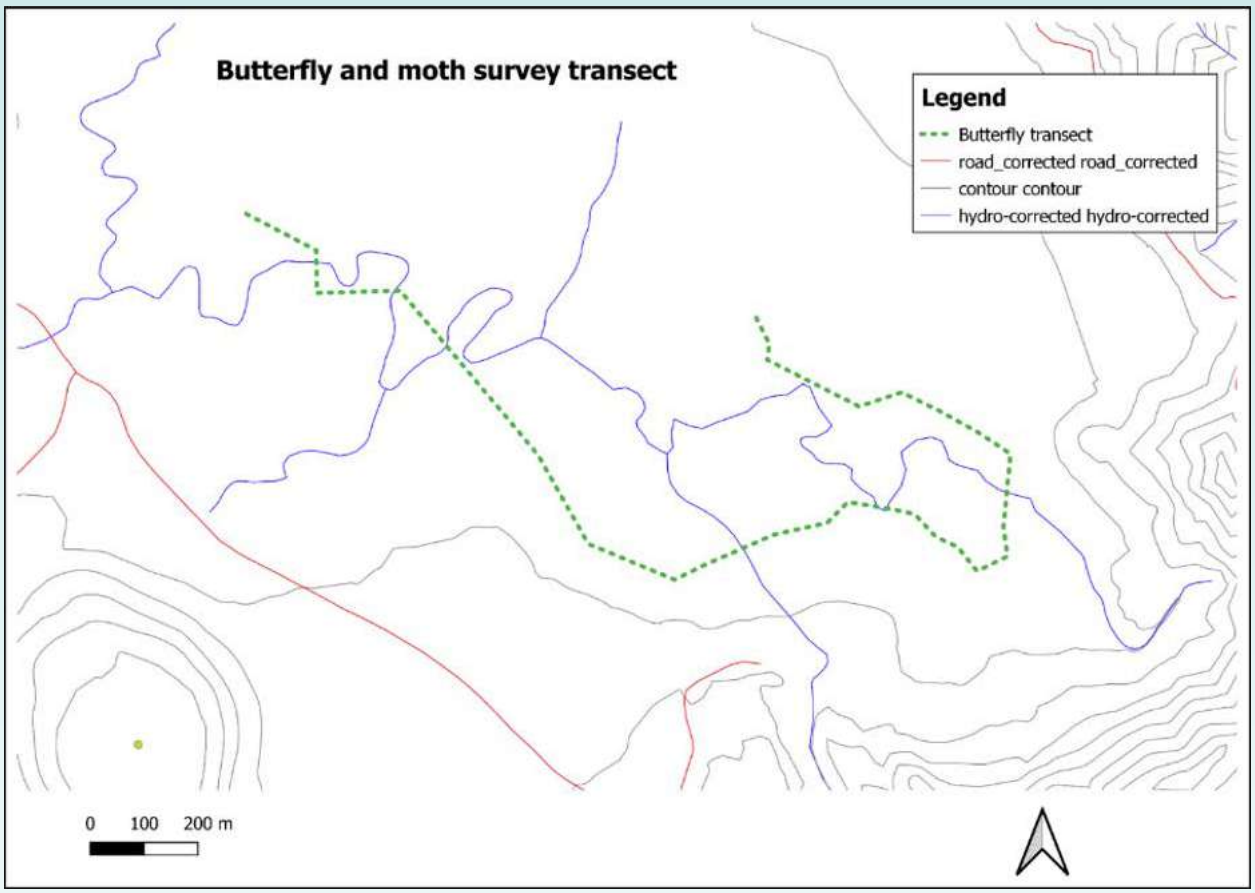
METHODOLOGY

The team used two methods to sample butterflies and moths in the survey. First they used sweep nets to collect butterflies flying in the air and through vegetation. Within 2 km of the Vaipu swamp are a number of ornamental gardens which provide good habitat for butterflies and the team made daytime observations of these areas and collected specimens.

In addition to sweep netting, observations were also made in the night time. The team also attempted to do light trapping under their tent. However, the absence of a powerful light for this technique and the damp weather conditions were not conducive to attracting moths. Therefore, the team's attention was more focused on sweep netting and daytime observations in the fields using the same 2.6 km long transect that provided the same access for all other taxa surveyed in the expedition (Figure 7).

Common specimens that the team were able to identify in the field were recorded and not trapped while those that they could not identify were either photographed and released or stored using the sterile specimen containers for later identification and confirmation by experts. During the survey, the team used the butterfly and moth identification guide by Edwards (2015).

Figure 7. Butterflies and moths transect



RESULTS

The high humidity and heavy rainfall on the south eastern side of the island is the probable explanation for the low diversity of moth and butterfly species collected throughout the survey. There were three butterflies and six moth species identified thus more time is needed for more sampling of the area. The team could not reconfirm the moth specimen thus the list is yet to be made available once we receive confirmation from the experts. The butterflies were mainly seen around human garden areas and within 50 m from the sides of the main road through the entrance track to the survey camp area. However, no butterfly was found along the survey transect during the survey hours possibly due to the bad weather. The species listed are commonly found in most places in Samoa and includes the Pacific eggfly (*Hypolimnas antelope lutescens*), Common crow (*Euploea lewinii bourkei*) and Blue moon (*Hypolimnas Bolinas pallescens*).

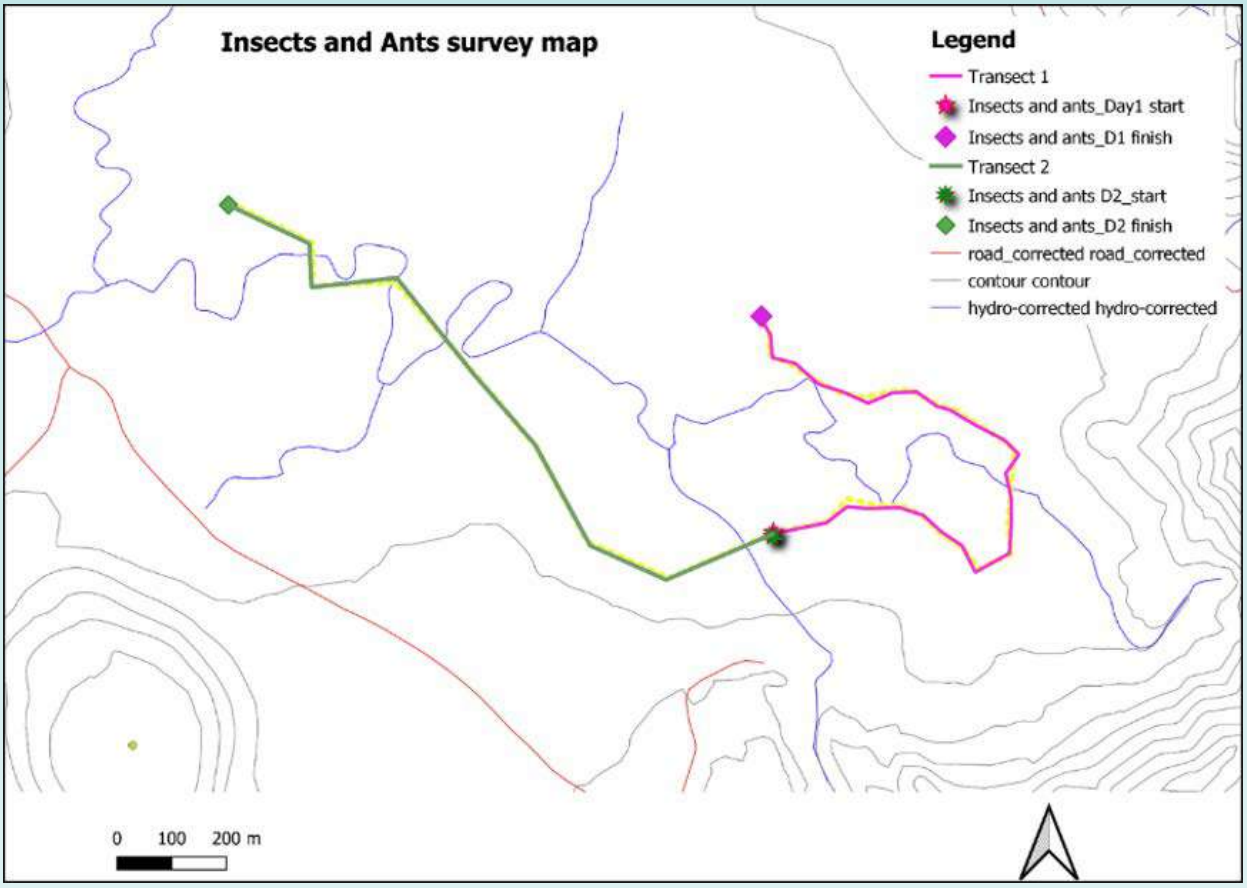
2.7. OTHER INSECTS

METHODOLOGY

There are various techniques and methodologies recommended for surveying other insects and their responses to different environmental variables. However, there is no standardized method that is recommended for surveying insects, and in particular beetles, flies and ants. For this survey, the team used our general knowledge and understanding of insects with the assistance of references as a guide. Our approach was to make visual observations while walking along the transect line for the reptile survey and observing the glue traps (Figure 9).

Figure 8. Survey Team

Figure 9. Insect survey transect



The team noted that since most of the Vaipu area is swamp with small gullies and streams, the use of pitfall traps is unsuitable in such wet conditions. The team's observations mostly relied on the reptile glue traps and therefore reptiles and insects were surveyed at the same time. After collection, recording and removal of any skinks attached to the glue traps, the remaining specimens were mostly ants and flies which we observed and recorded.

RESULTS

A total of four ant species were collected using sticky traps including the introduced *Anoplolepis gracilipes* (Yellow Crazy Ants) which were detected at the northern end of the site about 120 m from the main road (Annex 1.8). One dragonfly and two beetles were caught in the butterfly sweep net.

The timing of the survey caused limitations to sampling certain locations within the Vaipu swamp forests. The team is currently working on identifying the different specimens collected for insects including dragonflies and will be made available once results are available.

2.8. INVASIVE SPECIES

The Vaipu swamp forest shows high potential of providing suitable habitat for many native species in terms of its topographical isolation which can provide shelter from cyclones. However a number of invasive species threaten the swamp. Jungle Myna birds (*Acridotheres fuscus*) have invaded this part of the island but at low abundance with no roost trees identified for myna birds in this area. Introduced Tilapia (*Oreochromis niloticus*) are common in the Vaigafa stream with unknown impacts on native fish fauna. The Giant African Snail (*Achatina fulica*) is a threat to the native land snails as they have been observed throughout the swamp in large sizes. Some native species of land snails including the *Eua* genus were found with shells only and no live specimens were found. There were no house geckos found in the area obviously because there are no humans and or buildings in this location. Wild pig scats were observed which can be detrimental to native tree wildings and there are cattle ranches around the swamp and cattle occasionally enter the swamp area when fences break. Invasive weeds include the following plant species: fue lautetele (*Merremia peltata*), la'au laumamoe (*Clidemia hirta*) and vao mini (*Hyptis rhomboidea*).

Figure 10. Vaipu Swamp Forest

3. REPORT on HYDROLOGY of VSF

METHODOLOGY

The Water Resource Division (WRD) river gauge is located at -171.5816667 deg W and -13.9636111 deg S. See site 2 in Figure 12.

RESULTS

The water flow for the Vaipu swamp is perennial and according to the WRD database, the swamp has maintained an average stage reading of between 0.6 m for low flows and 0.9 m for high flows since 2009. The average volume of water passing through the swamp varies according to the wet and dry seasons of Samoa as seen in the average monthly flows in Table 5 below.

Table 5. Monthly average flows in Litres/Second for Vaipu

Monthly Flow Data for Vaipu Stream												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2009		767	2508	163	152	269	560	224	131	243	636	1867
2010	1356	318	130	191	563	206	185	161	359	554	267	563
2011	884	269	343	126	285	124	147	459	97	663	763	666
2012	301	137	343	378	303	156	295	194	191	242	2339	490
2013	4365	240	438	363	303	1417	356	245	163	2415	407	1155
2014	10518	2815	406	166	166	163	5291	561	567	3892	352	3488
2015	1235	168	1001	378	1643	1099	241	149	141	139	3604	5667
2016	123	74525	3306	3299	3306	163	116	203	234	221		

Figure 11. Vaipu Swamp Forest

4. REPORT on WATER QUALITY of VSF

METHODOLOGY

Water sampling was conducted at three locations in different parts of the swamp (Figure 12). The samples were given to the Scientific Research Organisation of Samoa (SROS) for chemical and biological analysis for a range of standard parameters.

Figure 12. Water Sampling Sites

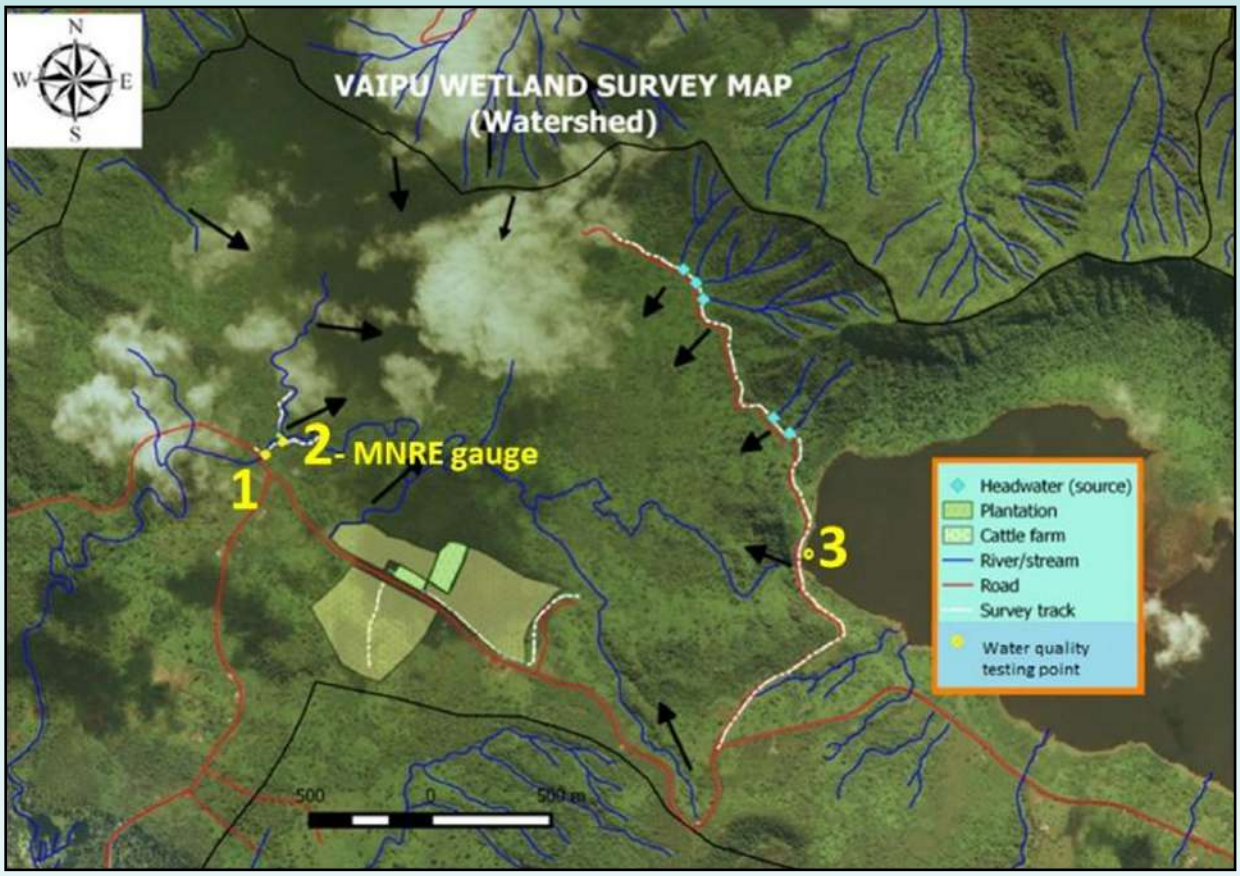


Figure 13. Water Sampling Site

Figure 12. Freshwater Survey Team

RESULTS

Table 6 show the results for the water quality tests carried out by the SROS team for the Vaipu Swamp survey.

Table 6. Water Quality Test Results from SROS

		Date of Survey: 29/03/2017								
		Site 1 -171.5819195; -13.96406868			Site 2 -171.5814303; -13.96357618			Site 3 -171.561446; -13.96827595		
Parameter	**Unit**	**1st reading**	**2nd reading**	**Average Reading**	**1st reading**	**2nd reading**	**Average Reading**	**1st reading**	**2nd reading**	**Average Reading**
Temperature	˚C	25.6	25.5	25.6	25.3	25.2	25.3	28.7	28.7	28.7
pH		7.99	8.02	8.0	6.78	6.78	6.8	8.52	8.5	8.5
DO	ppm	12.51	13.15	12.8	4.03	5.82	4.9	7.45	6.66	7.1
Conductivity	S/m	80.5	80.6	80.6	78.1	77.8	78.0	49	48.7	48.9
Ammonium	mg/L	0.15	0.1	0.1	0.1	0.07	0.1	0.09	0.11	0.1
Nitrate	mg/L	1.54	2.2	1.9	1.22	1.2	1.2	3.63	3.48	3.6
Chloride	mg/L	6.44	6.2	6.3	5.9	5.75	5.8	2.64	2.27	2.5
Salinity	ppt	Negligible	Negligible	Negligible	76.6	78.9	77.8	45.2	45	45.1
TSS	mg/L			70			65			78
BOD5	mg/L			8.1			7.4			8.6
Total Coliform	mg/L			5000			2000			6000
Fecal Coliform	cfu/100ml			<1000			<1000			<1000
E.coli	cfu/100ml			4000			2000			6000
Enterococci	cfu/100ml			110			80			575

A brief description of each site is provided below.

- Site 1 is the most downstream of all three sites where the water flows steadily and is relatively clear. This site also has long grass growing along the bank, with one containing a taro patch.
- Site 2 is next to where the MNRE water level monitoring station is located. The water flows much slower here compared to site 1, with the colour looking relatively brown. Mangroves grow along one side, and wild vegetation on the other.
- Site 3 is the Afulilo dam. This location is close to where the overflow is discharged into the swamp.

Overall, the water quality results for the Vaipu swamp for each of the components tested are within the World Health Organization standards.

3. RECOMMENDATIONS

Given the value of the Vaipu swamp as an unusual and rare ecosystem with a number of globally threatened and rare species, the following recommendations are made as key initial steps to secure the conservation values of the area:

- Development of a site management plan in collaboration with landowners and other stakeholders to detemine actions needed for the long term conservation of the Vaipu swamp.
- Restoration of degraded areas around the swamp via tree plantng programmes with appropriate species.
- Archaeological surveys of the Vaigafa historical site to determine if the site warrants restoration and/or preservation.
- Conduct biodiversity monitoring of key taxa every 5 years to detemine the status of indicator species, such as plants, birds, reptiles and butterflies.
- Conduct site vists and educational field programmes and training for the neaby communities to raise their awareness and help them learn and understand the significance of conserving the swamp area.

6. CONCLUSION

The 2017 baseline survey of the Vaipu swamp has confirmed the conservation values of the swamp and that it should be protected as part of the Eastern Upolu Craters KBA (CI, MNRE and SPREP 2010). The Vaipu swamp is the largest remaining mixed upland swamp in Samoa with an unusual wetland habitat and a number or rare and endemic species. Biodiversity recorded in the 278.318 ha swamp includes the following:

- 30 tree species, including the endangered bush palm, *Clinostigma warburgii*
- 25 bird species plus an uncorroborated observation of the Tooth-billed Pigeon (*Didunculus strigirostris*)
- 10 land snail species, including three endemic snails *Eua expansa, Samoana canalis* and *Succinea putamen*
- 7 skinks, half of Samoa's skink fauna
- 4 fish, including the endemic *Kuhlia rupestris*
- 4 ant species, mostly introduced
- 3 butterflies
- 2 flying fox species

The water quality results for the Vaipu swamp for each of the components tested were within the World Health Organization standards. The water flow for the Vaipu swamp is perennial and the river flowing through the swamp has maintained an average flow level of between 0.6 m for low flows and 0.9 m for high flows since 2009.

Additionally, adjacent to the swamp is the remains of the ancient village of Vaigafa and there are other nearby historical sites including a star mound.

The main threats to the site are from stray cattle, invasive species and hunting, and the potential development for a hydro power scheme in the future. It is highly recommended that efforts to ensure the long term conservation of the site are undertaken with local landowning communities. The objective of these discussons should be the development and implementation of a site management plan to safeguard the values of the swamp.

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ANNEX 1: TABLES OF SPECIES OBSERVATIONS

Annex 1.1. Location of Plant Plots

Plot No.	South Decimal Degrees	East Decimal Degrees
1	13.87805°	171.77342°
2	13° 57' 22.2"	171° 34' 51.0"
3	13° 57' 58.6"	171° 34' 45.1"
4	13° 57' 43.0"	171° 34' 14.3"
5	13° 57' 50.9"	171° 33' 57.6"
6	13° 58' 01.8"	171° 34' 09.2"

Annex 1.2. Summary of Tree Species Occurrence by Plot

Name	Scientific Name	No.1		No.2		No.3		No.4		No.5		No.6		Total								
		Number	Basal Area	Number	Basal Area	Number	Basal Area	Number	Basal Area	Number	Basal Area	Number	Basal Area	Occ.	Number			Basal Area				
															Total	Av. per occ.	Av. per 6	Total	Av. per occ.	Av. per 6	ex.big Tavai	Dominance
Olioli	*Cyathea lunulata*	2	364	11	2,375	14	5,419	22	2,524	9	1,400	1	227	6	59	9.8	9.8	12,309	2,052	2,052		1
Falaga	*Barringtonia samoensis*	16	2,468	9	1,463	2	208	1	314	2	107	11	1,275	6	41	6.8	6.8	5,835	973	973		2
Tamanu	*Calophyllum neo-ebudicum*	6	477	3	688	8	1,520	6	437	1	38	4	2,025	6	28	4.7	4.7	5,185	864	864		3
Afa	*Neonauclea forsteri*	4	354	29	2,105	4	836	7	365	3	135	1	283	6	48	8	8.0	4,078	680	680		8
Mosooi	*Cananga odorata*	1	683	1	683			1	133	6	2,529	1	754	5	10	2	1.7	4,782	956	797		7
Aamatie	*Elaeocarpus floridanus*	1	254	5	754	8	788	8	778	3	996			5	25	5	4.2	3,570	714	595		9
Fau	*Hibiscus tiliaceus*	4	584			2	173			11	1,243	20	3,028	4	37	9.3	6.2	5,028	1,257	838		5
Alaa	*Planchonella garberi*	4	353	2	151			2	48			2	76	4	10	2.5	1.7	628	157	105		
Tavai	*Rhus taitensis*	2	1,821			1	15,386			4	1,123			3	7	2.3	1.2	18,330	6,110	3,055	491	11
Gasu	*Palaquium stehlinii*			3	3,524			3	521			1	1,256	3	7	2.3	1.2	5,301	1,767	884		4
Niu vao	*Clinostigma samoense*	1	962							2	3,260	1	804	3	4	1.3	0.7	5,026	1,675	838		5
Masame	*Glochidion ramiflorum*	3	1,744	1	754			2	899					3	6	2	1.0	3,397	1,132	566		10
Asi toa	*Syzygium inophylloides*			2	837	2	143	1	133					3	5	1.7	0.8	1,113	371	186		
Atone	*Myristica inutilis*	1	38							6	312	4	450	3	11	3.7	1.8	800	267	133		
Fagaio	*Sterculia fanaiho*			3	351	1	95					2	163	3	6	2	1.0	609	203	102		
Filimoto	*Flacourtia rukam*	4	278									1	154	2	5	2.5	0.8	432	216	72		
Nonu vao	*Syzygium samarangense*					3	247	1	154					2	4	2	0.7	401	201	67		
Lau fatu	*Macaranga stipulosa*									1	201	2	190	2	3	1.5	0.5	391	196	65		
Pipi	*Hernadia moerenhoutiana*	1	20							1	133			2	2	1	0.3	153	77	26		
Pani	*Manilkara dissecta*			8	2,623									1	8	8	1.3	2,623	2,623	437		12
Tava	*Pometia pinnata*									1	452			1	1	1	0.2	452	452	75		
Atone ulu	*Myristica hypargyraea*					1	346							1	1	1	0.2	346	346	58		
Olasina	*Psydrax merrillii*	4	312											1	4	4	0.7	312	312	52		
Toi	*Alphitonia zizyphoides*							1	227					1	1	1	0.2	227	227	38		
Uugu	*Sarcopygme pacifica*							1	133					1	1	1	0.2	133	133	22		
Mamalava	*Planchonella samoensis*					1	61							1	1	1	0.2	61	61	10		
Endiandra	*Endiandra elaeocarpa*	1	50											1	1	1	0.2	50	50	8		
Ifi	*Inocarpus fagifer*											1	24	1	1	1	0.2	24	24	4		
28 Sp.	Total	55	10,762	77	16,308	47	25,222	56	6,666	50	11,929	52	10,709		337			81,596				

Annex 1.3. Summary of Undergrowth Species by Plot

Species	Plot Data												Total					
	No.1		No.2		No.3		No.4		No.5		No.6		Occ.	Coverage degree			Height	
	Cov.	Height	Cov.	Height	Cov.	Height	Cov.	Height	Cov.	Height	Cov.	Height		Total	Av. per occ.	Av. per 6	Total	Average
Nonu vao	r	50			+	50					r	30	3	+r	r	r	130	43
Olioli			1	130							2	150	2	3	1.5	0.5	280	140
fern 1					1	30	1	100					2	2	1	0.3	130	65
Atone									+	80	+	70	2	+	+	+	150	75
Aoauli							r	150			+	140	2	+r	+	+	290	145
Aamatie			r	60							+	80	2	+r	+	+	140	70
Alaa	r	50									r	30	2	r	r	r	80	40
Lafo									3	300			1	3	3	0.5	300	300
Fuesaina							2	-					1	2	2	0.3	-	-
Afa			1	120									1	1	1	0.2	120	120
Fau											+	160	1	+	+	+	160	160
Okeki 1									+	60			1	+	+	+	60	60
Okeki 2									+	20			1	+	+	+	20	20
Falaga	r	150											1	r	r	r	150	150
Malili					r	20							1	r	r	r	20	20

	tree species
	vine spicies
	grass species

Coverage Dgree:

5 : 76%<	4 : 51-75%	3 : 26-50%	2 : 11-25%	1 : Common but under 10%	+ : A little with low coverage	r : Rare

Annex 1.4. Freshwater Fauna Survey

March 2017 S. Yamamoto

The location of this survey was upstream of the river.
The rivers flow in wide Vaipu swamp.

Various trees and grasses grow in the swamp and the ground mainly consists of soils mixing mud and humus.

The water dissolved humic substances from the swamp is always pouring into the river.
For that reason, in spite of upstream of the river, the water was not necessarily transparent and clean.

The river water mixed with humic substances will probably be rich in nutrient.
It seems that the water quality affects the species of aquatic animals inhabiting.

St. 3; 10:00, Five species confirmed in the river.
- a kind of Tilapia; *Oreochromis niloticus*
- a kind of fresh water prawn; *Macrobrachium rosenbergii*
- a kind of caridean shrimp; *Caridea*, small
- a kind of freshwater snail with an operculum, an aquatic snail shell in *Semisulcospiridae*
- a kind of water strider; *Aquarius* sp.

St. 4; 12:00, 4 species confirmed Water temperature 24.7 ℃
- a kind of fresh water prawn; *Macrobrachium rosenbergii*
- a kind of caridean shrimp; *Caridea*, small)
- a kind of freshwater snail with an operculum, an aquatic snail shell in *Semisulcospiridae*
- a kind of water strider; *Aquarius* sp.

St. 2, 14:00, 4 species confirmed Water temperature 26.6 ℃
- a kind of fresh water prawn; *Macrobrachium rosenbergii*
- a kind of caridean shrimp; *Caridea*, small)
- a kind of freshwater snail with an operculum, an aquatic snail shell in *Semisulcospiridae*
- a kind of water strider; *Aquarius* sp.

◎ Checking items in the river
1. Water quality; water temperature, pH, DO (dissolved oxygen), COD, transparent, flow velocity, etc.
2 quality of river; soil, pebble, mud, rock, humus , vegetation
3 Fish and others;

Survey of Vaipu swamp and dam

1. Mosquitofish
   Gambusia affinis

   closely related species
   Mollie（Mola ; Samoa）
   Guppies (*Poecilia* sp.)

2. Jungle perch
   Kuhlia rupestris ENDEMIC
   Inako → big
   Sesele → small
   ・Spawning in the sea.
   Upstream in the river
   45cm in total length

3. Giant river prawn or ENDEMIC
   Giant freshwater prawn
   Macrobrachium rosenbergii

4. Blue Tiger Shrimp
   Caridina cf. cantonensis sp.
   "Blue Tiger"

5. Paofu

6. Tilapia

7. The dusky sleeper or
   brown spinecheek gudgeon
   Eleotris fusca

Annex 1.5. Bird Survey Locations

Station Numbers	Latitude	Longitude	Elevation (m)
VS01	-13.96755	-171.56998	272
VS02	-13.96811	-171.56653	266
VS03	-13.9652	-171.56757	266
VS04	-13.96398	-171.57018	268
VS05	-13.96609	-171.57399	371
VS06	-13.96212	-171.57916	266

Annex 1.6. Land snails identified at Vaipu wetland

Scientific Name	Status	Photograph
1. *Pleuropoma beryllina* (family Helicinidae) Collected on tree trunks	Native	
2. *Paropeas achatinaceum* (family Subulinidae) Collected on the ground Adopted photo for presentation	Introduced	
3. Unknown could be family Thiaridae Collected on the ground	Native	

Scientific Name	Status	Photograph
4.*Eua expansa* Collected on the ground, shell only	Endemic	 
5. *Eua zebrina* Collected on the ground, shell only	Native	
6.*Eua zebrina* Collected on the ground, shell only	Native	
7. Giant African Snail *Achatina fulica* Seen on the ground and on trees	Introduced Invasive	

Scientific Name	Status	Photograph
8.Probably a species of *Lamprocystis* (family Microcystidae, formerly placed in Euconulidae) or possibly *Eiconulidae Kororia palaensis* (Introduced) Collected on tree leaves Adopted photo for presentation	Native	
9. *Pleuropoma fulgota* (family Helicinidae) Collected on above ground on logs and litter Adopted photo for presentation	Native	
10. Probably *Succinea putamen* (family Succineidae, genus Succinea) Collected on tree leaves	Endemic	
11. *Samoana canalis* (family Partulidae) This specimen was attached to surveyor's clothing during survey	Endemic	

All photos taken by Moeumu Uili. Parks and Reserves Section. MNRE

Annex 1.7. Reptile field data records

Site	Date	time	weather	x-coordinate	y-coordinate	wpt	elevation	topography	Vegetation observations
R1	08-Apr-17	9.03am	fine, sunny and clear sky	-13.96755	-171.56998	609	272	flat, muddy and wet	fau, asa,saitamu,laumafiafia,fern,pualulu, fagufagu, dense undergrowth of mainly tall grass and fen allies
R2			fine, sunny and clear sky	-13.96738	-171.5694	609	273	flat, muddy and wet	
R3			fine, sunny and clear sky	-13.96738	-171.56906	610	276	flat, muddy and wet	
R4			fine, sunny and clear sky	-13.96712	-171.56874	611	276	flat, muddy and wet	
R5			fine, sunny and clear sky	-13.96715	-171.56837	612	275	flat, muddy and wet	niuvao,olioli,falaga,mamalava,ifi,mosooi, tamanu-fruiting,masame,mati,ifiifi
R6			fine, sunny and clear sky	-13.96708	-171.56783	613	273	flat, muddy and wet	tamanu,atone
R7			fine, sunny and clear sky	-13.96726	-171.56747	614	271	flat, muddy and wet	
R8		10.45	fine, sunny and clear sky	-13.96753	-171.56712	615	269	flat, muddy and wet	fau,laufala,niuvao,mosooi,tavai,kava,oliol i maota,ferns,masame,fuesaina
R9		10.55	fine, sunny and clear sky	-13.96774	-171.56673	616	269	flat, muddy and wet	
R10		11.15	fine, sunny and clear sky	-13.96811	-171.56653	617	266	flat, muddy and wet	
R11		11.28	fine, sunny and clear sky	-13.96813	-171.656598	618	267	flat, muddy and wet	
R12		11.35	fine, sunny and clear sky	-13.96787	-171.56598	619	269	flat, muddy and wet	cyrtandra
R13		11.47	fine, sunny and clear sky	-13.96738	-171.56593	620	270	flat, muddy and wet	cyrtandra,laufatu,merremia
R14		11.52	fine, sunny and clear sky	-13.96693	-171.56592	621	270	flat, muddy and wet	merremia,

Site	Date	time	weather	x-coordinate	y-coordinate	wpt	elevation	topography	Vegetation observations
R15		12.05	30% cloud, light wind	-13.96656	-171.56601	622	270	flat, muddy and wet	merremia,
R16		12.11	30% cloud, light wind	-13.9662	-171.56583	623	269	flat, muddy and wet	fau,laumafiafia,nonu vao,masame,ti vao, filimoto,tavai
R17		1.3	30% cloud, light wind	-13.96598	-171.56612	624	268	flat, muddy and wet	fau
R18		1.38	30% cloud, light wind	-13.96574	-171.56657	625		flat, muddy and wet	tree fern, lau fatu, niu vao,maota,tava,merremia
R19		1.49	30% cloud, light wind	-13.96555	-171.56694	626	268	flat, muddy and wet	
R20		1.57	30% cloud, light wind	-13.96545	-171.5672	627	260	flat, muddy and wet	
R21		2.08	30% cloud, light wind	-13.9652	-171.56757	628	266	flat, muddy and wet	niu vao, merremia, mostly,mati,mosooi,maota mea, asi,tava,masame,tamanu
R22		2.15	30% cloud, light wind	-13.96523	-171.56798	629	266	flat, muddy and wet	fau,tavai,mosooi,niu vao, masame, atone, mamalupe
R23		2.22	60% cloudy, no rain	-13.96534	-171.56839	630	267	flat, muddy and wet	vine,olioli,fau,tavai,mosooi,niu vao,masame,atone,mamalupe
R24		2.48	60% cloudy, no rain	-13.9652	-171.56879	631	268	flat, muddy and wet	malili,maota,niuvao,lau fatu,olioli,fau,merremia,fasa,fualole
R25		2.43	60% cloudy, no rain	-13.96503	-171.56921	632	269	flat, muddy and wet	merremia,olioli,maota,malili,fau,mosooi, falaga,laufatu

Site	Date	time	weather	x-coordinate	y-coordinate	wpt	elevation	topography	Vegetation observations
R26		2.43	60% cloudy, no rain	-13.96476	-171.5696	633	268	flat, muddy and wet	fau,merremia,olioli,niu vao,malili,pualulu,lau fatu, laufala, fasa
R27		2.49	60% cloudy, no rain	-13.96464	-171.56995	634	268	flat, muddy and wet	mamalupe,fasa,falaga,mamalava,malili, tamanu,atone,fau
R28		2.57	60% cloudy, no rain	-13.96426	-171.57004	635	269	flat, muddy and wet	laufala,falaga,mamalupe,lamafiafia,fau
R29		3.08	60% cloudy, no rain	-13.96398	-171.57018	636	268	flat, muddy and wet	falaga,mosooi,fau,atone,niu vao,tavai,alaa,nonu vao,malili,lau fala, tivao,olioli,ifi,mamalupe
				0	0				
DAY TWO				0	0				
R30	09-Apr-17	11.55am	light showers, 60% cloudy	-13.9683	-171.57185	640	271	flat, river streams and gullies	
R31			light showers, 60% cloudy	0	0			flat, river streams and gullies	
R32			light showers, 60% cloudy	0	0			flat, river streams and gullies	
R33		12.13	light showers, 60% cloudy	-13.96773	-171.5731	641	273	flat, river streams and gullies	
R34		12.2	light showers, 60% cloudy	-13.96609	-171.57399	642	271	flat, river streams and gullies	
R35		12.47	light showers, 60% cloudy	-13.96482	-171.57509	643	265	flat, river streams and gullies	merremia,fau,malili,niu vao

Site	Date	time	weather	x-coordinate	y-coordinate	wpt	elevation	topography	Vegetation observations
R36			light showers, 60% cloudy	0	0			flat, river streams and gullies	
R37		1.2	light showers, 60% cloudy	-13.96335	-171.5764	644	265	flat, river streams and gullies	
R38		1.37	light showers, 60% cloudy	-13.96342	-171.57782	645	264	flat, river streams and gullies	
R39		2.3	light showers, 60% cloudy	-13.96273	-171.57787	646	268	flat, river streams and gullies	
R40		2.49	20% cloudy, no rain	-13.76266	-171.57872	647		flat, river streams and gullies	
R41		3.15	20% cloudy, no rain	-13.96212	-171.57916	648	266	flat, river streams and gullies	metrosideros,tamanu,falaga-fruiting,aamatie-fruiting,mati,pipi-flowering,fau,laufala

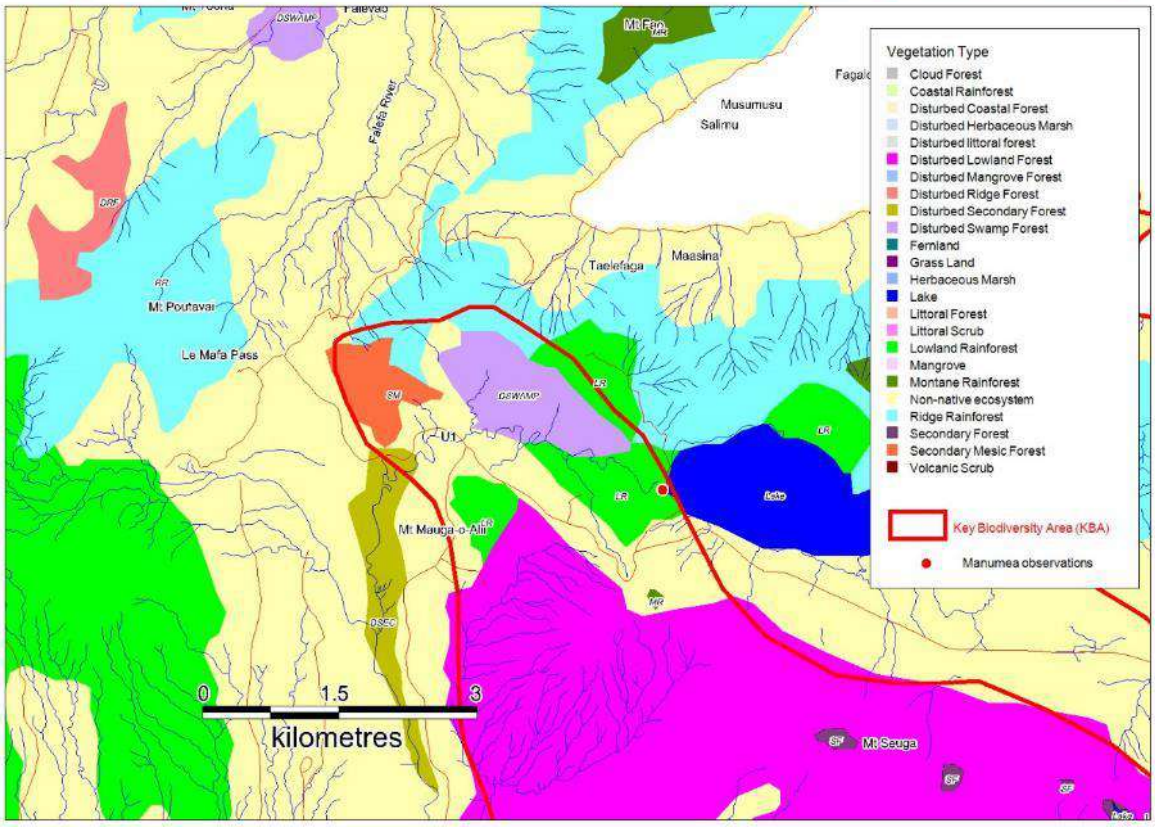
Annex 1.8. List of ants and other insects recorded at Vaipu swamp

Common Name ***Scientific Name***	**Photograph**
1. Black carpenter ant (*Camponotus chloroticus*)	
2. Brown ant	
3. Yellow crazy ant (*Anoplolepis gracilipes)*	
4. Small black ant	

Common Name ***Scientific Name***	**Photograph**
5. Wandering Percher Dragonfly (*Diplacodes bipunctata*)	
6. Long-horned beetle (*Xixuthrus* species?)	 
7. Metallic beetle	 

ANNEX 2: MAPS


TAELEFAGA
VAIPU
AFULILO
0
1,000
metres


Vegetation Type
Cloud Forest
Coastal Rainforest
Disturbed Coastal Forest
Disturbed Herbaceous Marsh
Disturbed littoral forest
Disturbed Lowland Forest
Disturbed Mangrove Forest
Disturbed Ridge Forest
Disturbed Secondary Forest
Disturbed Swamp Forest
Fernland
Grass Land
Herbaceous Marsh
Lake
Littoral Forest
Littoral Scrub
Lowland Rainforest
Mangrove
Montane Rainforest
Non-native ecosystem
Ridge Rainforest
Secondary Forest
Secondary Mesic Forest
Volcanic Scrub
Key Biodiversity Area (KBA)
Manumea observations
Mt Fea
Musumusu
Salimu
Faleta River
Taelefaga
Maasina
Mt Poutavai
Le Ma'a Pass
U1
Mt Mauga-o-Alii
Mt Seuga
0
1.5
3
kilometres