A Rapid Biodiversity Assessment & Archaeological Survey of the Fiji REDD+ Pilot Site:

Emalu Forest, Viti Levu

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Compiled by the Institute of Applied Sciences, University of the South Pacific, for the Forestry Department of the Ministry of Agriculture, Fisheries and Forestry, Republic of the Fiji Islands; and SPC/GIZ '*Coping with Climate Change in the Pacific Island Region*' Programme

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Institute of Applied Sciences (University of the South Pacific)

The Institute of Applied Sciences (IAS) was established in 1977 as part of the University of the South Pacific. The Institute operates as a consulting body within the university, applying the professional and academic expertise of its staff as required by government, NGO or private projects in Fiji and the Pacific region. IAS operates through six thematic units; the South Pacific Regional Herbarium, the Environment Unit, the Quality Control Unit, the Drug Discovery Unit, the Analytical Unit and the Food Unit. This survey was coordinated and headed by the South Pacific Regional Herbarium.

South Pacific Regional Herbarium

The South Pacific Regional Herbarium (SPRH) is the focal point for the study of taxonomy, conservation and ecology of plants in the Pacific. The collection of the SPRH includes over 50, 000 vascular plant specimens from Fiji and around the Pacific, as well as a wet collection of plant parts, bryophytes and algae. As a member of an international network of herbaria, the SPRH participates in programs to maintain collections of botanical plants specimens for study by local and international botanists. More recently it has extended its collection to include those of other taxa to include insects, freshwater invertebrates and vertebrates, reptiles and amphibians, birds and native mammals.

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EXECUTIVE SUMMARY

The land encompassed by the mataqali Emalu in the province of Navosa has been selected as the pilot site for the Fiji REDD+ programme. A survey to assess the biodiversity of the area and document its cultural heritage sites was carried out by a team of specialists from USP's Institute of Applied Science (the South Pacific Regional Herbarium and the Environment Unit), the Fiji Museum, NatureFiji-MareqetiViti and Conservation International. The expedition was implemented in two phases; in July 2012 and March 2013.

Flora, Vegetation and Ecology

A total of 707 plant taxa were recorded for Emalu, including 286 bryophytes and lichens, 375 angiosperms, nine gymnosperms, and 35 ferns and fern allies. Altogether, the vascular and non-vascular taxa recorded from the Emalu site spanned 182 families and 391 genera. Over a third (39%) of the vascular plant flora recorded are endemic to Fiji, including 160 species of flowering plants, two fern and fern allies, and two gymnosperms. Ten taxa were encountered that are important focal species due to their rarity, botanical significance, very recent discovery in Fiji and inclusion in the IUCN Red List. Five principal vegetation types were identified; lowland rainforest, upland rainforest, cloud forest, dry forest and talasiga.

Herpetofauna

Six species of herpetofauna: three endemic, two native and one invasive were captured over 22 man-hours of diurnal survey, 63 hours of sticky tape trapping and nine man-hours of nocturnal surveys. This survey has documented the first records of herpetofauna in this area and indicates a similar herpetofauna habitat to those typically observed in other parts of Viti Levu. The endemic Fiji tree frog (*Platymantis vitiensis*) was encountered in the area and is possibly the western-most record of the occurrence of this species in Fiji.

Avifauna

A total of 35 species of birds were recorded during the survey, which included 25 endemic species and one exotic species. Two species of bats were also recorded during the surveys. Ten focal species were identified (eight bird species and two bat species). The bird diversity of Emalu is comparable to the four Important Bird Areas on Viti Levu and ranks even higher in terms of bird density.

Terrestrial Insects

The target taxa Coleoptera (beetles) recorded 26 families in total and there was also a high abundance of the family Formicidae (ants). These taxa provide critical ecosystem services in forests systems such as soil processing, decomposition, herbivory, pollination and seed dispersal. Insects of conservation value recorded from Emalu included: *Hypolimnas inopinata* (a rare and endemic butterfly), *Nysirus spinulosus* and *Cotylosoma dipneusticum* (rare and endemic stick insects) and *Raiateana* *knowlesi* (the rare and endemic cicada). These findings suggest that the Emalu area is pristine and an important site for rare insects on Viti Levu.

Freshwater Fish

A total of ten species of fish from six families were recorded from the study area. Three species of gobies (*Awaous guamensis, Sicyopus zosterophorum, Sicyopterus lagocephalus*), two species of eels from the family Anguillidae (*Anguilla marmorata* and *Anguilla megastoma*), and the freshwater snake eel from the family Opicthidae (*Lamnostoma kampeni*) were collected in the area. The Mavuvu mid reach had an exceptionally high abundance and biomass of jungle perch *Kuhlia rupestris* when compared to other streams in Fiji. No endemic species were observed or caught during this survey. Around areas of human habitation there is evidence of the removal of riparian buffer zones as well as unrestricted livestock access to waterways which, coupled with uncontrolled slash and burn activities has exacerbated environmental degradation in these areas. The use of traditional fish poison (*Derris* roots) is also a common problem seen throughout the survey sites.

Freshwater Macroinvertebrates

A total of 76 freshwater macroinvertebrate taxa were identified from the 16,370 specimens collected in the three catchments of the Emalu region. The highly diverse freshwater macroinvertebrate community of Emalu included a high proportion of endemic taxa (75%), with insects being the most commonly occurring group. A total of 14 macroinvertebrate taxa were selected as potential bioindicators. The high rate of endemism, as well as the large number of species with large populations, is indicative of the intactness of both the stream system and the surrounding forest.

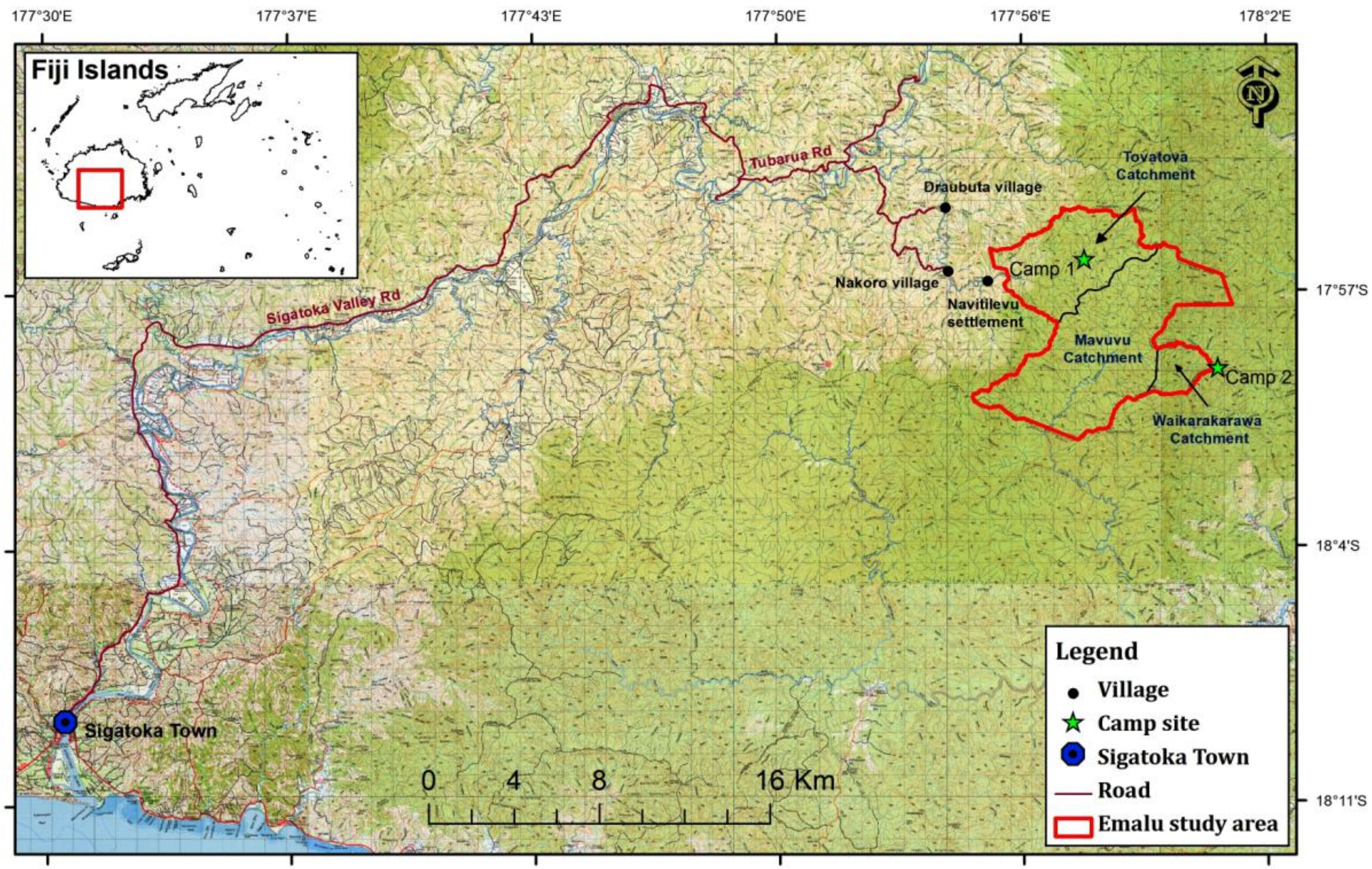
Invasive Species

A total of 26 invasive plants and eleven invasive animals were recorded in the study area, thirteen of which are listed in the 100 most invasive species in the world. Generally, the occurrence and abundance of invasive was associated with proximity to human habitation and to disturbed areas such as tracks, temporary campsites and cultivated areas. The invasive plant species were generally low in abundance, with the exception of *Piper aduncum* which was locally common, and *Clidemia hirta* and *Mikania micrantha* which were both widespread.

Archaeological Survey

The land belonging to the mataqali Emalu is rich in historical and cultural sites that have never been documented until this survey. A total of 77 sites of historical and cultural significance were documented, including old village sites, hill fortifications, pottery sites, agricultural terraces, sacred pools, house mounds and fortification trenches. Generally, the archaeological finds during this survey have considerable cultural value to the local community as well as at national level.

MAPS



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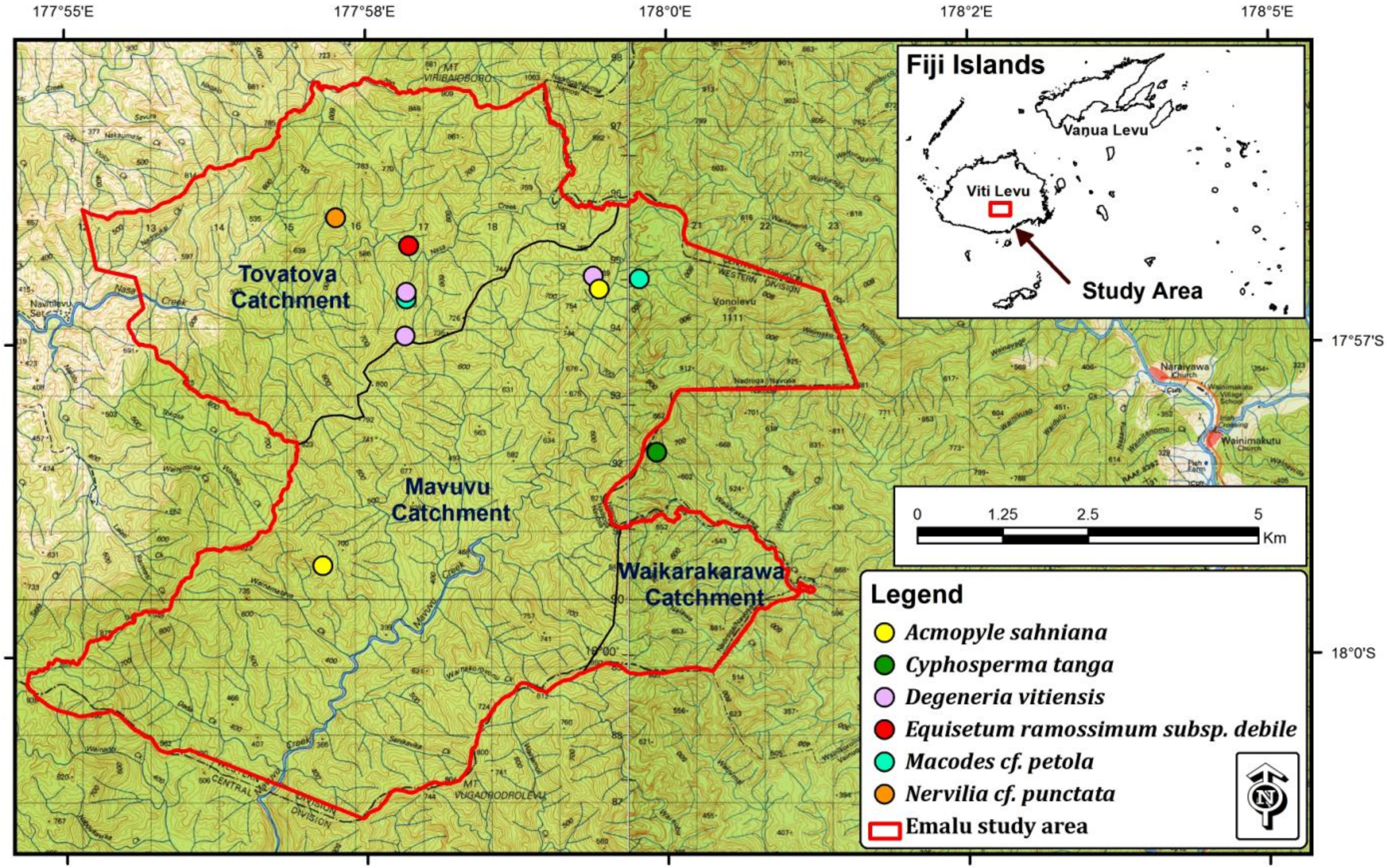

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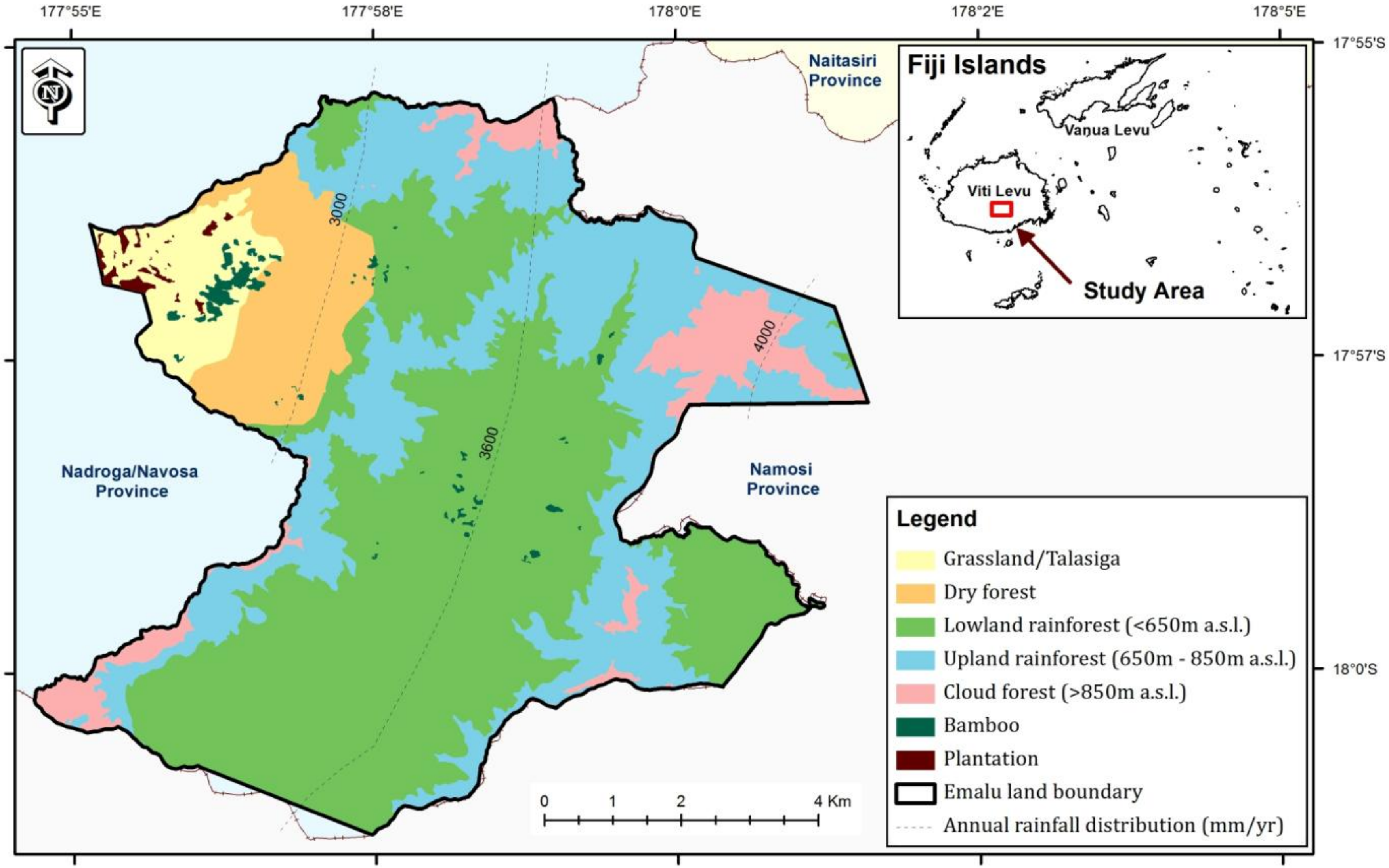

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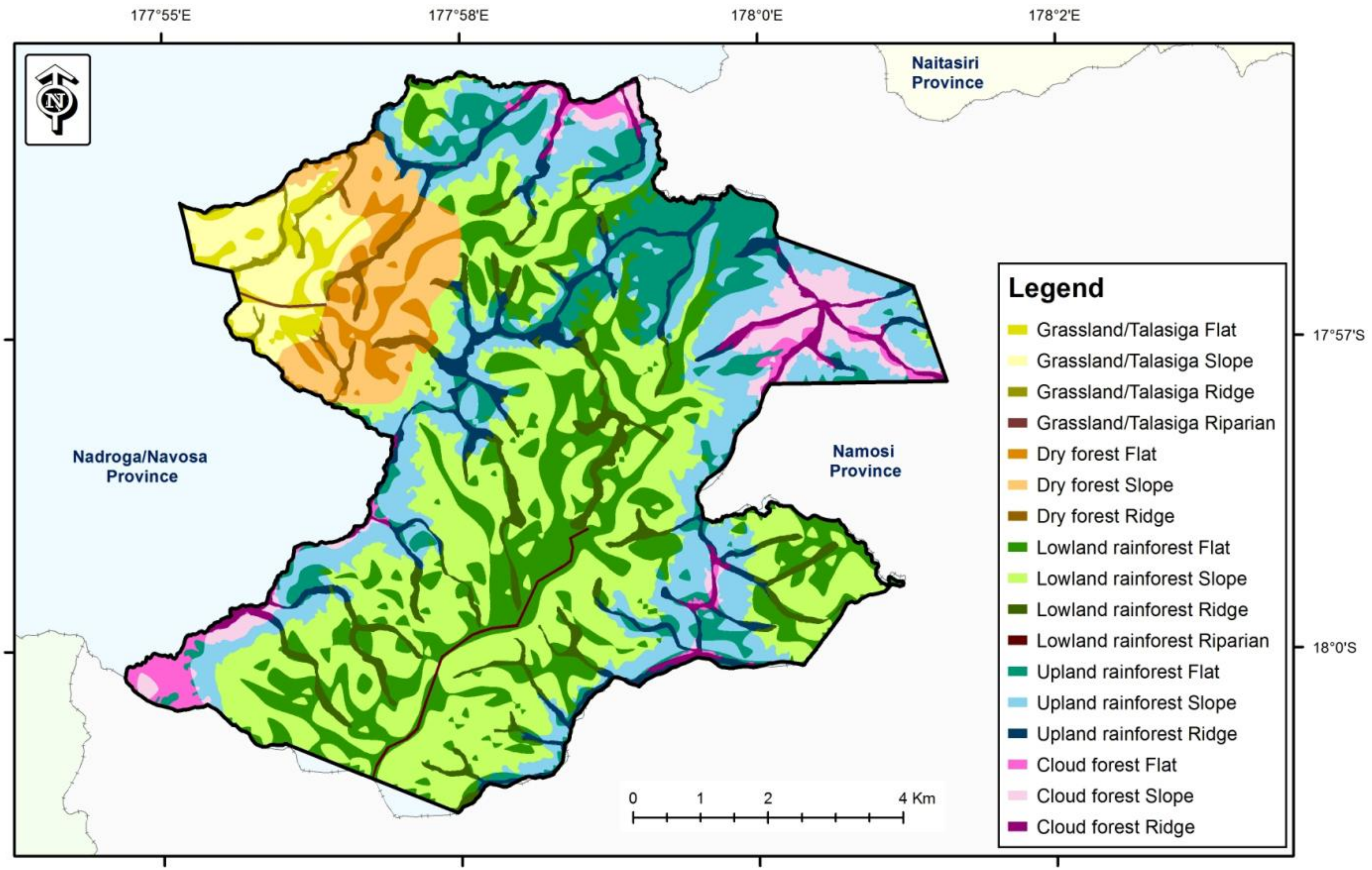

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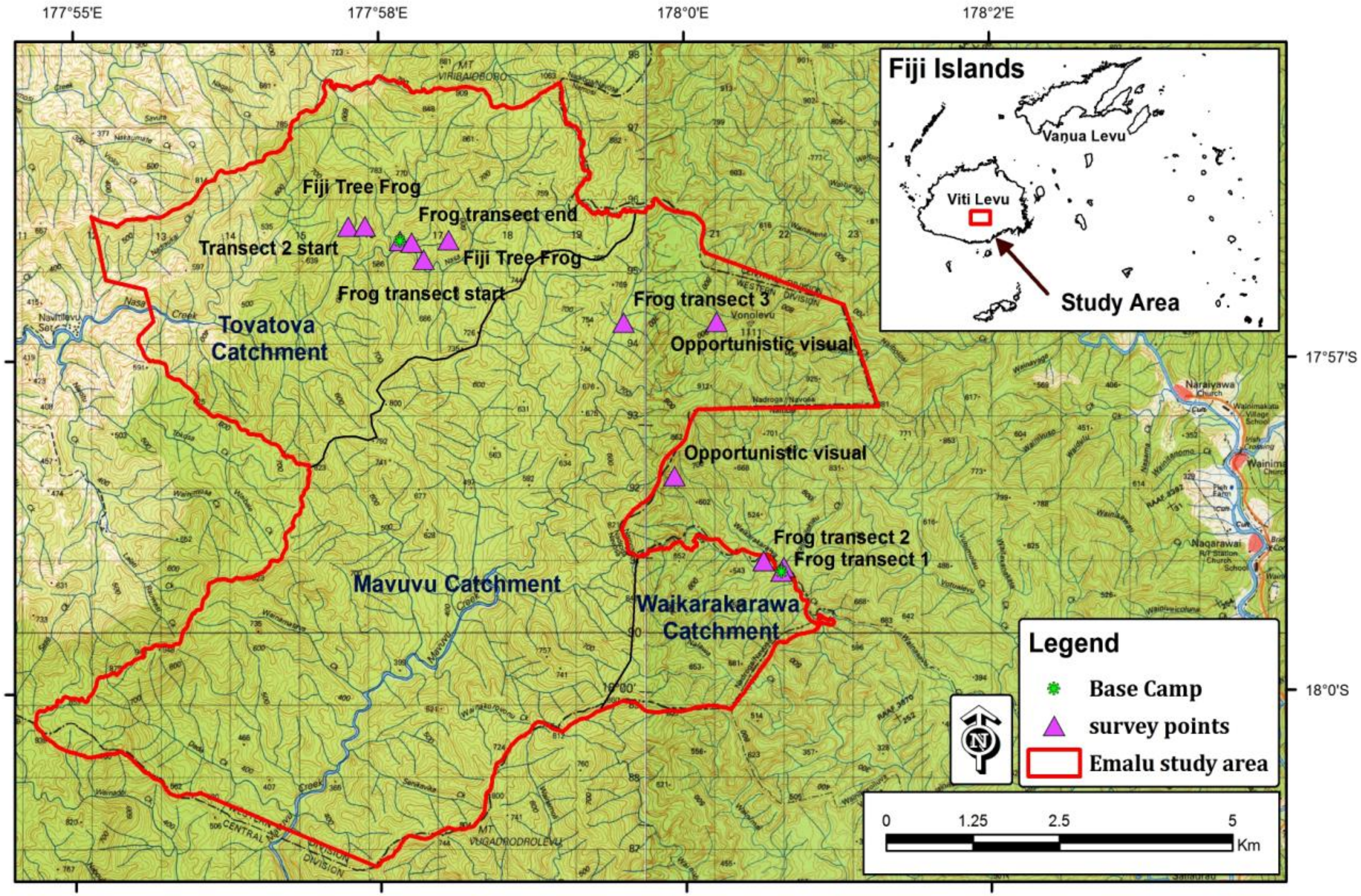

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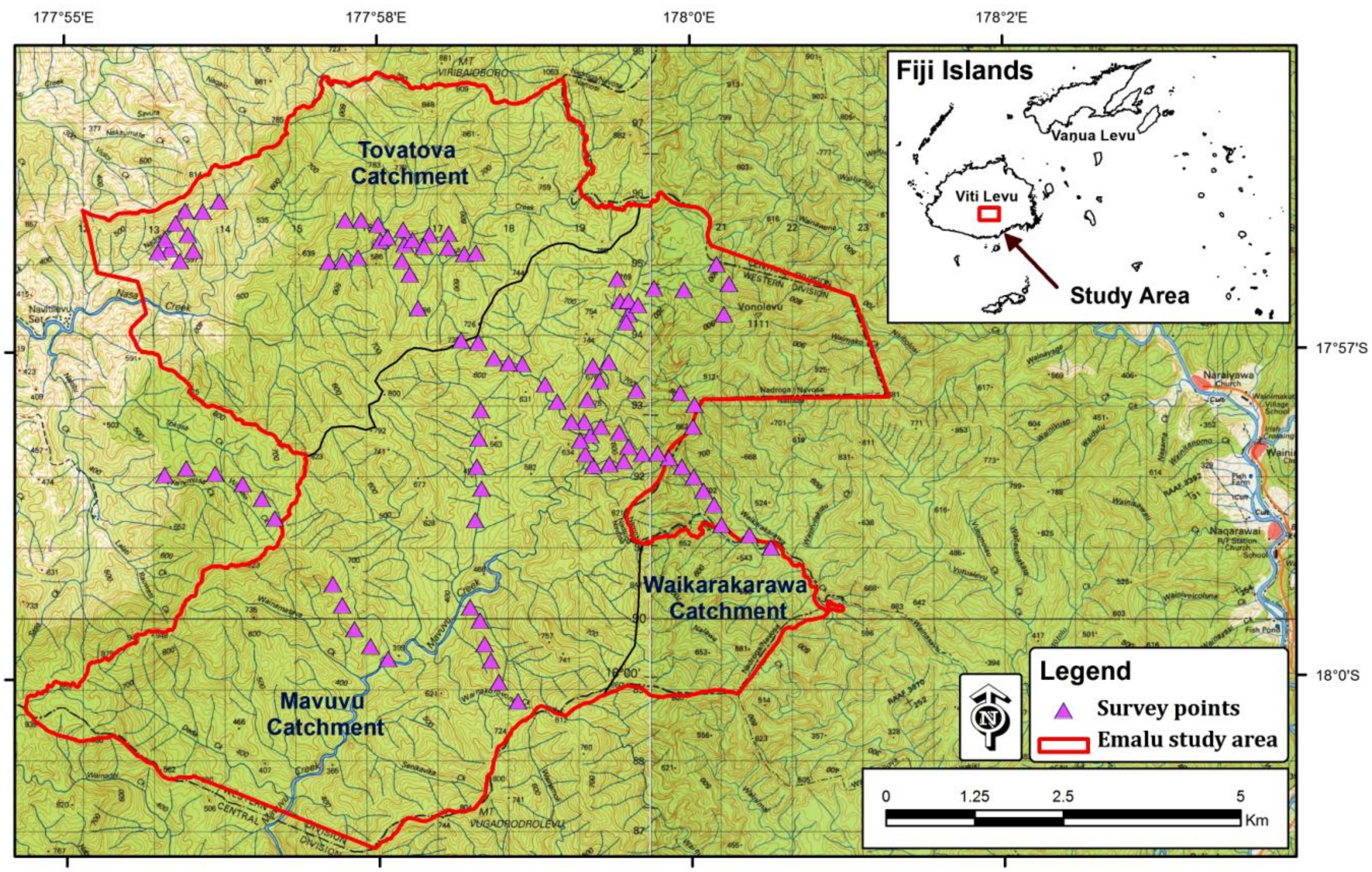

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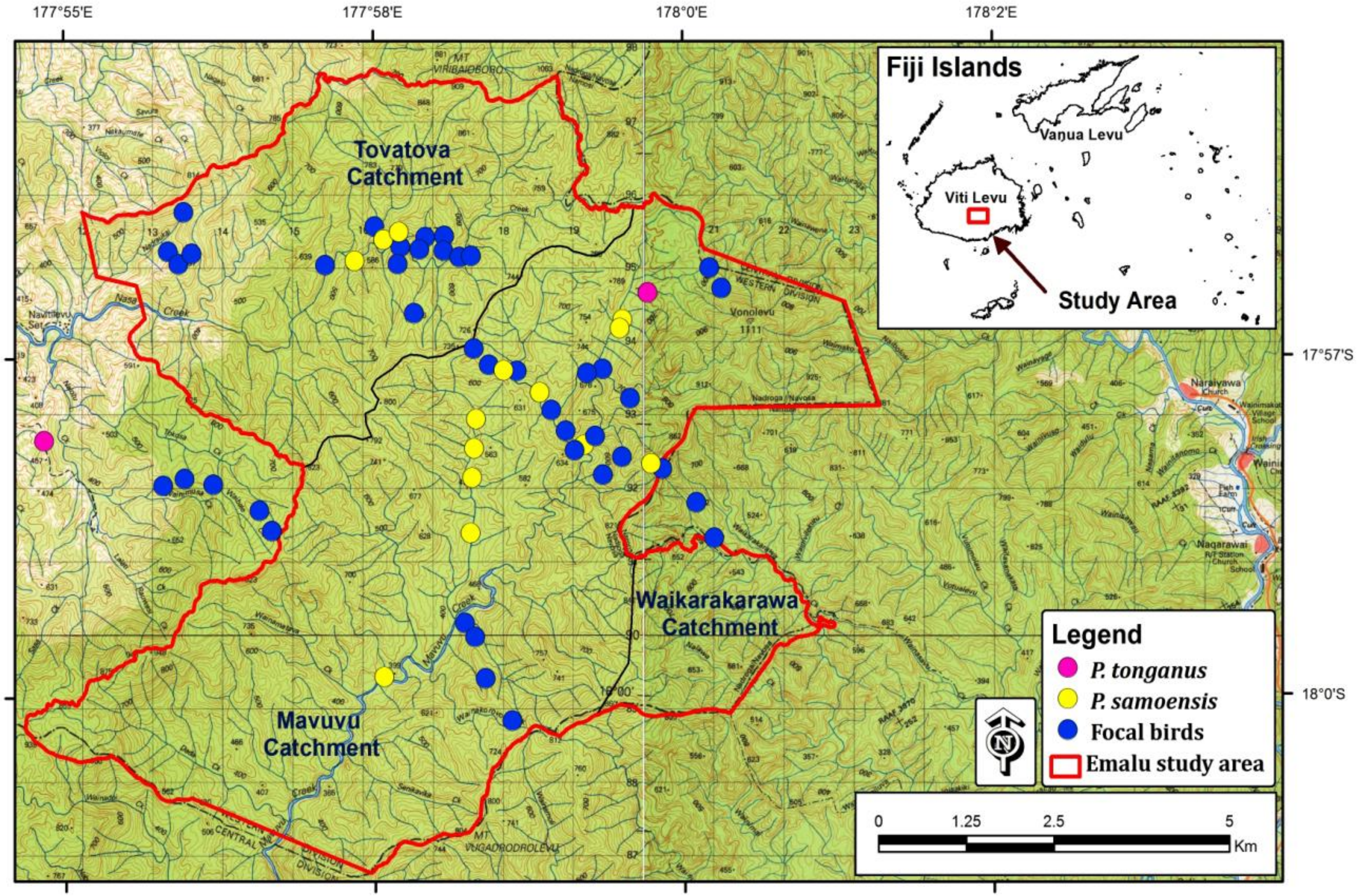

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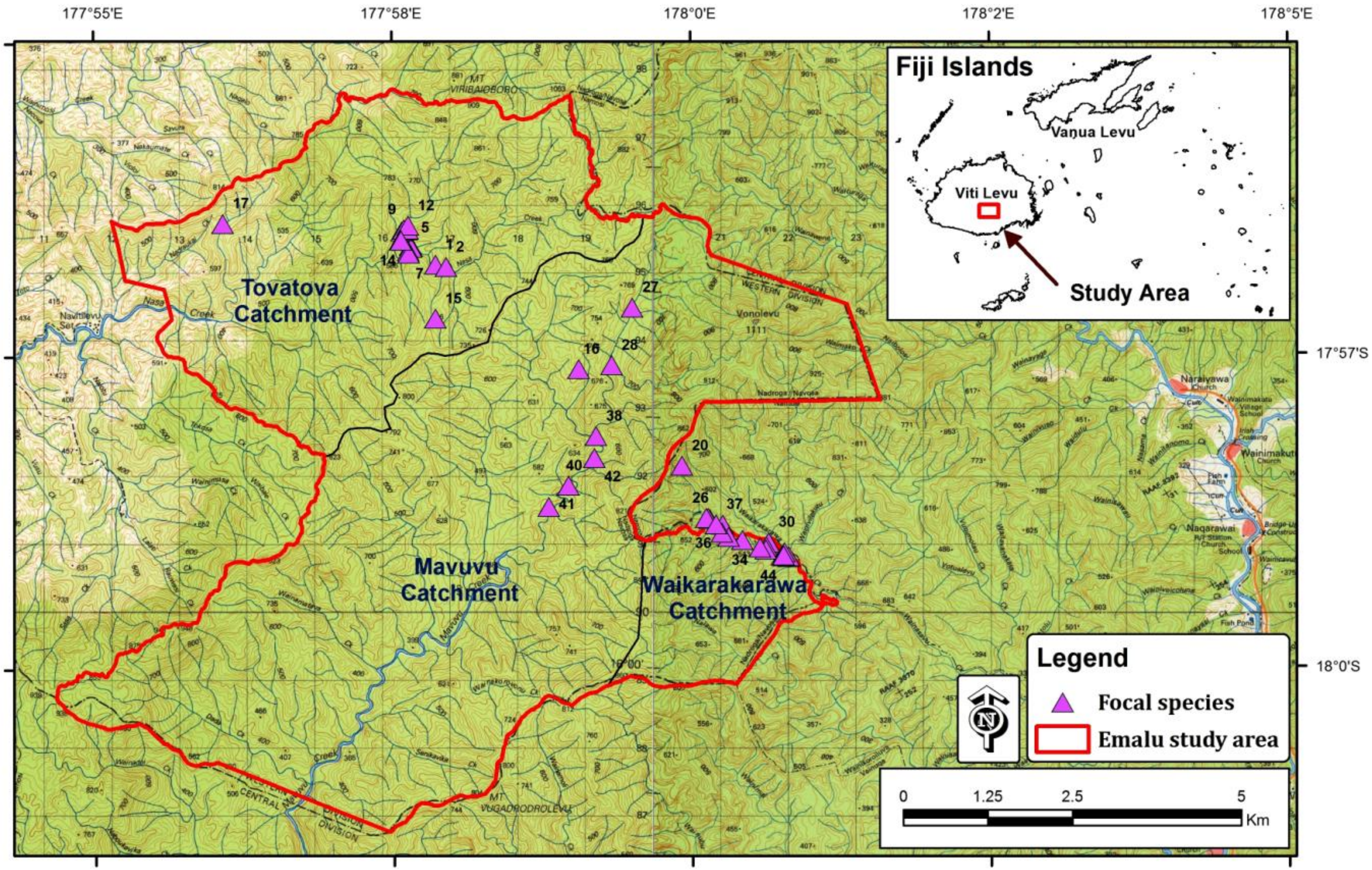

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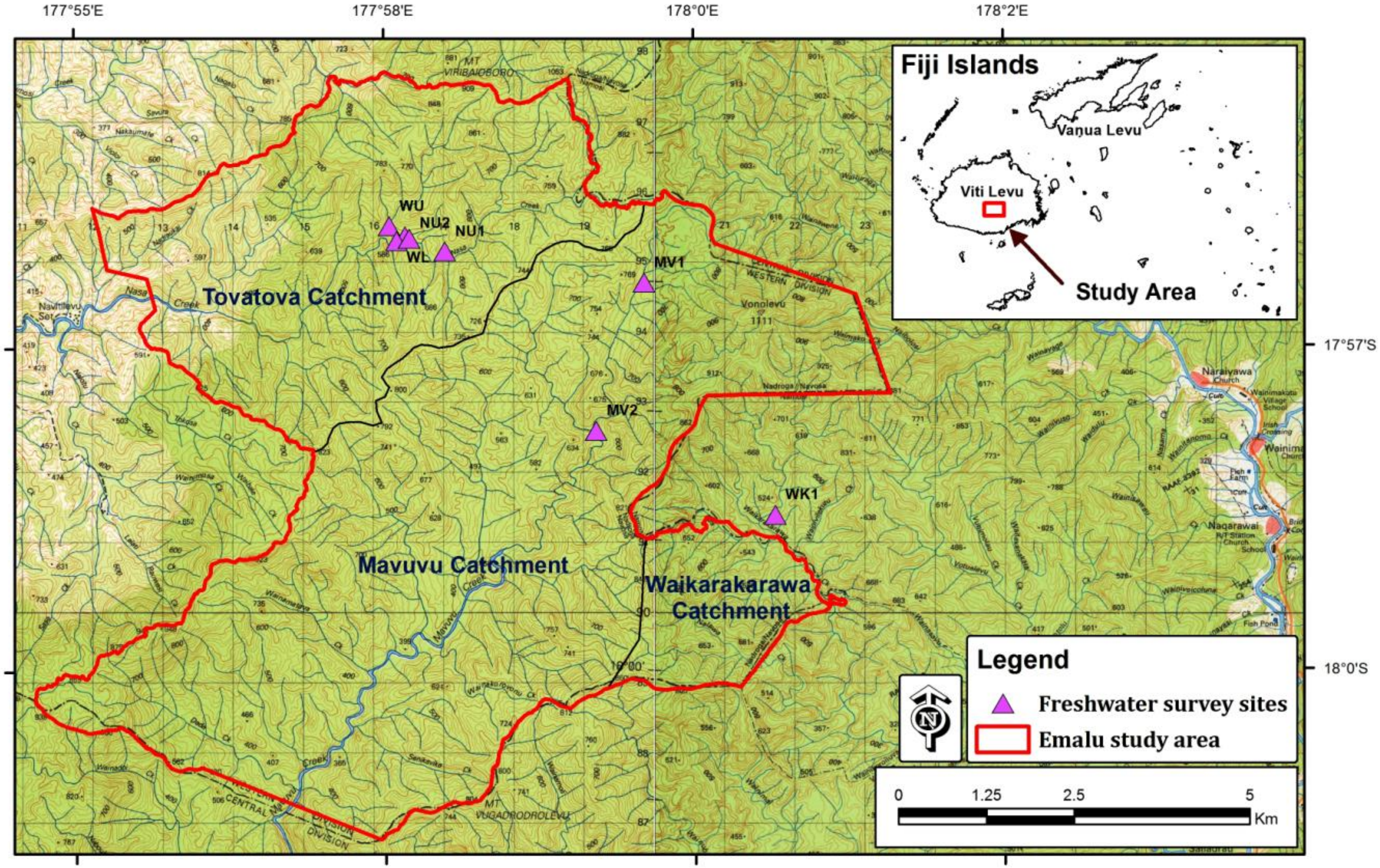

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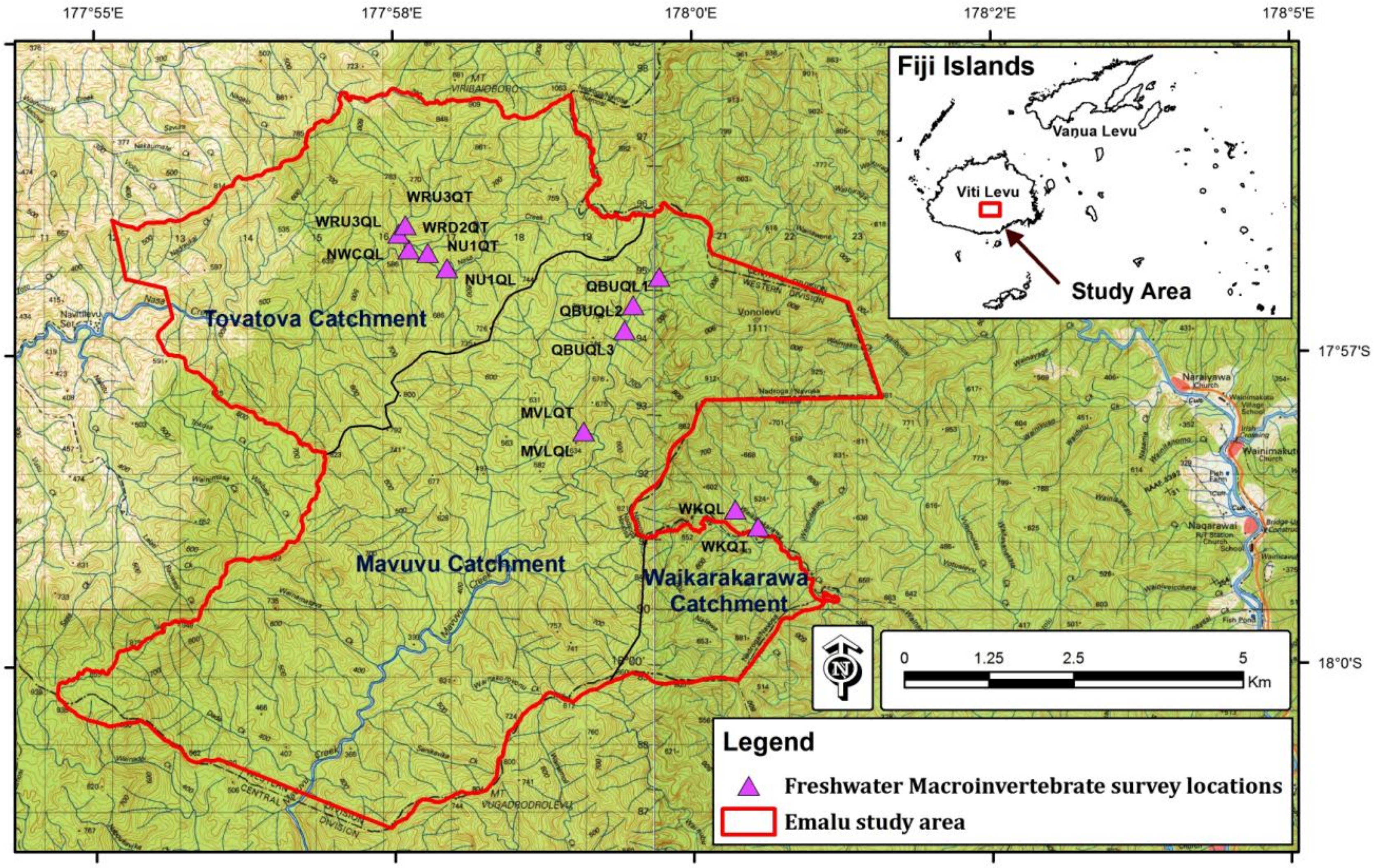

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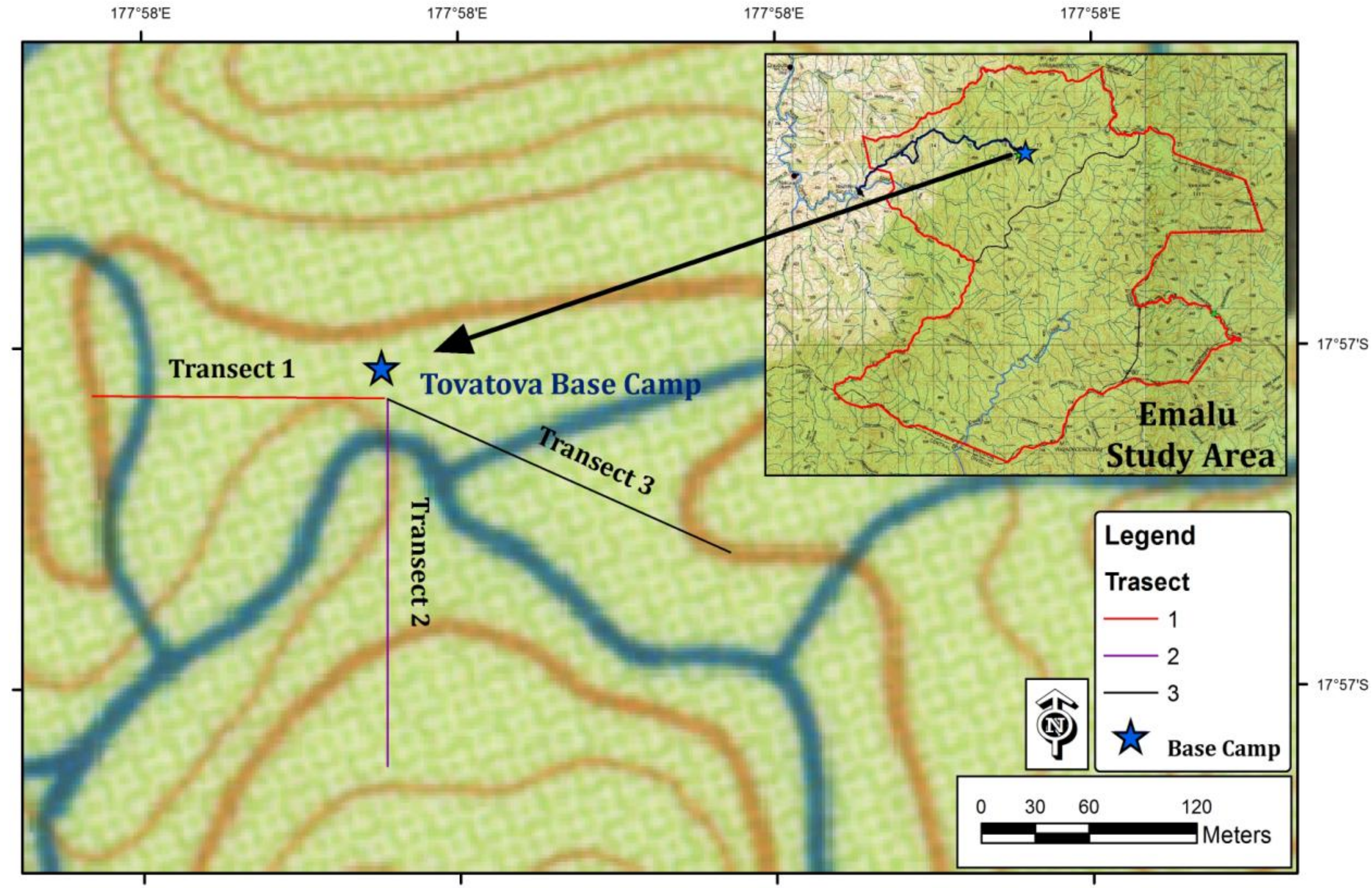

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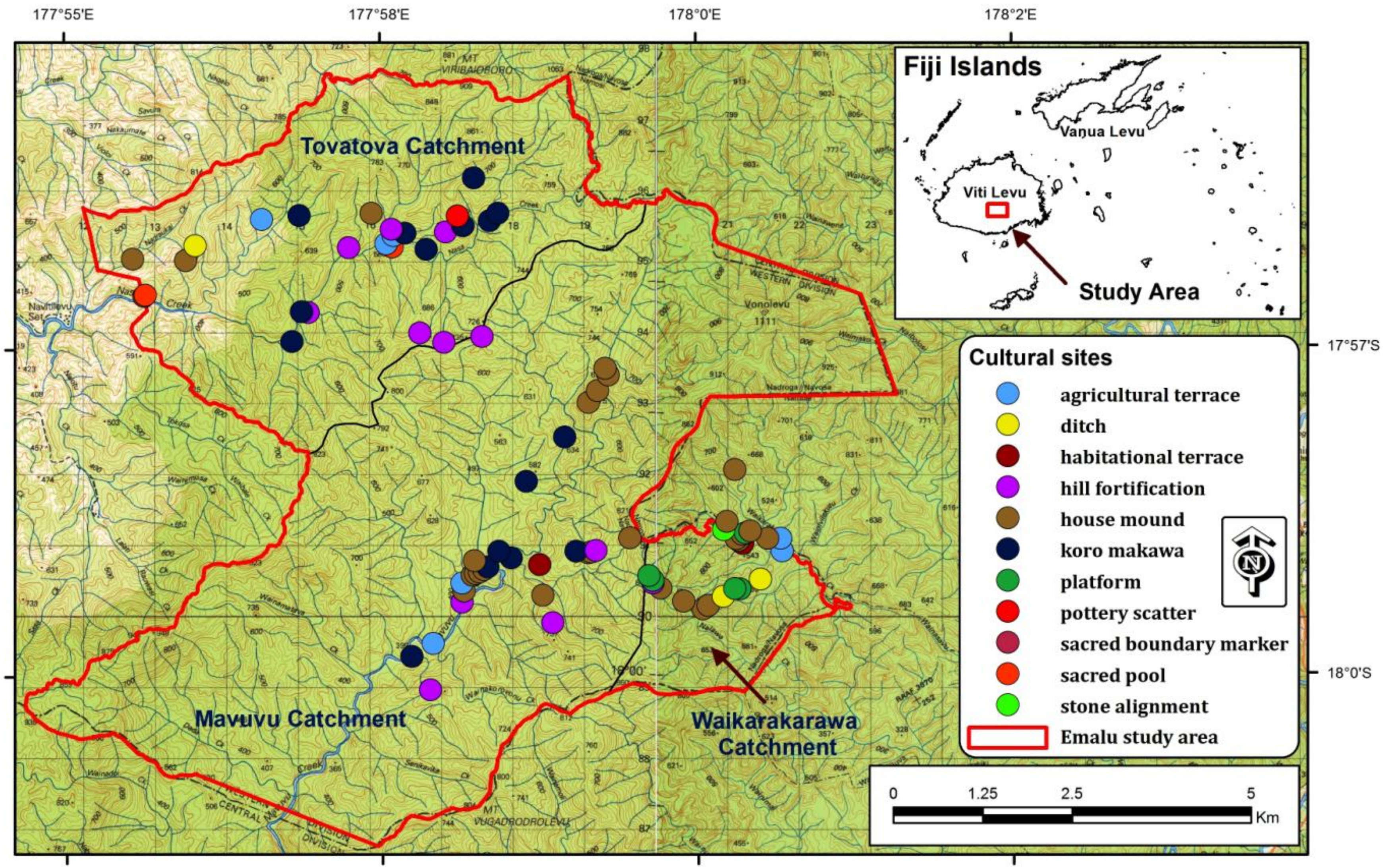

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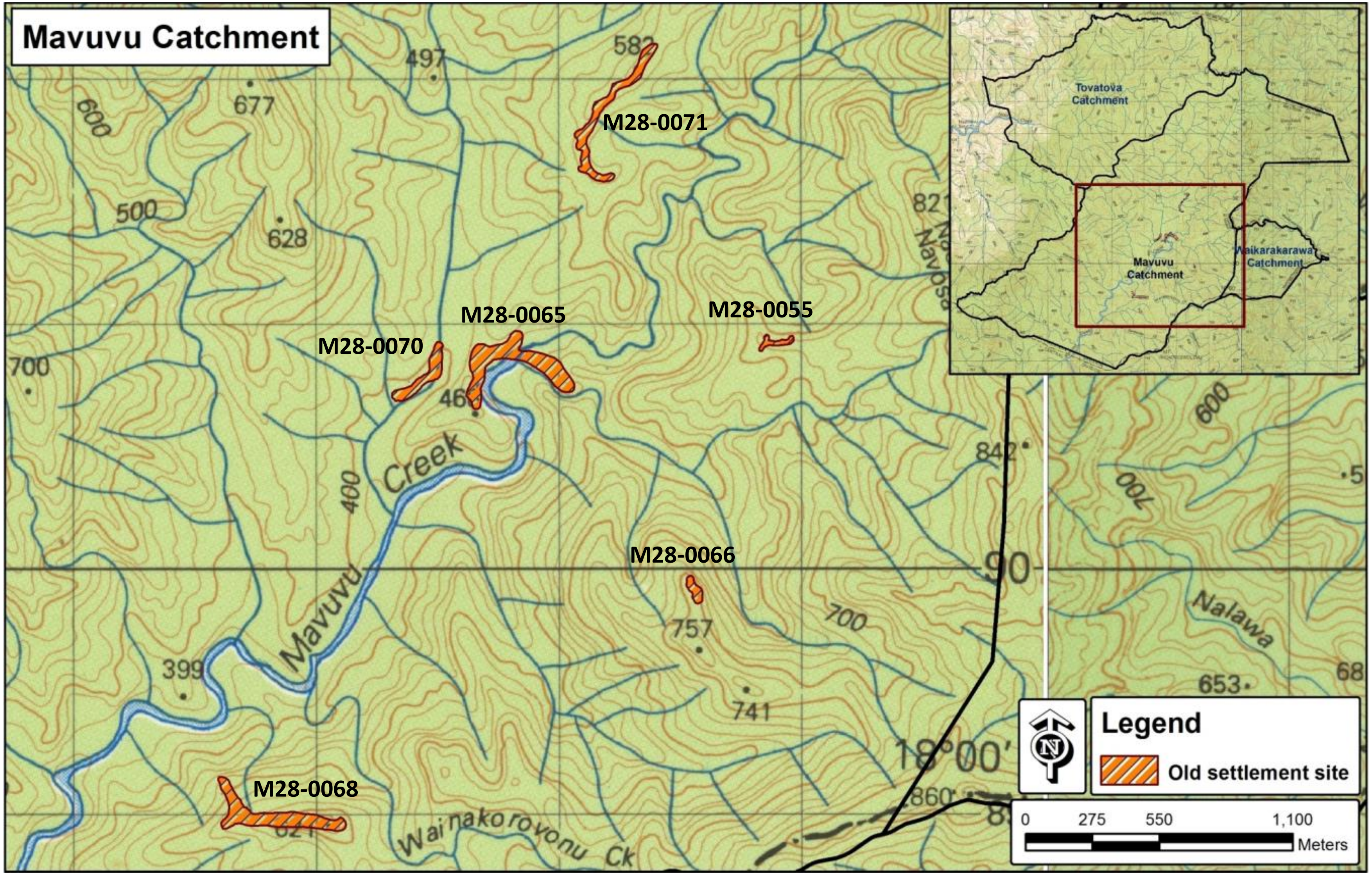

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PHOTOGRAPHS

Photographers initials are indicated in the captions: AN=Alivereti Naikatini, AL=Apaitia Liga, BR=Bindiya Rashni, EN=Elia Nakoro, IR=Isaac Rounds, LC=Lekima Copeland, MT=Marika Tuiwawa, NT=Nunia Thomas, SK=Sakiusa Kataiwai, SP=Sarah Pene, SHT=Senilolia H. Tuiwawa, SPRH=South Pacific Regional Herbarium

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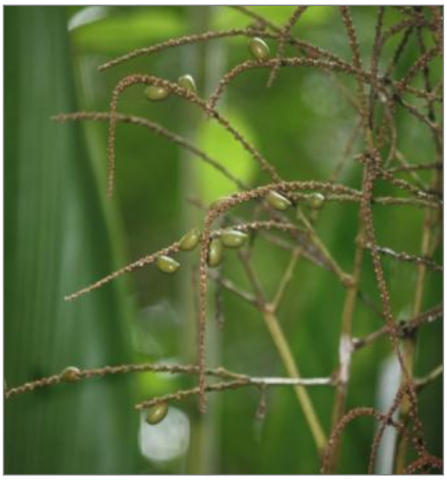

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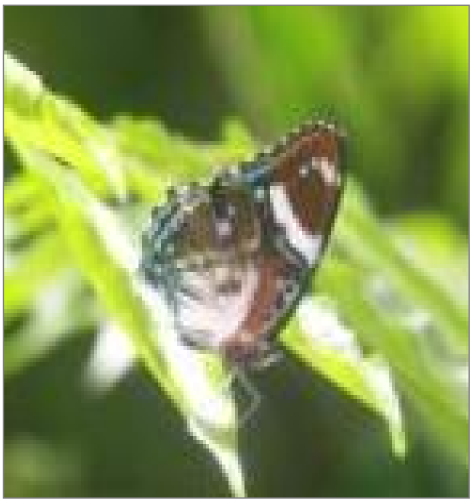

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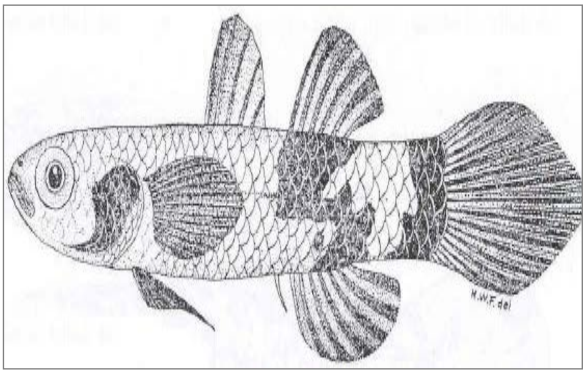

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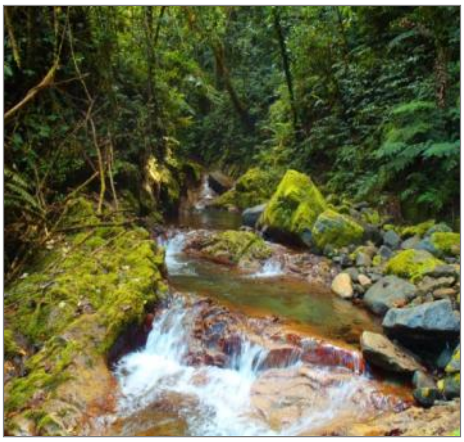

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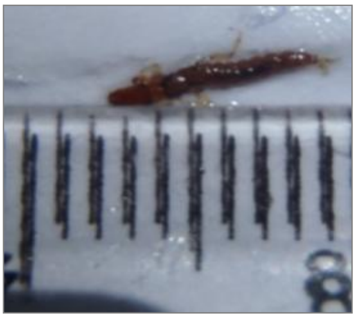

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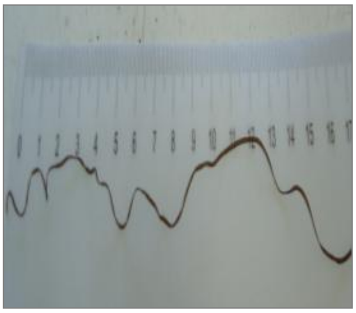

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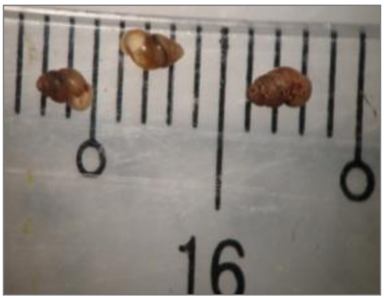

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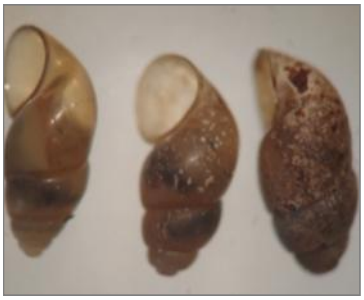

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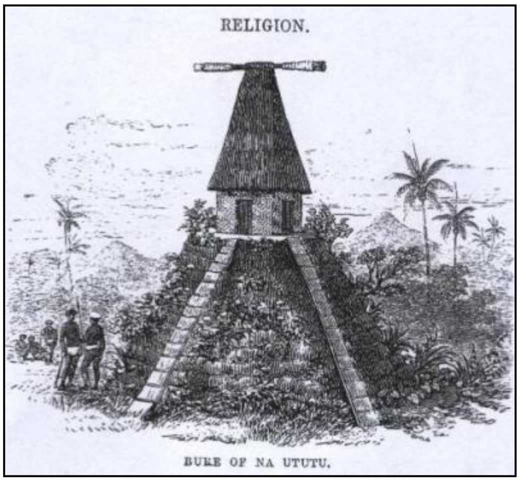

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CHAPTER 1: INTRODUCTION

The Fiji REDD+

REDD+ is an international programme so named for countries' efforts to reduce emissions from deforestation and forest degradation, and foster conservation, sustainable management of forests, and enhancement of forest carbon stocks (Forest Carbon Partnership Facility, 2013)

Fiji's participation in the programme was formalised through the Fiji REDD+ Policy which the Fiji Government endorsed in December 2010 (Fiji Forestry Department, 2011). REDD+ in Fiji is supported and funded by the Secretariat of the Pacific Community (SPC), the Federal Ministry of Economic Co-operation and Development, Germany (GIZ) through the Programme *Coping with Climate Change in the Pacific Island Region* and the Fiji Department of Forestry.

One of the REDD+ policy activities is the establishment of a pilot site for Fiji, for which the mataqali Emalu of the yavusa Emalu in Navosa Province, Viti Levu was selected. This programme focused on four key objectives:

- To conduct a forest inventory and carbon pool measurement of the Emalu pilot site. The intended outcomes are to test the carbon pool measurement methodology recommended for Fiji, to contribute to the development of a national protocol for forest carbon measurements and monitoring, and to have a Tier 3 level carbon stock calculation.
- To conduct rapid biodiversity surveys and develop instruments to monitor biodiversity changes in the pilot site. This will contribute to a national biodiversity monitoring protocol for REDD+ projects.
- To undertake a socio-economic survey of the people of the Emalu forest using participatory appraisal tools, establish social and economic baselines and assess the social and economic implication of the REDD+ project following relevant international guidelines and standards. Indicators will be developed as part of the monitoring procedure. An assessment of drivers of deforestation and forest degradation of the Emalu REDD+ pilot site and the surrounding area will also be undertaken.
- To carry out a cultural and archaeological mapping of the pilot site.

To protect Fiji's terrestrial biodiversity it is critically important that protected areas have sufficient connectivity to meet the area requirements of wide-ranging threatened species and ecological processes, and that these protected areas are managed as a coordinated system for effective conservation.

It is also vital to create awareness and appreciation of the importance of biodiversity amongst local communities. Equally important is a forward defence against emerging threats to biodiversity, by providing information to decision-makers, establishing support and incentives for biodiversity conservation, and building capacity to manage biodiversity resources.

Survey Overview

The South Pacific Regional Herbarium (SPRH) at the Institute of Applied Science (IAS), University of the South Pacific coordinated the biodiversity and archaeological surveys. The surveys were carried out in two phases; 17-26 July, 2012 and 18-26 March, 2013.

The focus of the surveys was to map areas of high biodiversity and archaeological importance, develop monitoring protocols following Climate, Community & Biodivesity Alliance (CCBA) standards, and later contribute towards a national biodiversity monitoring protocol for REDD+ projects.

Study Area

The REDD+ pilot site is the land encompassed by the mataqali Emalu in the province of Navosa (Map 1). The Emalu area lies in the climatic transitional zone in central Viti Levu in the province of Navosa, which is adjacent to five other provinces; Nadroga, Ba, Namosi, Naitasiri and Serua. The Emalu site covers an area of 7, 347ha, predominately covered by closed forest.

The Emalu land is under the ownership of the Draubuta landowners, a population of about 400 people living in more than 30 households in the village of Draubuta. They constitute five land-owning units, or mataqali, namely:

1. Mataqali Koroivabeka (Tokatoka : Naboseiwale, Narogairua).
2. Mataqali Naqio (Yavusa: Mota, Tokatoka: Nadurusila).
3. Mataqali Navesiqiyani (Tokatoka: Navesiqiyani).
4. Mataqali Naocotabua (Tokatoka: Naocotabua).
5. Mataqali Emalu (Yavusa: Emalu, Tokatoka: Emalu, Duiyabe).

Situated on an alluvial plain, with the Nasa Creek running along the village and spilling into the upper reaches of the Sigatoka River, accessibility to Draubuta is a steep 1.5km descent by foot from the nearest dirt road. The main source of income is through commercial agriculture, mainly kava and taro.

The Emalu land encloses two important catchment areas; (1) the Nasa catchment (on the drier part of Viti Levu) which drains into the Sigatoka river, and (2) the Mavuvu and Waikarakarawa catchments (on the wetter part of Viti Levu) discharges into the Navua River.

The terrain is primarily steep with the highest peak of Mt. Vonolevu having an elevation of 1,111m. The western side of Emalu forest, which is the drier part of the transition zone, borders the talasiga grassland. On the eastern side towards Namosi, which is the wetter part of the transition zone, are the closed rainforests.

The underlying geology of the area is Tholo Plutonic Suite, an intrusive type of rock which intruded into the Wainimala Group and which is dated to the Upper Miocene period or later (Rodda, 1967, Rodda, 1976). The alluvial soils from the tributaries in the Navosa region are classified as Wainibuka sandy clay loam (Twyford and Wright, 1965, cited in King, 2004). These soils contain high phosphate levels (King, 2004) therefore making it optimum for planting. Rainfall is the major factor determining the different vegetation systems (requiring different microclimates) and on average ranges from 2000 to 4000 mm annually (Derrick, 1951)

CHAPTER 2: FLORA, VEGETATION & ECOLOGY

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2.1 Summary

A total of 707 plant taxa were recorded for Emalu, including 286 bryophytes and lichens, 375 angiosperms, nine gymnosperms, and 35 ferns and fern allies. Altogether, the vascular and non-vascular taxa recorded from the Emalu site spanned 182 families and 391 genera. Over a third (39%) of the vascular plant flora recorded are endemic to Fiji, including 160 species of flowering plants, two fern and fern allies, and two gymnosperms. Ten taxa were encountered that are important focal species due to their rarity, botanical significance, very recent discovery in Fiji and inclusion in the IUCN Red List.

Five principal vegetation types were identified: lowland rainforest, upland rainforest, cloud forest, dry forest and talasiga/grassland. The lowland rainforest, dry forest and the associated riparian vegetation were the most heavily impacted, indicated by the evidence of garden terracing and communal living and can be classified as anthropogenic primary forest. The upland rainforest and cloud forest were the least impacted vegetation types and can be described as relatively primary rainforests with comparatively higher tree species diversity and density.

2.2 Introduction

There is literally little or no botanical information available for the Emalu area. This report is therefore the first documentation of vascular and non-vascular plants of the Emalu forest. The objectives of this survey were:

- To document the range of vegetation types and typical botanical communities within the study area,
- To identify the presence (or potential presence) of species or ecosystems of national and/or international significance, and,
- To assess the susceptibility of the biological communities (in particular plant communities) to the potential impacts associated with the proposed project.

2.3 Methodology

The first phase of the botanical work was carried out within the Tovatova catchment. The field work assessment began in the open grasslands about 500m upstream from Navitilevu Village along the Nasa Creek. This was necessary for comparative purposes towards the incursion of similar forest/habitat types at higher altitudinal areas within the Emalu boundary.

The second phase of the botanical work was carried out within the Mavuvu catchment from a basecamp located along Waikarakarawa stream. At Waikarakarawa, Mavuvu and Mt. Vonolevu, field work began at the lowland rainforest and progressed towards the cloud forest.

Habitat analysis

Prior to the fieldwork an initial assessment of the study area was made using satellite imagery. It was noted that areas closest to Navitilevu Village were covered in grassland, and that farming activities were further upstream along the Nasa River. Bamboo stands were plentiful in areas that have been left as fallow for long periods of time. Areas beyond these farms were covered with forest. The higher altitude mountainous landscape towards Mt. Vonolevu (1,111m) was earmarked as an area of interest. This area would have cloud forest vegetation, normally found at elevations above 850m, although some have been reported from mountain top from lower elevations e.g. Mt. Korobaba at 400m elevations (Kirkpatrick and Hassall, 1985). Cloud forest is a system known to have very unique plant life, and the forest was expected to be relatively intact.

Flora Survey

Opportunistic collections were made of mosses, liverworts, hornworts and lichens on different substrates. These were packeted for further processing and identification (Fig. 11, Fig. 12) at the South Pacific Regional Herbarium. Bryophyte collections of Harris (1967), Fife (2004), Pocs (2004) and Renner (2012) were cross-referenced including the most recent cryptogram work undertaken for Fiji (von Konrat *et al*., 2011, Lumbsch *et al*., 2011, Soderstrom *et al*., 2011).

Native plant species, especially those endemic to Fiji, and any species flowering and/or fruiting, were opportunistically collected and documented whilst trekking through the area. Additionally plant species observed within the belt transects set up to quantitatively assess plant density, distribution and diversity within the forest types, were also documented. Collected specimens were deposited at the South Pacific Regional Herbarium where verification of specimen identification was later carried out. In validating the identification, the collection of fertile materials with special emphasis on the unknown groups i.e. bryophytes and focal species (on the IUCN Red List) was carried out. The distribution of these taxa within the area covered was also marked (Map 2) and recommendations for their protection are also highlighted. Plant names follow those used by Smith (1981, 1979, 1985, 1988, 1991) for gymnosperms and flowering plants, and those used by Brownlie (1977) and Perrie and Brownsey (2011) for the pteridophytes (ferns and fern allies).

Vegetation community structure

In documenting the range of principal vegetation types and forest or habitat communities, the topographic and forest cover maps for Fiji, as well as satellite images were initially used to identify representations of the various plant communities. A reconnaissance of the area was carried out during which sites were selected for location of transects and plots.

Quantitative assessment of the communities in different forest types was carried out using 10m x 10m plots along a 100m transect, a methodology used previously in other sites in Fiji (Mueller-Dombois and Fosberg, 1998, Tuiwawa, 1999).

Plots were used to:

- assess the presence and absence of focal species,
- characterise associated vegetation communities with each principal vegetation type, and
- confirm boundaries between biological communities encountered.

Within each plot, every tree with a diameter at breast height (dbh) greater or equal to 5cm was measured, identified and recorded. The bole height, crown height and width were estimated for each tree enumerated. Ground cover vegetation was described, canopy cover estimated and in addition, the epiphytic flora recorded. Where feasible GPS locations and photographs of the vegetation were taken.

Habitat characterization

Habitat characterisations for forested areas relied on a number of sources of information, and was undertaken to produce a stratified hierarchical habitat classification. These sources of information and levels of classification were as follows:

- plot data to determine vegetation community structure,
- principal vegetation types (Mueller-Dombois and Fosberg, 1998),
- 1:50,000 topographic map indicating terrain features, and
- plot data to determine impact status and likely dominant species and their associates.

The non-forested areas included open country (rivers, open riparian areas, roads, villages and settlements) and agricultural land (subsistence plantations, commercial farms, pastures and fallow land). These non-forested areas were not assessed in detail but were briefly described and highlighted in the vegetation map for the project (Map 3 and Map 4). The assessment of the vegetation was focused more on forested area then on non-forested areas.

For the forest or habitat typing process the most prominent topographical feature of the forested area was used and categorised as follows:

- Slope - forested area found on slopes with a gradient ranging from 10 to 85 degrees.
- Ridge top - forested area found on top or along a ridge or mountain range. The width of such ridges could range from a few centimetres up to 20m, with an unlimited length.
- Flat - forested areas with a gradient ranging from 0 to 10 degrees. These areas also included raised river flats and flood plains.

In addition to the forest typing, a system of assigning an impact status to each area was developed (Appendix 4). Whilst rudimentary, the aim of this system was to provide guidance on which areas of forest have previously been subjected to disturbance. The categories for the impact were as follows:

- Low - Primary forest in which there is little or no evidence of disturbance;
- Medium - Secondary forest that is recovering and displays some of the ecological complexity and function associated with a secondary and primary forest type or a transition forest type; and
- High - Secondary forest that shows signs that the disturbance is recent and on-going.

2.4 Results and discussion

2.4.1 Diversity of non-vascular plants (bryophytes) and lichens

A total of 286 non-vascular plant taxa were collected, recorded and assigned to 72 families, and 133 genera (Appendix 1). The largest families for each of the main bryophyte groups were Neckeraceae (for mosses), Lejeuneaceae (for liverworts), Anthocerotaceae (for hornworts) and Graphidaceae (algal symbionts or lichens).

Bryophytes and lichens in the area are typical features in the various systems given the high elevation. The diversity and density is, at a glance, expectedly low given that the study area is on the dry side of the island. The collections made will all contribute to documented range extensions of these species. These records will be incorporated in the planned publication of the Flora of Bryophytes for the Fiji Islands, currently in preparation. These non-vascular groups of plants are also fundamental to climate change research.

2.4.2 Diversity of vascular plants

A total of 421 taxa were recorded, of which 395 taxa were identified to species level and 36 taxa to genus level. Of the total taxa recorded there were 375 angiosperms (315 dicots and 60 monocots), 35 ferns and fern allies, and nine gymnosperms. For those taxa identified 350 were native, which comprised 185 indigenous species (145 angiosperms, 32 ferns and eight gymnosperms) and 165 endemic species (160 angiosperms, two ferns and two gymnosperms). A total of 71 exotic species (48 dicots, 22 monocots and one fern), were also recorded. Ten taxa were encountered all of which were native and considered important focal species. The full species checklist is provided in Appendix 2.

2.4.3 Focal Species

There were a total of ten species encountered which were considered important due to their rarity, botanical significance, their very recent discovery in Fiji or their IUCN Red List status. The locations of some of these ten focal species within the study area are shown on Map 2, and photographs of them in Fig. 1-Fig. 10.

Acmopyle sahniana Buchh. & N.E.Gray (Fig. 1)

The species is endemic to Fiji and found only on the island of Viti Levu. On this survey a relatively large and viable population was recorded in the upland vegetation of the Mavuvu Creek at 600-700m. In Fiji, this species is quite restricted in distribution with an estimated 150 trees recorded to date from the highlands of Namosi, Naitasiri and Ra Province and is currently classified as Critically Endangered on the IUCN Red List (Thomas, 2013). *A. sahniana* is locally known as kautabua or drautabua and its greatest threats are from mining or logging operations. Its occurrence in the lower and upper Mavuvu catchment is a promising confirmation of a new population of *A. sahniana* and more importantly, a range extension of its current distribution.

Degeneria vitiensis I.W.Bailey & A.C.Sm. (Fig. 2, Fig. 3)

This species and the two others within the genus are endemic to Fiji. *Degeneria* is the sole genus of the family Degeneriaceae, also a Fiji endemic, and one of the oldest flowering plant families in the world. *D. vitiensis* is a timber tree found in lowland and upland areas on the islands of Viti Levu, Vanua Levu and Taveuni, and is categorised as Vulnerable on the IUCN Red List (World Conservation Monitoring Centre, 1998). *D. vitiensis* is locally known as vavaloa or masiratu and its greatest threats are from the clearance of forest for agriculture and human habitation. Its occurrence in the upper parts of the lowland and upland area of the study area (590-650m) suggests a range extension of its current distribution.

Macodes cf. *petola* (Fig. 4)

This orchid was not documented in Smith's *Flora Vitiensis Nova* (1979), and the closest occurrence of the genus is in Vanuatu. Its occurrence in Fiji is seemingly the result of long distance dispersal but given evidence of human habitation in adjacent lower rainforest, it is likely that the taxon was part of an early introduction to Fiji by early settlers. This species was collected for the second time in Fiji since 2005 and was recorded in the upland rainforest vegetation on the slopes adjacent to the ridges, at 650-750m. Further research on its population structure and distribution is required to confirm the mode of introduction into Fiji's archipelago.

Nervilia cf. *punctata* (Fig. 5)

This species of orchid is rare in Fiji, known previously from a single collection on Mt. Korobaba in 1979. Outside of Fiji it is also known to occur in Borneo and Sumatra. This terrestrial orchid was recorded on slopes of the lowland rainforest vegetation at about 450-550m.

Equisetum ramosissimum (Desf.) subsp. *debile* (Roxb.) Hauke (Fig. 6)

This species of fern ally is not common elsewhere apart from Viti Levu with extensions eastwards into the tropical Pacific. There are only three records of the species from Ba, Naitasiri and Serua. It is recorded as common along the edges of river and creeks. It was recorded in the riparian vegetation off the banks of Nasa River, at about 500m and is a strong indicator of an intact riparian system.

Metroxylon vitiense (H.Wendl.) Hook. f (Fig. 7, Fig. 8)

This species of palm is endemic to Fiji and is locally referred to as <u>soga</u>. It is common on the south east of Viti Levu and Vanua Levu but is highly threatened due to its harvesting for food (palm heart) and for leaves for thatching. Its habitat (swamp) is targeted for land reclamation both for agriculture development and human habitation. Very few trees were observed along the river embankments in the lower Mavuvu River catchment.

Cyphosperma tanga (H.E.Moore) H.E.Moore (Fig. 9, Fig. 10)

This palm is endemic to Fiji and is locally referred to as <u>taqwa</u> and is one of the most threatened palm species in Fiji due to logging and establishment of plantations (Watling, 2005). Its only other known wild population occurs along the western slopes of Mt. Tomaniivi (Fiji's highest mountain, 1323m). The second viable population, encountered during this survey, lies just outside the eastern Emalu boundary.

A*lpinia parksii* (Gillespie) A.C.Sm.

This species of coarse herb, unlike *Alpinia boia*, is uncommon. It grows up to 5m high along river banks and ridges. It becomes more prominent further up along ridges and slopes. Its leaves are used for thatching and it is locally known as <u>locoloco</u> or <u>boiaboia</u>.

Balaka diffusa Hodel

This species of palm is known to be restricted to the Nabukavesi River catchment on Viti Levu. Its occurrence in the cloud forest of Mt. Vonolevu is a range extension of the current population. It is an endemic species, locally referred to as <u>balaka</u>, and is the largest of all <u>balaka</u> in Fiji in terms of its height and girth.

Geanthus cevuga (Seem.) Loesener

This species of ornamental plants is native to Samoa (where it is common) and Fiji (where it is rare). It was thought previously to only occur in Namosi but recent findings have confirmed its occurrence in other parts of Fiji as an ornamental. The leaves are used to scent coconut oil and necklaces and as a food spice. It is locally referred to as <u>cevuga damu</u>. In Emalu it was found in an old village site growing alongside <u>sacasaca</u>, <u>moli kania</u> and <u>koka</u> trees.

2.4.4 Vegetation community structure

Of the nine principal vegetation types recorded for Fiji, five were encountered in the study area: lowland rainforest, upland rainforest, cloud forest, dry forest and talasiga grassland. The dry forest refered to here is a mesic forest. All vegetation types except the talasiga grassland were quantitatively assessed.

The detailed results of the quantitative assessment of plots in these different vegetation types are given in Appendix 3. In total 136 plots were analysed; 40 in lowland forest, 41 in upland forest, 44 in dry forest and eleven in cloud forest. Within each of these vegetation types the plots were distributed over a variety of forest habitats.

Vegetation type 1: Lowland rainforest

Lowland rainforest is typically found on the windward side of large islands from sea level to 650m, with annual rainfall of over 2000mm. In Emalu the lowland rainforest is restricted to the Mavuvu and Waikarakarawa catchments. Overall, the forest in this principal vegetation type is best described as primary forest. All tree species recorded from the plots are either endemic or indigenous species and none of the tree species associated with human habitation was encountered or even observed outside plots. Stocking of good quality timber tree species is high and so is the size of merchantable tree species.

Three different forest types were observed and quantified using 40 plots in four transects. The forest types were characterised as follow:

Ridge top forest type

The 20 plots assessed contained an average of 26 (range 9 to 54) trees per plot, and an average of thirteen (range 7 to 23) species per plot. The most common species was *Garcinia myrtifolia* (laubu), which was present in more than 50% of the plots assessed. The largest individual trees were *Decussocarpus vitiensis* (amunu) with a dbh of 107cm, followed by *Endospermum macrophyllum* (kauvula) with a dbh of 95cm and *Calophyllum vitiense* (damanu) with a dbh of 82cm. The average dbh was 15cm (range 5-107cm). Overall, the twenty plots assessed had no single dominant species but the combined biomass (as reflected in the dbh) of *D. vitiensis*, *E. macrophyllum*, and *C. vitiense* gave a relative dominance of 52%.

Slope forest type

The seventeen plots assessed had an average of nineteen (range 11 to 28) trees per plot, and an average of eleven (range 7 to 16) species. *Garcinia myrtifolia* occurred in more than 60% of the plots assessed, and was the most common species. The average dbh of trees in the plots was 15cm (range 5-100cm). The largest tree documented in the plots was *Endospermum macrophyllum* with a dbh of 100 cm followed by *Storckiella vitiensis* (marasa) with a dbh of 78 cm. There was no single dominant species as the tree sizes were evenly distributed amongst all species, but the combined biomass (as reflected in the dbh) of *E. macrophyllum*, *S. vitiensis* and *Calophyllum vitiense* gave a relative dominance of 51%.

River flat forest type

The three plots assessed had an average 23 (range 15 to 33) trees per plot, and an average of fourteen (range 12 to 16) species per plot. The most common tree species were *Garcinia myrtifolia, Garcinia pseudoguttifera and Endiandra gillespiei*. The average dbh of trees in the plots was 18cm (range 5-131cm). The largest tree encountered was *Decussocarpus vitiensis* with a dbh of 131cm, and this was also the dominant species with a relative dominance of 86%.

Vegetation Type 2: Upland Rainforest

The survey on this principal vegetation type was restricted to forested areas at elevations of 650-850m. Three forest types were observed and quantified using 41 plots in six transects, and were characterised as follows:

Ridge top forest type

A total of 24 plots along three transects were used to analyze this forest type. There was an average of 30 trees (range 17-55) recorded in each plot, and an average of eighteen species (range 12-29) per plot. The most common species were *Syzygium* spp. (yasiyasi) and *Litsea* sp. (lidi). The largest tree encountered was *Agathis macrophylla* (dakua makadre) with a dbh of 152cm. Other large trees included *Syzygium* sp. (150cm) and two other *A. macrophylla* (140, 111cm). The average dbh was 18cm (range 5-152cm) with the dominant species being *A. macrophylla* (45% relative dominance). All dominant trees recorded from each plot are important timber tree species with dbh ranging from 31cm to 152cm and these include *Calophyllum vitiense, Dacrydium nidulum* (yaka), *Syzygium* spp., *A. macrophylla*, and *Burckella* spp. (bau). Together these five species comprised approximately 75% of the biomass of all trees in this forest type.

Slope forest type

Fifteen plots along two transects contained an average of 28 (range 10 to 40) trees per plot (100m^2) with an average number of 17 (range 8 to 25) species per plot. The most common species were *Gironniera celtidifolia* (sisisi) and *Cyathea* spp. (balabala) whilst other common species in some of the plots included *C. vitiense* and *Saurauia rubicunda* (mimila). The largest tree encountered was *Garcinia myrtifolia* with a dbh of 89cm. Other large trees recorded included *Endospermum macrophyllum* (dbh of 71, 65cm), *A. macrophylla* (69cm) and *C. vitiense* (68, 65cm). The average dbh was 19cm (range 5-152 cm). Overall there was no dominant species for this forest type, but across the plots the trees that together made up 80% of the total biomass were *E. macrophyllum, A. macrophylla, Syzygium* spp., *C. vitiense, Semecarpus vitiensis* (kaukaro), *Degeneria vitiensis* (vavaloa, masiratu) and *Buchanania attenuata* (maqo ni veikau).

Vegetation Type 3: Cloud Forest

On Emalu the cloud forest was restricted to mountain tops and ridges above 850m and is almost always shrouded in clouds. Precipitation is high and temperature is generally much lower with trees generally stunted and heavily covered with bryophytes. A series of eleven plots placed along a fragmented transect over a slope/ridge towards the summit of Mt. Vonolevu (1,111m) was used to quantitatively assess this forest type.

An average of 42 trees per plot (range 31 to 70) with an average number of 15 species per plot (range 11 to 22) was recorded for the area. The most common species were *Syzygium* spp. and *Cyathea* spp. The largest tree, with a dbh of 181cm, was *Syzygium* sp. Other large trees included *Calophyllum vitiense* (60cm dbh) and *Degeneria vitiensis* (43 cm dbh). The average dbh was 12cm (range 5 -181cm) and the average bole height was 1.8m (range 1 to 5m). *C. vitiense* and *Syzygium* sp. were dominant species from some of the plots assessed but overall *D. vitiensis* and *C. vitiense* were the dominant species with greater than 80% relative dominance.

Vegetation Type 4: Dry Forest

The native dry forest vegetation type on the leeward side of Viti Levu has been almost completely destroyed by combined grazing, agriculture and fire. The survey on this principal vegetation type was restricted to forested areas adjacent to the grassland in elevations ranging from 250m to 650m within the Nasa catchment. In a seasonal dry forest the mean annual rainfall is about 2,000mm.

Three habitat or forest types were quantified using 44 plots in six transects. The forest types and their characteristics were as follows:

River flat forest type

The nineteen plots assessed along three transects held an average of fifteen (range 7 to 24) trees and an average of seven species (range 4 to 11) were present within a plot. The most common tree species were *Syzygium malaccense* (kavika) and *Citrus grandis* (moli kania). The largest trees were *C. grandis* and *Dysoxyllum richii* (tarawau kei rakaka), having a dbh of 89cm and 86cm, respectively. The average dbh of trees was 21cm (range 10-89cm). The dominant species from some of the plots assessed was *D. richii* with a relative dominace of 80% and *S. malaccense* with 69%. Overall, there were no dominant species across the haitat as the biomass was fairly evenly distributed amongst the larger trees. Most of the trees discussed above are associated with human habitation.

Ridge top forest type

Within the ten plots used to analyze this habitat there was an average of 35 trees (range 21 to 51) and sixteen species (range 10 to 25) per plot. The most common species was *Litsea* sp., followed by *Garcinia myrtifolia* and *Citrus grandis.* The largest tree observed was *Ficus obliqua* (baka ni viti) with a dbh of 132cm. Other large trees included several *Bischofia javanica* (86, 77 and 76cm dbh) and *Dysoxyllum* sp. (76cm dbh). The average tree dbh was 23cm (range 10-132cm). The dominant trees from some of the plots assessed were *F. obliqua* and *Dysoxyllum* sp. with a relative dominance of 57% and 53%, respectively. Overall there was no dominant tree species in this habitat despite *B. javanica* having a relative dominance overall of 48%. Like the river flat above, the presence of tree species like *C. grandis, S. malaccense* and *B. javanica* is indicative of past human habitation and activity in this area.

Slope forest type

Fifteen plots along two transects were used to analyze this habitat. An average of 23 trees (range 8 to 37) with an average number of ten species (range 6 to 14) per plot was recorded. The most common species was *Litsea* sp. with the largest tree encountered being *F. obliqua* with a dbh of 148 cm and other large trees that included *Dysoxylum quercifoliuma* and *Neonauclea fosteri* (vacea) with dbh of 120 and 113cm, respectively. The average dbh was 22cm (range 6 to 148). The dominant species assessed were *D. quercifolium, F. obliqua* and *N. fosteri* all with relative dominance of greater than 74%. Overall, the dominant species for this forest type were the *Dysoxylum* spp. (4 taxa) and *Ficus obliqua* which together comprised 75% of the total biomass in this habitat.

Overall, the forest or habitat types found in this principal vegetation type are best described as an anthropogenic primary forest as most of the more dominant and common tree species are associated with human activity. Other species not found in the plots that testify to this include *Codiaeum variegatum* (sacasaca), *Cordyline fruticosa* (qai), *Schizostachyum glaucifolium* (bitu dina) and *Veitchia joannis* (saqiwa, niuniu).

Vegetation Type 5: Talasiga Vegetation

Grassland/talasiga habitat type

The grassland is restricted to the slopes and ridge tops and is mostly made up of the grass *Pennisetum polystachyon* (mission grass), *Sporobolus* spp. (wire grass), *Dicranopteris* spp., (qato or bracken ferns), *Pteridium esculentum, Miscanthus floridulus* (gasau or reed) and many other smaller weedy plants. The general lack of tree cover is characteristic of such a landscape. The grassland is regularly set on fire to allow for new re-growth of grass for use as fodder for cattles and horses. Areas closer to the edge of the gully forest are used for subsistence farming.

Woody shrubland habitat type

This vegetation was observed growing between the grassland and the forest edge and is also referred to as savannah grassland. The area was dominated by secondary pioneer plant species like *Commersonia bartramia* (sama), *Parasponia andersonii* (drou), *Tarenna sambucina* (vakaceredavui), *Trema orientalis, Dillenia biflora, Decaspermum vitiense* (nuqanuqa) and larger patches of *Schizostachyyum glaucifolium* and *M. floridulus*. This habitat is where active agricultural activities are occurring both at the subsistence level and on a semi-commercial scale. Gardens or plantations of yaqona, banana and taro are common and so are patches of abandoned (fallow) gardens. Such activity expands the grassland habitat types into forested areas and as noticed from the survey will continue to do so especially with increasing pressure from subsistence farming and a growing population.

River bank/riparian habitat type

The vegetation along the creek and river system that is found adjacent to the grassland was mostly dominated by important introduced and native fruit trees. Also found here were important trees species that have cultural uses, such as *Inocarpus fagifer* (ivi, chestnut), *Pometia pinnata* (dawa), several species of *Citrus* spp., *Artocarpus altilis* (uto, breadfruit), *Cocos nucifera* (niu), *Spondus dulcis* (wi), *Syzygium malaccense* (kavika) and *Terminalia catappa* (tavola). Other culturally important trees include *Aleurites moluccana*, *Bischofia javanica*, *Cananga odorata* (makosoi), *Cordyline fruticosa* (qai) and *Euodia hortensis* (uci).

2.5 Conclusions and recommendations

The discovery of the focal species detailed above, in particular, the priority conservation species on the IUCN Red List, as well as rare orchids, parasitic plants, and palms is an indication of the micro-sensitivity and function of the upper catchment areas that have yet to be fully explored, and which needs protecting. Based on current knowledge of these taxa, any level of development (logging or agricultural) could seriously affect their existence, thus more effort needs to be invested in their protection. Overall the presence of a large number of these high value conservation species within the Nasa, Mavuvu and Waikarakarawa Creek catchment highlights the biodiversity importance of Emalu. For Viti Levu (and for Fiji as a whole) it is an area with the highest concentration of important plants of conservation priority.

In terms of the vegetation, the level of human impact decreases as you move further inland or away from current human habitation, and also towards the higher altitudes of Mt. Vonolevu. Demarcation of these habitat types is quite obvious in the grassland vegetation but almost near impossible to detect under heavy canopy in the forested lowland and upland vegetation including the riparian system running across these vegetation types. It is recommended that more extensive future surveys be carried out in these areas.

CHAPTER 3: HERPETOFAUNA

Nunia Thomas and Isaac Rounds

3.1 Summary

This report documents the first record of herpetofauna biodiversity within the Emalu study area. Emalu, like many other parts of Viti Levu, contains habitats ideal for herpetofauna. Despite weather and time constraints this survey produced results similar to surveys carried out in other areas of Viti Levu, encountering six species of herpetofauna: three endemic, two native and one invasive. Further surveys will very likely reveal the existence of additional herpetofaunal species.

3.2 Introduction

To date, there has been no documented information on the herpetofauna of the Emalu area. This report is therefore the first documented study of these organisms. The objectives of this baseline herpetaofauna survey were to:

- Document the herpetofauna diversity in the study area.
- Identify ideal herpetofauna habitat.
- Trial herpetofauna survey methods with recommendations for long-term monitoring in the study site.

3.3 Methodology

Field Assessment

During the survey periods the weather was generally fine every day with occasional and sometimes heavy afternoon showers. At the Waikarakarawa survey site heavy rain on one day resulted in flashflooding. Weather conditions dictated the number of days, type of traps and survey methods conducted, and these are summarised in Appendix 5. Average air temperatures recorded for the nocturnal surveys were 20.6°C and 26°C for the Nasa and Waikarakarawa catchments respectively.

Habitat Assessment

The objective of the expedition was to record all herpetofauna species captured and/or observed within the study site; and develop appropriate long term monitoring methods. For this reason, all potential habitats within good forest cover and outside of the forest were surveyed. The study area generally had ideal herpetofauna habitats: riparian vegetation, ridge forest, forest floor cover of leaf litter and rotting wood, and trees with dense epiphyte cover. Systematically, the survey targeted a ridge habitat, riparian forest habitat and lowland forest habitat. A total of ten sites were intensively surveyed (Map 5).

Diurnal and Nocturnal Herpetofauna Surveys

There are several accepted methods for herpetofauna surveys that generally fall under two categories: **opportunistic** diurnal and nocturnal searches and trapping, and **standardised** nocturnal and diurnal searches and trapping. A summary of the methods used in this survey is given in Appendix 5

Herpetofauna surveys in Fiji have generally been opportunistic, but their methods standardised to allow for comparison between sites. Other long term herpetofauna monitoring plots on Viti Levu: the Sovi Basin Conservation Area and the Wabu Forest Reserve are limited to nocturnal frog searches. Because of the cryptic and heliophilic nature of Fiji's reptiles; and Fiji's climate, survey and trap methods are wide ranging, albeit limited by weather conditions.

The herpetofauna surveys in the Emalu study site consisted of three techniques but were constrained by the rainy weather. These are described below:

Standardised sticky trap transects whereby sticky mouse traps (Masterline®) are laid out at intervals along a transect. Each station is designated a station number (1-10) with a cluster of three traps per station for three placements to represent local habitat structure at each location (tree, log and ground). Transects are laid out along identified ideal habitats e.g. ridge tops and along river banks/ riparian vegetation. Leaf litter cover, canopy cover and undergrowth are all recorded. Left overnight, traps are checked regularly for captured specimens. These traps target both terrestrial and arboreal species.

Frogs and geckoes are active and more visible at night. **Standardised (time constrained) nocturnal visual encounter surveys** (2 hours) in ideal frog habitat are used. This method gives an encounter rate for comparison with other surveys within Fiji. Search efforts with a minimum of two observers at any one time targeted streams and adjacent banks/ flood plains.

Opportunistic Visual Encounter Surveys outside of the standardised searches allow for a record of presence/absence of herpetofauna. Skinks are more likely to be seen during the day, particularly during hot and sunny conditions. Opportunistic diurnal surveys were conducted along trails enroute to the camp site, vegetation plots, along stream edges, and in forest habitats surveyed by other survey teams in the expedition. Search efforts targeted potential skink habitat and frog and burrowing snake diurnal retreat sites. The diurnal surveys began at 09:00 and ended at 15:00 on each of the survey days. The team had a minimum of two searchers at any one time.

Environmental variables such as air temperature, water temperature, weather conditions (rain/fine) and cloud cover (%) were taken at the beginning and end of each nocturnal survey. Habitat characteristics and other basic ecological and biological information of herpetofauna found were recorded. Observations on possible threats to herpetofauna species and populations were also noted.

Geographic coordinates of survey sites were captured using the Thales Mobile Mapper Pro Navigator and Garmin GPSmap 60*CSx*.

3.4 Results

Based on the current knowledge of herpetaofauna on Viti Levu there are a total of 26 species that could potentially occur in the study area (Appendix 6). Prior to the survey a target list of 12 of these species was drawn up, based on their endemism and conservation status.

In total six species were encountered over the course of the survey, including three of the 12 target species. These were the green tree skink (*Emoia concolor*), the bronze-headed skink (*E. parkeri*) shown in Fig. 13 and the Fiji tree frog (*Platymantis vitiensis*) shown in Fig. 14.

3.4.1 Nasa catchment

A total of six species were captured during the survey of the Nasa catchment. Three of these were endemics (*Platymantis vitiensis, Emoia parkeri* and *E. concolor);* two were native (*Nactus pelagicus,* Fig. 15 and *Gehyra vorax,* Fig. 16*);* and one was an invasive species (*Bufo marinus,* Fig. 64). These findings were the result of over 14 man-hours of diurnal survey, 49 hours of sticky trapping and six man-hours of nocturnal surveys.

Two species were reported to occur by local villagers: the endemic banded iguana (*Brachylophus bulabula*) and the Pacific boa (*Candoia bibroni*), but were not encountered during the expedition.

Herpetofauna were observed at all the three habitat types targeted; but at only two of the survey sites. The majority of the species were encountered during opportunistic surveys (4 species); with lower encounter rates for the sticky traps (2 species), and standard diurnal (2 species) and nocturnal surveys (1 species).

Interestingly, the sticky traps did not yield any rats or invasive ants – which have been encountered in other survey sites on Viti Levu.

3.4.2 Waikarakarawa and Mavuvu Catchments

For these two catchments the same six herpetofauna species that were encountered in the Nasa catchment were also found here. The survey of the Waikarakarawa and Mavuvu catchments consisted of 8 man-hours of diurnal survey, 14 hours of sticky trapping and 3.3 man-hours of nocturnal surveys.

One of the main target species known to occur from historical records to occur in the area of Waikarakarawa catchment, the Fiji burrowing snake (*Ogmodon vitianus*), was not encountered during this survey.

3.5 Discussion

This report documents the first record of herpetofaunal diversity in the Nasa, Waikarakarawa and Mavuvu catchments on land belonging to the mataqali Emalu. Fiji's terrestrial herpetofauna are significantly impacted by introduced mammalian predators. This is particularly true for Viti Levu which has experienced the extirpation of two large terrestrial skinks (*Emoia trossular* and *E. nigra*) in the presence of the mongoose, feral cats, feral pigs and rats.

The presence of the Fiji Tree Frog, *Platymantis vitiensis* (Fig. 14) in the study area is of exceptional interest – this is a new record for the area and is possibly the western-most record of the occurrence of the species (in relation to the wet parts of Viti Levu) in Southern Viti Levu to date.

The apparent absence of the common ground skinks such as *E. cyanura* both within the study area and in the agricultural land is interesting and warrants more intensive searches both within and outside the forested areas, taking into consideration that weather impacts the observer's ability to find these species.

The low encounter rates and low diversity of herpetofauna in the study sites do not necessarily mean an absence of the species. Low encounter rates of heliophlic species is not uncommon in Viti Levu's forests; and is typical globally in rainforest habitats (Ribeiro-Junior *et al*., 2006, Ribeiro-Junior *et al*., 2008). Consequently, there are efforts to develop better quantitative survey methods of forest dwelling herpetofauna – and these will be considered in the development of an appropriate long term monitoring method for the Emalu study area. However, sites to target for the establishment of long-term monitoring plots should ideally be adjacent to the vegetation sample plots, as done so in this study because of the dependence of native herpetofauna on the health of the forest. Herpetofauna survey sites will also be extended to the non-forested parts of the study area to assess the presence/absence of the more common native ground skinks in the area.

3.5.1 Indicator species

Selecting which herpetofauna species could act as indicators of high conservation value forest was problematic for several reasons. Firstly, the tree frog (*P. vitiensis*) was not a suitable indicator species as it was found all over the study area from disturbed areas right up to the cloud forest. Furthermore, skinks or geckos are not ideal indicator species as they are cryptic. The invasive cane toad (*B. marinus*) was found everywhere except the cloud forest.

3.6 Recommendations

Considering that baseline survey within the Emalu forest has now been conducted, the best option available will be to build on this by conducting subsequent surveys and standardising the survey techniques especially for the sticky traps and frog surveys, carrying them out over different seasons and assessing species densities. Any changes in terms of presence/absence and density over time will indicate the status of the forest. It is recommended that these intensive and dedicated surveys focus on a particular area or along standard transects. It is also recommended that tree climbing techniques be used to enable better capture rates of cryptic skinks and gecko species.

CHAPTER 4: AVIFAUNA

Alivereti Naikatini

4.1 Summary

The main objectives of the study were to compile a checklist of the birds and bats species present and observed, and determine the presence of species of high conservation importance (focal species) for monitoring in the future. The assessment methods used during the survey were the Point Count Method with a fixed radius of 50m; evening (dusk) bat counts using a Bat Detector device to detect presence of micro-bats; interviewing of local guides, and opportunistic surveys. About 4000 minutes of avifauna studies were conducted during the two surveys where 59 points were assessed in 2012 and an additional 37 points in 2013. A total of 35 species of birds were recorded during the two surveys which included 25 endemic and one exotic species. Two species of bats were also recorded during the surveys. Ten focal species were identified (eight bird species and two bat species). The bird diversity of Emalu is comparable to the four largest Important Bird Areas (IBAs FJ07, FJ08, FJ09, and FJ10) on Viti Levu and ranks even higher in terms of bird density.

4.2 Introduction

Fiji's bats play an essential role as seed dispersing agents, major pollinators, and insect control agents in the rainforest and other terrestrial ecosystems (Palmeirim *et al*., 2007). However, bats are understudied in Fiji in terms of ecological research and there is little public awareness of their role and importance. Bats are the only native terrestrial mammals of Fiji and six species occur in Fiji, four of which are native and two endemic (Flannery, 1995, Palmeirim *et al*., 2007). Four bat species are listed as threatened (Palmeirim *et al*., 2007).

Like bats, birds are also very important indicators of the forest health. They are important seed dispersers, pollinators and insect control agents. In a pristine forest system, one would expect to find more native and endemic species. There are 68 species of land birds found in Fiji, eleven of which are introduced species.

No previous bird or bat surveys have been carried out in the Emalu area. A few recent studies were carried to areas close to Emalu, including a bat survey of the Tatuba caves in the vicinity of Saweni in the Namataku District (Palmeirim *et al*., 2007). The most recent bird survey close to the study area was carried out by Birdlife International (Fiji) in the Southern Viti Levu Highlands (IBA FJ10), which is to the south of Emalu, Sovi Basin (IBA FJ08) to the east and the Rairaimatuku Plateau (IBA FJ09) to the north (Masibalavu and Dutson, 2006).

The main objectives of this survey were to:

- Provide a checklist of all avifauna species (birds and bats) present in the site,
- Highlight species that are of conservation importance (focal species),
- Provide preliminary abundances of species present, and to
- Develop a methodology for avifauna monitoring work in the future.

4.3 Methodology

The survey methods used in the survey were the:

- Point count method (for both bats and birds),
- Evening counts for bats,
- Bat detector surveys in the evenings,
- Opportunistic surveys,
- Interviews with local communities.

The point count method was the most commonly used method to survey for the bats and birds. It was only carried out in the morning and afternoons when birds are more active. Counts in a point were restricted within a 50m radius for a period of ten minutes according to an established methodology (Naikatini, 2009). Stations were not randomly located, due to the rugged terrain of the area, but were placed along tracks and accessible areas. To maximise the size of the area covered, points were placed at least 200 – 400m apart. This was also done to minimise the likelihood of double counts. Each morning or afternoon session would last two to four hours depending on the weather. All birds detected within the 50m radius area were recorded and GPS locations noted. The inclusion of as many sub-habitats as possible – riparian, flat, slope, ridge and ridge top - in disturbed and undisturbed areas was attempted. The total number of points, birds and species recorded were tabulated to give the relative abundance or density of each species.

Bat surveys were also carried out by conducting bat counts in the early evenings (from about one hour before sunset – 17:00 to 18:00) from a good lookout or open area to determine what bat species were flying over and their direction of flight. The total number of bats counted in an hour would give an idea of the bat activity and abundance in the study area. Bat detectors were also used in the evenings near the camp site by walking along the trail and stopping at various points where there was an opening or gap in the canopy and pointing the bat detector into the direction of the sky. The bat detector enabled us to tune to the frequencies at which the two micro-bat species (present in Fiji) would be detected if they flew over or were feeding nearby. These surveys were only carried out for about an hour between 1900 and 2200 hours, and also when weather conditions were favorable for such surveys.

Opportunistic surveys were also conducted whilst travelling from one point station to another, or whilst travelling within the area from one base camp to another. Interviews with the local guides were carried out on some evenings. Local guides knew the area well, including where the main bat roosts are located, as well as the species of birds they may have encountered in the area previously.

4.4 Results and discussion

In total approximately 4000 minutes were spent actively conducting bat and bird surveys, and over 70 hectares were covered using the point count method. A total of 35 species of land birds and two species of bats were recorded in the study site, and these are listed in Appendix 7. Identifications were verified using a published field guide (Watling, 2001). A total of 96 point stations were surveyed during the 20 days of survey. These point stations (shown on Map 6) were located in the different sub-habitat types found with the main vegetation systems; lowland rainforest (<600m elevation), upland rainforest (600-800m elevation) and cloud forest (>800m elevation). A table of the location and habitat of each station and a summary of the species diversity and bird abundance is provided in Appendix 8

Of the 35 species of land birds recorded, one is an exotic species and 25 are endemic to Fiji. The exotic species, commonly known as the red-vented bulbul (*Pycnotus cafer*) on the IUCN Red List as being a species of Least Concern (Birdlife International, 2012a) and is more common on the western edges of the Emalu site. Eight species of birds recorded are listed as focal bird species for conservation in Fiji because of their status (Appendix 9). Stations where bird and bat focal species were recorded are marked on (Map 7).

The long-leggd warbler (Fig. 18), classified as Endangered on the IUCN Red List (Birdlife International, 2012b) was found to be common in the upland and undisturbed riparian vegetation; an example of this habit is shown in Fig. 17. Sightings of the collared lorry, *Phigys solitarius* (Fig. 19), and the golden dove, *Ptilinopus luteovirens* (Fig. 20), were also made during the survey.

Only two species of bats were recorded throughout the survey; *Pteropus samoensis,* the Samoan flying-fox and *P. tonganus* the Pacific flying-fox. *Pteropus samoensis (*Fig. 21) is listed in the IUCN Red List as Near Threatened (Brooke and Wiles, 2008). *P. tonganus (*Fig. 22) was not commonly encountered in the study area in 2012 however it was common in the areas surveyed in 2013 and seemed to be more common in the upper Mavuvu catchment. Here, two of the guides were able to catch seven bats one evening in just one hour, with sticks. The guides also mentioned that the upper Mavuvu area was well known for bats. No bat roost for *P. tonganus* was sighted in the Emalu REDD+ site. The closest roost was located outside the study area, and consisted of over 1000 bats. There could be roosts located in the forested areas on the Namosi side of Emalu however time constraints did not allow for a confirmation of this. No micro-bats were detected using the bat detectors. However this should not imply that there are no micro-bats foraging for food in Emalu as there needs to be more follow up studies to confirm this.

Table 1. Comparison of Emalu to the four largest Important Bird Areas (IBAs) of Viti Levu.

Emalu & IBAs	Area	Native species	Endemic
Emalu	57km²	34	25
Greater Tomaniivi	175km²	34	24
Rairaimatuku	287km²	34	24
Sovi Basin	407km²	34	24
Viti Levu Southern Highlands	670km²	34	24

Table 1 shows that native bird species diversity in Emalu is comparable to Viti Levu's four largest Important Bird Areas (IBAs), and has a slightly higher number of endemic species. In terms of species density it is the highest ever recorded for anywhere in Fiji to date.

4.5 Recommendations

To better understand the ecology and abundance of the avifauna of Emalu there is a need to carry out further monitoring work. To monitor the bird and *Pteropus samoensis* populations, we recommend the use of the point count method with a fixed 50m radius and 8-10 minute counts per station. For best practice, future monitoring surveys should include approximately 70 point count stations spread out over the various vegetation systems present; cloud forest (10 stations), upland rainforest (20 stations), lowland rainforest (20 stations), grassland (10 stations), secondary forest(10 stations), and ensuring within these that there is coverage across the different sub-habitats (riparian, flat, slope, ridge, and ridge-top).

To monitor for the other bat species a further survey of the area is needed to locate the roosts, both in the area and the surrounding forest systems as it is most likely that bats roosting outside the Emalu site will be flying in to forage for food, e.g. from the *P. tonganus* roost at Vurunamasima near Navitilevu Village and the *Notopteris macdonaldi* roost in Saweni (Navosa) and Nabukelevu (Serua). These roosts are both about 10 km from the edge of the Emalu site. When the roosts are located, population counts will be performed for monitoring purposes.

The Emalu REDD+ site should be an area of conservation priority for the Government of Fiji. As yet Fiji has no dedicated bird reserve and it is recommended that, given the species diversity and high endemism levels as well as its ideal location, the Emalu area be designated an established protected bird area.

Conservation should be a priority and logging should not be permitted in this area if you take into account the true value of the site ecosystem function, rich biodiversity, cultural and spiritual importance, all of which are invaluable monetarily.

CHAPTER 5: TERRESTRIAL INSECTS

Hilda Waqa-Sakiti

5.1 Summary

A total of 26 families of the target taxa Coleoptera (beetles) was recorded in the Emalu areas, as well as a high abundance of the family Formicidae (ants). These taxa provide critical ecosystem services in forests systems such as soil processing, decomposition, herbivory, pollination and seed dispersal. Insects of conservation value recorded from Emalu included: *Hypolimnas inopinata* (a rare and endemic butterfly), *Nysirus spinulosus* and *Cotylosoma dipneusticum* (rare and endemic stick insects) and *Raiateana knowlesi* (the rare and endemic cicada). These findings suggest that the Emalu area is pristine and an important site for rare insects on Viti Levu.

5.2 Introduction

This was the first entomological survey to be conducted within the Emalu forest. A baseline survey was carried out with the primary aim of determining the general diversity of insects in the area. The survey targeted a diversity of habitats (slopes, flats, ridges and riparian areas) and vegetation types (grassland, lowland, upland and cloud forest). A variety of collection techniques (light traps, leaf litter sampling, pitfall trapping, 1km transect counts, active and opportunistic surveys) was employed. The general diversity of insects and those species of higher conservation value (i.e. focal species) were sampled as an indicator of the status or health of the forest in Emalu.

5.3 Methodology

Site selection and habitat considerations

A number of key habitat types (shown on Map 3 and Map 4) were surveyed to maximise the chance of encountering individuals of focal species as well as to adequately sample the diversity of insects;

- Lowland forest areas: targeted specifically to find Fiji's rare endemic butterflies *Papilio schmeltzi* and *Hypolimnas inopinata*.
- Upland forest areas: leaf litter sampling, pitfall traps and light traps on slopes mainly targeted the general diversity of insects within this specific habitat. Active searches for the endemic phasmids (stick insects) were also conducted.
- Ridges: leaf litter sampling and light traps on ridges targeting the general diversity of insects found within this specific habitat. A high diversity of

insects (and in particular the focal order Coleoptera) is indicative of intact forest systems.

- Riparian surveys in all vegetation types: These sruveys specifically targeted butterflies (namely Fiji's rare endemic butterfly, *H. inopinata)* and damselflies (namely those of the endemic genus *Nesobasis*). These often fly out to open areas on a fine day in search for sunlight and food, and usually aggregate along the streams in forested areas. Their presence, abundance and richness are excellent indicators of forest and stream systems in good health.

Survey methods and sites

Nocturnal surveys

Nocturnal surveys were conducted using ultra violet (UV) light traps. These were set up and left to run for 12hour periods from 6pm-6am. Insect specimens were sorted to Order and then to Family level. Specimens are currently being curated, catalogued and stored at the South Pacific Regional Herbarium, USP.

Leaf Litter surveys

Leaf litter surveys were conducted targeting different habitat types (i.e. river flats, slopes and ridges) in the lowland and upland vegetation types. $1m^2$ quadrats were laid at 5m intervals along a 50m transect. Leaf litter from each quadrat was sieved through 12mm mesh sieves and transferred into Winkler bags (Fig. 24 and Fig. 25). The Winkler bags were hung out for at least 48 hours to allow drying of the leaf litter. Insect specimens were stored in ethanol for further sorting and identification.

Pitfall Traps

Pitfall traps were set in varous habitat types (i.e. river flats, slopes and ridges) in the lowland and upland forest areas. Pitfall traps were placed at 5m intervals along a 50m transect within the vegetation plots used by the botany team. Specimens were collected and transferred into ethanol after 48 hours.

Active sampling- Lepidoptera (butterflies) and Odonates (damselflies)

Butterflies and damselflies were also actively sampled in open grassland and riparian areas along creeks and streams using handheld nets. Voucher specimens were taken for identification.

1km Transect Count Method

1 km transect counts were conducted for the indicator taxa *Hypolimnas inopinata* (for abundance) and Odonata (damselfly) diversity along streams within the Mavuvu and Waikarakarawa catchments.

Opportunistic Encounters

In addition to the survey methods described above, collections were made during the course of the survey period in response to opportunistic encounters of interesting taxa.

Identification and curation

Identification of specimens was carried out with the aid of available taxonomic references for each of the main groups; butterflies and moths (Waterhouse, 1920, Robinson, 1975, Prasad and Waqa-Sakiti, 2007), dragonflies and damselflies (Donnelly, 1990, Van Gossum *et al*., 2006), ants (Folgarait, 1998), beetles (Lawrence and Britton, 1994) and spiders (McGavin, 2000). The specimens are currently being curated and catalogued at the South Pacific Regional Herbarium.

5.4 Results and discussion

Insect Diversity

The results of the insect survey of each catchment are provided in Appendix 10, Appendix 11 and Appendix 12. A total of 26 Coleopteran (beetle) families were sampled from within the entire study area. The most abundant taxa sampled included the beetle families Curculionidae (weevils) and Scolytidae (bark beetles) and from the Order Hymenoptera, Family Formicidae (ants). Rare beetle families: Cerambycidae (long-horn beetles), Eucnemidae, Cantharidae, Lathridiidae and Passalidae were also encountered in the surveys. The great diversity of the target taxa Coleoptera and the Hymenopteran family Formicidae are a good indication that ecosystem services such as soil processing, decomposition, herbivory, pollination and seed dispersal within the study area of the lowland, upland and cloud forests in Emalu are well intact.

Another interesting find was in the order Odonata (i.e. damselflies). The endemic genus *Nesobasis* were abundantly found along tributaries, creeks, stream and rivers especially for the species *Nesobasis angolicolis* (Fig. 26), *N. erythrops* and *N. heteroneura*. Their diversity along streams is an excellent indicator of good water quality and intact status of neighbouring ecosystems. Moths sampled from light traps (nocturnal surveys) were also significant especially for a few species which are native and known to be restricted to primary forested areas i.e. *Cleora diversa, Agathia pisina, Pyrrhorachis pyrrhogona, Thallasodes figurate* and *Mecodina variata.*

Focal Species

Hypolimnas inopinata (Order Lepidoptera)

Hypolimnas inopinata (Fig. 27 and Fig. 28) is a rare butterfly, endemic to the Fiji Islands. It is a montane species and lives in rainforests. It is often found in or near pristine mountain areas, usually in semi-open areas along streams leading up to the mountains. Its presence and abundance has also proven to be a very good indicator of the pristine nature of the rainforest system. *H. inopinata* was sampled along the Nasa Creek, adjacent tributaries including the Wairovurovu stream (Tovatova catchment), Waikutukutu stream (Waikarakarawa catchment) and the Wainasiga stream and Wainasoba Creek (Mavuvu catchment) suggesting that these catchment areas in Emalu are intact and pristine (i.e. sites P4, P7, P11 & P16, P26, P30, P31, P32, P33, P39 & P40 on Map 8). Extent populations have only been located on Viti Levu in the forests of Navai and Nasoqo (Ra Province) and Waisoi, Wainavadu and Saliadrau (Namosi Province) and Naikorokoro (Rewa Province). This find is a first record for the Navosa Province and the study area has a healthy population of this species.

*Nysirus (*syn. *Cotylosoma) spinulosus* and *Cotylosoma dipneusticum* (Order Phasmida)

Nysirus spinulosus (Fig. 29), a rare endemic stick insect was first described in 1877, and previously recorded from Viti Levu, Fiji and only recently (i.e. 2008 & 2009) from Nakauvadra and Nakorotubu ranges in the Ra Province. *Cotylosoma dipneusticum* is another rare endemic stick insect and has been previously recorded from Taveuni and Viti Levu (Nakorotubu range and Savura Forest Reserve). Both were sampled from intact upland rainforests near Tovatova Creek, a tributary of the Nasa Creek and upland forest within the Waikarakarawa catchment. From previous observations, these two species of stick insects have been known to be closely associated with such pristine forest systems (P13, 14, 15, 20, 21 on Map 8).

Raiateana knowlesi (Order Hemiptera: Family Cicadidae)

Raiateana knowlesi (Fig. 23) is an endemic and rare cicada with a unique life cycle in which adults emerge every eight years (periodic emergence). The last appearance of the adults was in 2009 from within this vicinity. It is locally known as <u>nanai</u> and has been previously recorded from parts of the Serua and Navosa provinces. It is of great cultural significance to the mataqali Emalu, being one of their 'totem' species. The chiefly daughters of the mataqali are usually accorded the title <u>Rokonai</u>**.** Also the year of emergence of the <u>nanai</u> signifies <u>yabaki ni sautu</u>, i.e. a year of plenty from their agricultural produce. The <u>tobu ni nanai</u>**,** a sacred natural pool which provides the final resting place for these endemic cicada is also located within the Nasa catchment. The <u>nanai</u> also bears a national significance; it is the insect that is featured on Fiji's highest legal tender note ($100), an acknowledgment of the magnitude of its importance.

5.5 Discussion and recommendations

The Emalu forest is of great significance as it harbors a good population for one of Fiji's rare and endemic butterflies, *H. inopinata,* owing to the pristine nature of its habitat i.e. one of Fiji's last remaining primary forests. More importantly, it is home to one of Fiji's rare and localised endemic cicada, *Raiateana knowlesi* (<u>nanai</u>) that has both cultural significance (as the totem of the mataqali Emalu) and national significance (as featured on Fiji's $100 note).

This area is also significant for the Odonates (i.e. damselflies) which recorded a good diversity along the Nasa Creek, Wainisiga stream, Wainikutukutu stream and adjacent tributaries. This included the genus *Nesobasis* which is endemic to Fiji and has radiated successfully in Fiji having a total of 36 species, a few of which are currently new to science. With extensive sampling targeting this group within this pristine inland forest of the Navosa Province, it is suspected that there may still be species new to science within the Emalu area. This however warrants further research.

With an overall high diversity of insects, it further suggests that ecosystem services provided by the abundant and diverse Coleoptera (beetles, 26 families) and Formicidae (ants) are well represented with forests systems being quite intact. These groups of insects have proven to be excellent indicators of the forest and water systems and their abundance and richness further suggests that much of the Emalu forest area is pristine.

Recommendations

- Sampling efforts within the study sites were compromised due to adverse (rainy) weather conditions in some areas. A long-term monitoring and seasonality study of the insects in Emalu is recommended.
- The results of this suvey in terms of this area's insect diversity and the presence of focal and iconic species strongly support that Emalu be identified as a Key Biodiversity Area for Fiji.

CHAPTER 6: FRESHWATER FISHES

Lekima Copeland

6.1 Summary

A total of ten species of fish from eight genera and six families were recorded in the Emalu site through sampling and interviews. Three species were documented from the Gobiidae family (*Awaous guamensis, Sicyopus zosterophorum, Sicyopterus lagocephalus*). In addition two species of eels from the family Anguillidae were also collected (*Anguilla marmorata* and *Anguilla megastoma*) as well as the freshwater snake eel from the family Opicthidae (*Lamnostoma kampeni*). Mavuvu mid reach had an exceptionally high abundance and biomass of jungle perch (*Kuhlia rupestris)* compared to other streams in Fiji. Also documented were the introduced exotic species tilapia (*Oreochromis niloticus)* family Cichilidae. Notable absences around the headwaters of Nasa Creek were the gobies *Stiphodon* spp. and the monkey river prawn *Macrobrachium lar*. No endemic species were observed or caught during this survey. Water quality was well within habitable range in terms of dissolved oxygen, conductivity, temperature and turbidity across all sampling stations. The introduced tilapia (*Oreochromis* spp.) are present in mid and lower reach sites and may account for the low abundance and diversity of native stream fishes. Around areas of human habitation there is evidence of the removal of riparian buffer zones as well as unrestricted livestock access to waterways which, coupled with uncontrolled slash and burn activity has exacerbated environmental degradation in these areas. The use of *Derris* roots (a traditional fish poison) is also a common problem seen throughout the survey area. Reforestation of buffer zones and the setting of a riparian buffer width for agricultural or development purposes are reccommended.

6.2 Introduction

The freshwater fishes of the Fiji Islands have only been extensively studied in the last decade, by various researchers that have discovered species new to science and elucidated some of the various factors affecting these insular fish assemblages (Jenkins and Boseto, 2005, Boseto, 2006, Boseto and Jenkins, 2006, Jenkins, 2009, Jenkins and Mailautoka, 2010, Larson, 2010, Jenkins and Jupiter, 2011). On a global scale the freshwater fishes of Fiji have been recently recognised in terms of endemic species per unit land area (Abell *et al*., 2008). The oceanic islands of the Pacific are distinct from continental land masses in that they have developed unique freshwater fish assemblages that have important ecological linkages between marine and freshwater environments (McDowall, 2008a). In Fiji, 166 species (47 families) have been recorded from tidal reaches upwards, with 156 of these (43 families) indigenous to Fiji (Jenkins, 2009). Ten species (4 families) have established invasive or non-indigenous populations in the wild although at least fifteen non-indigenous species have been introduced (Jenkins, 2009). At least eleven species (in 3 families), which constitute 7% of freshwater fish in Fiji, are considered endemic.

This survey constitutes the first documented work carried out on freshwater fishes for Nasa River, but work has been undertaken previously in neighbouring water systems. King (2004) documented several species of fish and invertebrates in the neighboring Solikana stream. The species documented by her were *Kuhlia marginata*, *K. rupestris* (flagtails), *Anguilla* sp. (eels), gobys (Gobiidae family), *Oreochromis niloticus*, *O. mossambicus* (tilapia) and an eel. The eel that King recorded as *Archirophichthys kamperi* is most likely *Lamnostoma kampeni*.

Invertebrate species such as several crustacean species of *Macrobrachium* spp. (Paleomonidae) were also noted by King (2004). In the lower reaches of the Sigatoka River, Fowler (1953) based on two badly damaged specimens described a presumed endemic genus of freshwater fish collected from hoof print puddles *Lairdina hopletupus*, (Eleotridae, Fig. 31). However the voucher specimens have since been redescribed and this species is now known as *Giuris margaritacea*.

The Mavuvu River drains into the Navua River, where previous research by Jenkins & Boseto (2003) within the Upper Navua River Conservation Area documented thirteen species, including two Fiji endemic species i.e. *Redigobius leveri* and *Schismatogobius vitiensis*, and an introduced species *Oreochromis mossambicus.*

6.3 Methodology

Due to the remoteness of the study area, several methods of gathering data were used. The field methods described herein were designed to enable the most comprehensive documentation of fishes present in Emalu. A portable Global Positioning System (Garmin eTrex 20) was used to take the position and altitude of the sampling sites. A map of the study area and several pictures of the locations sampled are provided (Map 9, Fig. 35 - Fig. 38).

Physiochemical parameters

Before fishing commenced water quality parameters were recorded to minimise disturbances to in-situ water quality characteristics. Temperature, pH, conductivity, salinity and dissolved oxygen were measured using a commercial hand held GPS Aquameter and AP-1000 Aquaprobe.

In-stream fish sampling

The beach seine (3m x 2m, 1mm mesh) was set several meters downstream and held by two people. Upstream, one person kicked and dislodge rubbled to enable the collection of bottom dwelling fish. This was done for about an hour, over approximately a 100m stretch of stream. To get a thorough documentation of species presence or absence, snorkeling was also undertaken in streams sampled. This was also aided by visual observations on the side of the stream bank, as some species of the gobies are easily distinguishable due to their bright colors. Opportunistic collections and interviews with villagers were also documented.

Preservation

Voucher specimens were collected, fixed in a 10% formalin solution and transferred to 70% ethanol solution after five days of fixation. Voucher specimens were deposited at the University of the South Pacific marine collection.

6.4 Results and discussion

Species richness and abundance

Overall a total of six species of fish were directly observed or collected during this survey (Appendix 13). There was high species richness near villages compared to the headwaters of Nasa stream. This is characteristic of insular systems of Oceania where this attenuation in species richness with increase in altitude has been documented by Jenkins & Jupiter (2011). Three of the species collected were from the Gobiidae family i.e. *Sicyopus zosterophorum* (Fig. 32), *S. lagocephalus* and *Awaous guamensis.* In addition, two species of eels (family Anguillidae) were also collected, *Anguilla marmorata* and *Anguilla megastoma.* The jungle perch, *Kuhlia rupestris*, was also collected. A further four species were documented from village interviews as being present in the area i.e. *Kulia marginata, Oreochromis niloticus, Eleotris fusca,* and *Lamnostoma kampeni.*

Upper reaches of the Nasa stream

The headwater sections surveyed ranged in altitude from 500-570m. The freshwater fish found at this altitude are characteristic of upper catchments on oceanic islands of the Indo-West Pacific. The native species *Sicyopus zosterophorum* and *S. lagocephalus* found here are known as amphidromous fish in which the adults spawn in freshwater, fertilised eggs hatch within a period of 48 hours. Larvae are transported to the sea for several weeks of growth and then return upstream (as post-larvae or juveniles) to complete their lifecycle (McDowall, 2008b). These two species are hardy fish and are ubiquitous in geographic range. Both are capable of surmounting large barriers such as waterfalls and can survive in degraded catchments.

There were also two native species of catadromous eels found at this altitude (*Anguilla marmorata* and *Anguilla megatsoma*). Catadromous species are those in which adults migrate to sea to breed. The juvenile eels then return upstream for more feeding and growth before returning to sea to complete their lifecycle (McDowall, 2008a). On the last day of the survey a total of 55 eels were caught by villagers (Fig. 30) in Wainirovurovu stream. It is highly likely that traditional fish poison (*Derris* roots) were used to catch these eels.

The use of traditional fish poison and other chemicals occurs in inland fishing communities. A study undertaken in Nawairabe Village (about 10 km west of Emalu) found that 2.2% of households blamed the use of *Derris* roots and other fish-suffocants for the depletion of fish but "*excessive burning (46.7%); and the associated soil erosion in the wet season (17.8%) were by far the most important environmental problems in Nawairabe*" (King, 2004).

Mid to lower reaches of the Emalu area within and outside the boundary

There were no mid and lower reach sites sampled during this survey though some visual observations around Navitilevu settlement found the native goby *S. lagocephalus*. Informal interviews with villagers recorded native species such *Kuhlia marginata, Awaous guamensis, Eleotris fusca, Lamnostoma kampeni* and the introduced tilapia *Oreochromis niloticus*. The presence of these species can only be confirmed using proper survey techniques such as electrofishing around this site.

A total of eleven jungle perch *Kuhlia rupestris* (Fig. 33) were caught around mid Mavuvu. The size of these fishes ranged from 11 to 39cm. This mid-reach site just below the waterfall is traditionally known as sukasuka ni ika droka, a natural barrier to fish migration (Fig. 34). Only those species adapted to climbing are able to surmount such barriers. This area within Emalu is an important area in terms of fish biomass and strict measures must be taken to protect it from over-fishing and unsustainable practices such as the use of *Derris* roots.

Water Quality

Results of the on-site measurements are tabulated in Appendix 14. Temperature at the sites was between 19.7°C and 20.4°C. Dissolved oxygen levels were fairly high, above 8mg/L, making it readily available for fish at the six stations sampled. Conductivity at all sites ranged from 0.047-0.084µS which is well within the suitable habitat range for stream fish. Turbidity was very low at all sites (<10 NTU), and the bottom was visible at all the stations.

6.5 Conclusion and recommendations

The proper management and use of aquatic resources in Emalu entails a holistic approach due to life-history strategies employed by aquatic fauna that traverse different habitats throughout their life. It is true that management must begin at the catchment level; however, it goes hand in hand with the protection of marine and coastal habitats such as reefs, seagrass meadows, mangrove habitats, including lower and mid sections of rivers and streams. This survey did not find any endemic species, for several reasons such as degradation of buffer zones along mid-reach sites, the high number of introduced species such as tilapia which is known to prey on the larval species of native fauna and the possible use of *Derris* roots in the streams surveyed.

The following are suggestions for the proper management and conservation of aquatic fauna in Emalu:

1. The first priority is protection of the catchment areas of the Sigatoka River. The headwaters should be set up as a protected area with a complete ban on slash-and-burn techniques around the catchments.

2. Secondly, the other major issue identified is the importance of restoring buffer zones around mid-reach sites. This will also require the proper education of farmers (landowners) on setting up farms near rivers, and the importance of a buffer width and restricting livestock access across streams.

3. A complete ban should be in place on the use of poison for fish capture. *Derris* roots, weedicides and pesticides should be banned in Emalu.

4. The need for proper waste management care. In the three villages visited, the use of flush toilets is strongly recommended. Villagers have running tap water and flush toilets should be implemented for all households.

5. Pit toilets in the village need to be built away from the stream. The majority of the toilets seen across the villages are built on sandy areas within the vicinity of the stream and are directly leaching into the stream.

CHAPTER 7: FRESHWATER MACROINVERTEBRATES

Bindiya Rashni

7.1 Summary

A total of 76 freshwater macroinvertebrate taxa were identified from the 16,370 specimens collected. Of these 76 taxa, a total of 57 (75%) were endemic to Fiji, most of them insects. A total of fourteen macroinvertebrate taxa were selected as potential bioindicators. These include four species of mayfly larvae (Ephemeroptera: two *Pseudocloeon* spp. and two *Cloeon* spp.); two species of damselfly larvae (Odonata: *Nesobasis* "orangish", *Nesobasis* "dark green"); four species of caddisfly larvae (Trichoptera: *Apsilochorema* "light green", *Hydrobiosis* "pinkish", *Hydrobiosis* "green" and *Chimarra* sp.); one cranefly larvae (Tipulidae: *Tipula* sp.); one snail (*Fluviopupa* spp.); one nematode worm (unknown species) and one moth larvae (Lepidoptera: unknown species). The high number of endemic taxa recorded, together with a large number of species with large populations, is indicative of the intactness of both the stream system and the surrounding forest.

7.2 Introduction

The freshwater macroinvertebrate fauna of Fiji is currently represented by 45 families, namely; 25 families of insects, eight families of molluscs, four families of crustaceans, three families of segmented worms, two families of nematodes, two families of sponges, and one family of flatworms (Haynes, 1988, Haynes, 1999, Haynes, 2001, Jeng *et al*., 2003, Haynes, 2009). Many of these are yet to be fully described to genus and species level and many aquatic insect larvae need to be matched with their described flying adults.

Prior to this study, no surveys had been carried out to identify the composition of macroinvertebrate communities within the waterways of this study site or their tributaries. There is, however, some documentation of previous macroinvertebrate surveys in other waterways of Viti Levu.

Three tributaries of the upper Sigatoka River (which is located about 23km from Emalu) were surveyed for possible effects of the Sigatoka-Ba hydropower dam. Damselfly and mayfly species were noted to be of very sensitive nature to this development (Haynes, 2004).

In Namosi province macroinvertebrate composition from an unlogged catchment drained by Wainikovu Creek (23km from Emalu) was compared to that of Nabukavesi Creek in a logged catchment. After five years, the abundance of invertebrates in both streams was the same except Nabukavesi Creek had lost five species which had been present in sparse populations prior to logging and Wainikovu Creek had more species of an endemic genus of damselfly, *Nesobasis* spp (Haynes, 1999). A survey of Lake Monasavu revealed the presence of damselfly nymphs (*Nesobasis* spp.) prior to dam construction. But eight years after the dam construction, the damselfly nymph species were wiped out (Haynes, 1994).

These studies were conducted in areas outside the Emalu catchment boundary. Therefore the present study represents the first detailed and comprehensive study of freshwater macroinvertebrates and aquatic habitat within the three catchments of Emalu; Tovatova, Mavuvu and Waikarakarawa.

The key objectives of the study were:

To provide a comprehensive list of taxa.

Describe community structure.

Identify taxa that are unique, rare and endangered in Fiji.

Identify taxa that can be used as indicators of environmental changes.

This report also provides information relating to water physiochemistry and invertebrate habitats which will assist with interpretation of freshwater macroinvertebrate results and identify potential areas of monitoring interest related to the identified biological indicative taxa.

7.3 Methodology

Survey Stations

During the first phase of the Emalu survey (July 2012), three main stations were sampled within Tovatova catchment inclusive of the upstream Nasa Creek and its tributary, Wainirovurovu Creek. During the second phase of the survey (March 2013), six main stations were sampled within the Mavuvu and Waikarakarawa catchments, including the headwaters of Mavuvu River (Qalibovitu stream), the Mid Mavuvu River (Wainasoba Stream) and Waikarakarawa Creek. The descriptions of the sampling stations are summarised in Appendix 15 and their locations shown in Map 10.

The area is densely forested with numerous tributaries connected to the main riparian systems; Nasa Creek and Mavuvu River. The mid to upper portion of the Nasa Creek is a medium to high gradient undisturbed stream with well vegetated, highly stable bank and good or moderate canopy cover providing suitable habitat conditions for thriving freshwater community. The mid Mavuvu River tributary (Wainasoba Creek) and upper Mavuvu River tributary (Qalibovitu Creek) are undisturbed waterways with well-vegetated, stable to highly stable banks and good or moderate canopy cover, providing suitable habitat conditions for thriving freshwater communities.

Water physiochemistry

Water physiochemical parameters were measured at each sampling station using a calibrated multi-water quality meter (Aquaread AV 1000). Parameters measured included temperature, dissolved oxygen (DO), conductivity (milisiemens per centimeter (mS/cm), pH, Total Dissolved Solids (TDS), turbidity (Nephelometric Turbidity Units (NTU)) and salinity.

Habitat characteristics and aquatic flora

Habitat characteristics were assessed along 20m reaches per site to assist with interpretation of macroinvertebrate community data. The following habitat data was either measured or visually estimated and recorded on a standard habitat assessment form:

Channel Description:

Wetted width and water depth – channel width (m) was measured using a 30m measuring tape. Water depth (m) at wadeable sites was measured using a calibrated meter ruler or estimated at sites that were too deep (i.e. >*1m*).

Water velocity – velocity was calculated by timing how many seconds a specimen bottle cap took to travel over a set distance of three metres. This procedure was repeated three times and averaged to give a mean velocity for each site.

Habitat type – the relative proportion of each habitat type (e.g. run, riffle, pool and chute) present at each site was visually estimated.

Streambed substrate – streambed substrate composition was assessed at each sampling station. Assessment procedure involved measuring approximately 100 sediment particles following the Wolman scale (Wolman, 1954). Size classes included bedrock, boulder (>256mm), large cobble (128-256mm), small cobble (64-128mm), large gravel (32-64mm), medium-large gravel (16-32mm), small-medium gravel (8-16mm), small gravel (2-8mm) and sand/silt (<2mm). Gravel size classes were combined into a single gravel class (2-64mm) for easier data presentation.

Streambank stability – this involved visual characterisation of streambank stability at each site as (i.e. stable, partially stable or unstable).

Organic matter present – observation of woody debris, leaf litter and detritus at sampling stations. This provides an indication of potential food availability for certain macroinvertebrate functional feeding groups or additional stable habitat.

Riparian character and channel shade – at each sampling station, a general assessment of percentage channel shade and the riparian vegetation characteristics was carried out.

Periphytons (algae) – visual estimation of present streambed periphyton cover (%) and type (i.e. film, mat, filamentous) and colour (i.e. green, light brown, dark brown, reddish) at wadeable sampling sites.

Macrophytes (aquatic plants) – an assessment of macrophyte streambed cover and species present at sampling stations

Macroinvertebrate sampling

Macroinvertebrate samples were collected using both quantitative and qualitative survey methods to allow an assessment of macroinvertebrate density at selected stations and to compile a list of suitable taxa as potential bioindicators for future monitoring. The quantitative and qualitative sampling methods were adapted from Stark *et al.* (2001) and modified to suit the time constraints and objectives of this particular survey. They are described as follows:

Quantitative assessment – This is a quantitative method that provides a measure of macroinvertebrate density is adapted and modified from Protocol C3 (Stark *et al.* 2001). Two replicate Surber samples (area $0.1m^2$, 0.5 mm mesh) were collected from riffle habitats at stony streambed sites. A riffle is a shallow area (water depth ≤0.5m) where water flows swiftly over stones, creating surface turbulence. Surber samples were collected from the Nasa Creek and its tributary, Wainirovurovu stream in Tovatova catchment and Waikarakarawa Creek in Waikarakarawa catchment. Samples were collected by placing the Surber sampler over a defined area of streambed in riffle habitat and disturbing the habitat by washing the particles with the water flowing through the net to collect dislodged macroinvertebrates. A sample was also quantitatively collected using a kick-net sampler in Wainasoba Creek (WSLQT), collecting from same surface area as that of Surber sampler.

Qualitative assessment – a single sample was collected from each sampling station either via kick-net or visually inspecting slow flowing edge habitats for taxa that prefer these habitats (e.g. snails and damselflies). Typical habitats sampled included runs, riffles, chutes, pool edges, trifles, woody debris, leaf litter, stream edges, and tree roots along banks, streambank vegetation and sand/silt substrates.

Macroinvertebrate samples collected from the Surber sampler, kick-net or hand collection were placed into 250ml specimen jars with 70% ethanol for sorting and identification by the author. New taxa were verified by Dr. Haynes. The guides referenced in the identification process included; Haynes (2009), Haynes (in prep.), Haase *et al.* (2006), Williams (1980) Winterbourn *et al.* (2006), and Nandlal (unpub). Identified macroinvertebrates were placed for preservation in small vials containing 70% ethanol for long term storage.

Data analysis

Community composition and structure: the combined Surber and opportunistic data set was used to calculate the relative abundance of the main taxonomic groups.

Macroinvertebrate density: an assessment was made of macroinvertebrate density in riffle habitats at selected stony streambed sites based on quantitative Surber sample data by multiplying the mean Surber sample abundance data (per $0.1m^2$) by a factor of ten to give abundance/m^2.

Status and distribution of taxa: taxa were classified as either endemic to Fiji, native to other regions (e.g. Pacific, South Pacific, Indo-Pacific, Fiji-Australia and South East Asia), introduced tropical species or other (i.e. marine, worldwide).

Focal species/ taxa of interest: macroinvertebrate taxa of potential interest for being key indicators of environmental change in the catchment were selected.

7.4 Results

Water physiochemistry

The water physicochemistry parametres measured at the different stations are summarised in Appendix 16. Waterways sampled ranged from almost neutral to slightly acidic. The freshwater macroinvertebrate communities described in this study are unlikely to be significantly affected by pH values within this range.

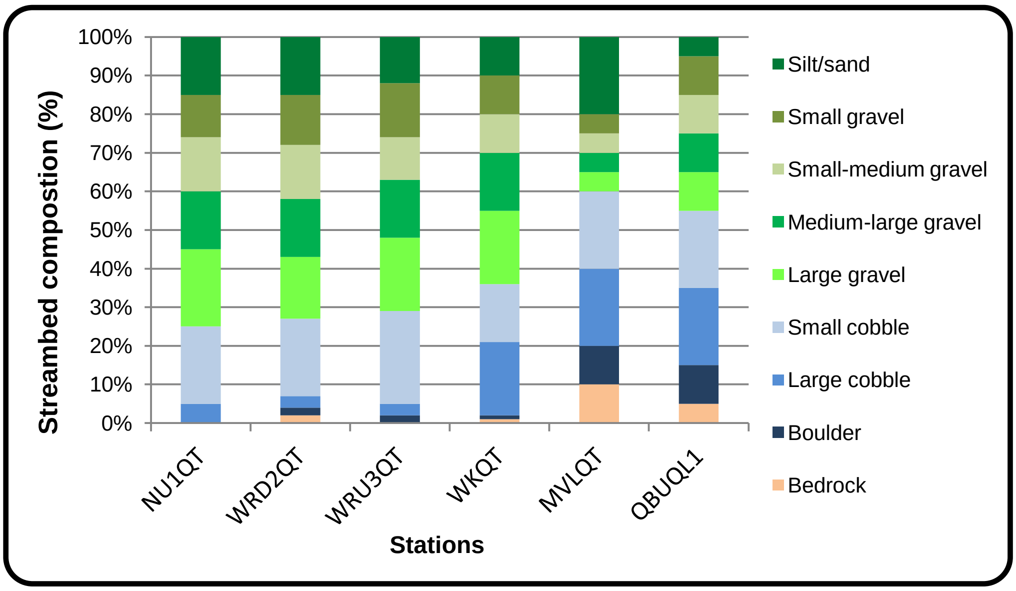
Conductivity is a measure of the total ions in water and ranged between 0.084 mS/cm in the mid Mavuvu (MLVQT) and 0.047 mS/cm in the upper Nasa (NU1QT).

Turbidity (NTU) is a measurement of particles in the water column and provides an indication of water clarity. Turbidity values ranged between 0 NTU in the Wainirovurovu Creek sites (WRD2QT & WRU3QT) and Mavuvu catchment streams (WKQT, WSLQT & QB1QL) to 5.8 NTU in the Nasa Creek (NU1QT). Turbidity in Nasa Creek was higher due to heavy rainfall the night prior to surveying. Though turbidity above 5 NTU signifies poor water quality; this was a temporary impact and water clarity had returned to normal by late afternoon with NTU of less than 5. In Wainirovurovu Creek (WRD2QT & WRU3QT), turbidity values were 0 NTU, which signifies excellent water quality for macroinvertebrate survival as well as the absence of sediment-raising activities in the catchment.

Dissolved oxygen concentrations ranged between 8.27g/m^3 in Waikarakarawa Stream (WKQT) and 8.99 g/m^3 in Nasa Stream (NU1QT) All dissolved oxygen concentrations were above the level considered sufficient for macroinvertebrate survival (i.e. >5 /m^3). This was due to unaltered waterway hydrology allowing suitable water flow coupled with sufficient canopy cover to reduce excess temperature and highly stable bank reducing any sedimentation impacts. Salinity measurements at the survey stations demonstrated levels that are expected in the headwaters of any tropical inland stream.

Habitat Characteristics

The aquatic habitat and riparian characteristics of the stations surveyed are summarised and presented in Appendix 17. The streambed of waterways surveyed was dominated by cobble/gravel and sand and provided a diverse stable habitat for the macroinvertebrate community (Graph 1).



Graph 1. Streambed composition at sampling stations.

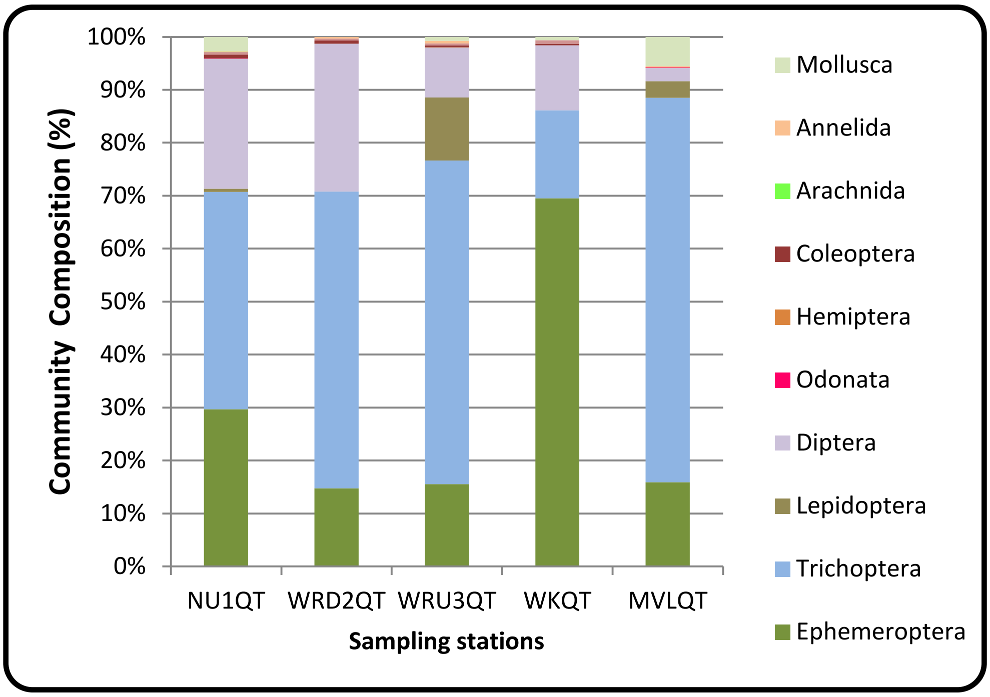
Periphyton

Thin light/dark brown films (<0.5mm) (i.e., 40-80% cover) was the most common form of periphyton recorded at sampling stations with stony streambeds. This periphyton type is a source of food directly or indirectly for macroinvertebrates and fishes in streams.

Macroinvertebrate density

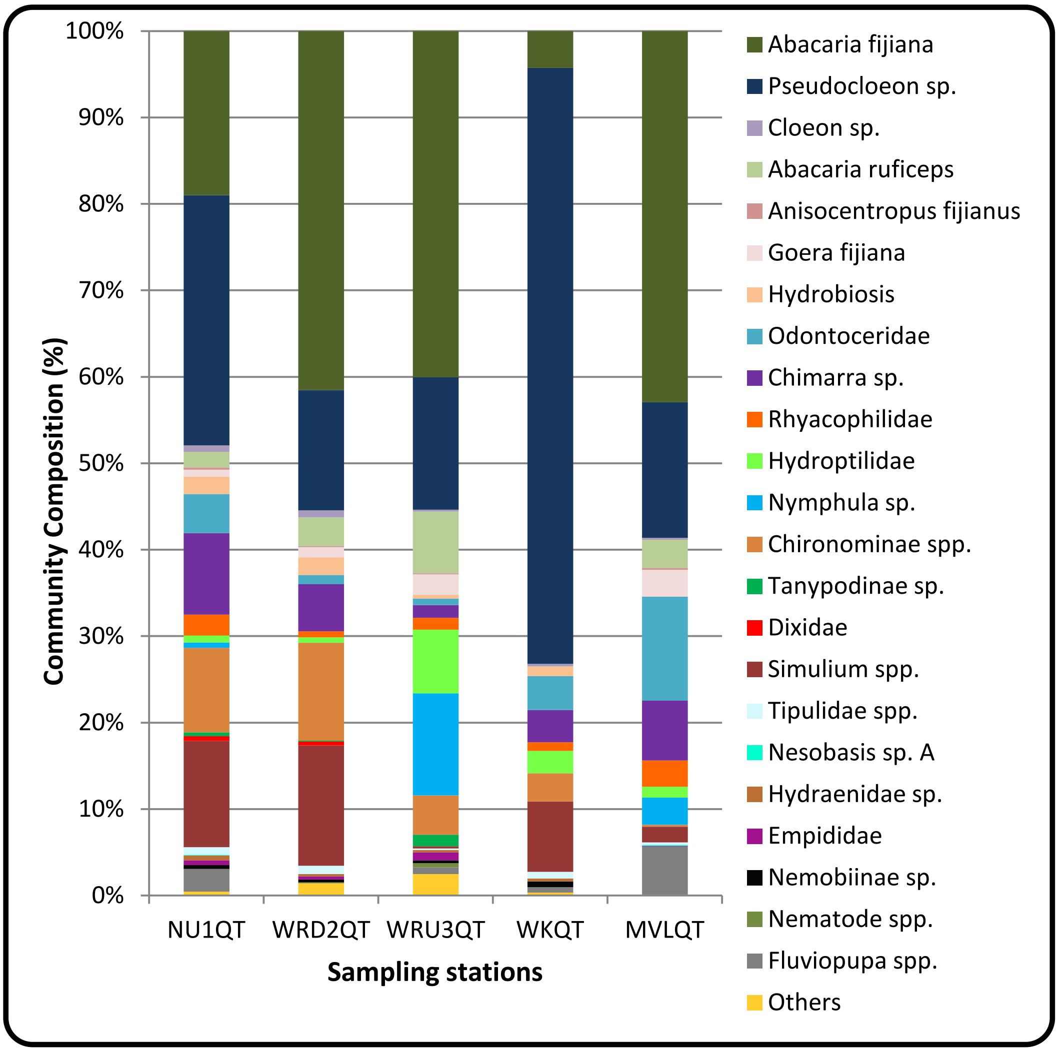
A summary of the freshwater macroinvertebrates collected and their abundance is presented in Appendix 18 (Surber sampling) and Appendix 19 (opportunistic collections). The abundance is given as numbers of individuals, and is also grouped into abundance categories as follows: very abundant (>100), abundant (20-99), common (5-19), few (2-4) and very few (1). The overall (all taxa) abundance ranged from 2049 individuals/m^2 at Waikarakarawa Creek downstream (WKQT) to 3686 individuals/m^2 in Nasa Creek upstream (NU1QT).

Insect larvae/nymphs were the most dominant taxa at all three sites (Graph 2). This was strongly represented by caddisfly, mayfly and dipteran larvae. This result is typical of the headwaters of tropical inland streams with intact or pristine catchments. Insect larvae are well adapted to fast flowing waters of stream/river headwaters, compared to crustaceans and molluscs which are found in higher numbers in lower reaches of streams/rivers with swifter flows. The small *Fluviopupa* (<4 mm) snails were also recorded as abundant at two sites and very abundant at one site. These particular gastropods are usually catchment endemic and found in higher densities in headwaters with narrow channels, swift flows and very clean water. They have been found to be only present in streams undisturbed from cattle/horse grazing. Hence they were abundant in the intact waterways surveyed. The moth larvae (*Nymphula* spp.) also ranged from abundant to very abundant at two stations. They are known to be found in higher densities in streams with adequate algal film covering stream substrata and open-partial canopy shading and good water quality; hence there abundance in these streams.



Graph 2. Community composition by major taxonomic group.

The macroinvertebrate communities documented were typical of pristine/intact inland tropical stream headwaters. The waterways sampled provided suitable habitats for diverse taxa composition. The sites surveyed had coarse stony streambed substrates and a high proportion of turbulent riffle/chute habitats, which resulted in caddisflies (Trichoptera) being the most dominant group at the majority of stations, followed by mayflies (Ephemeroptera) and flies (Diptera). These groups combined to give 95% (NU1QT), 98% (WRD2QT), 85% (WRU3QT) and 98% (WKQT) of the total species recorded (Graph 2). An exception to this pattern is at site MVLQT whereby the Mollusca group was more abundant than the Diptera, and togther with the Trichoptera and Ephemeroptera comprised 80% of species composition.



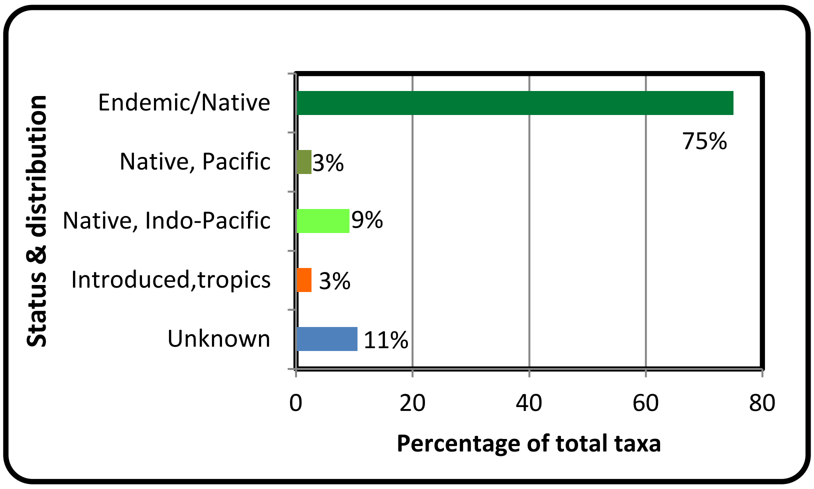
Graph 3. Community composition by taxa.

The most abundant caddisfly taxon recorded was the net-spinning filter-feeder *Abacaria fijiana*. This species were most abundant in riffle habitats at Mid Mavuvu tributary, Wainasoba Creek (WSLQT) and Wainirovurovu downstream (WRD3QT) where they represented between 40 and 43% of total abundance respectively. Other caddisfly larvae such as *A. ruficeps*, Odontoceridae, Hydroptilidae and *Chimarra* sp. were also common or abundant but represented less than 9% of total abundance. *Chimarra* sp. was recorded in highest proportions in the Nasa Creek (NU1QT) and Wainasoba Creek, in the downstream Mavuvu (WSLQT).

Mayflies were also a dominant taxonomic group recorded at survey sites and represented 69% of the community in the Waikarakawa Creek and 30% in the Nasa Creek (NU1QT). The most abundant mayfly taxon was *Pseudocloeon* sp. This is because *Pseudocloeon* sp. has a dorso-ventrally flattened body that allows it to graze on thin algal films covering the surfaces of large boulder/cobble substrates in turbulent riffle/chute habitats. In contrast, *Cloeon* spp. mayflies which are mostly associated with gentle flowing habitats and are more common along stream margins and runs were recorded in much lower proportions across the sites. Therefore many *Cloeon* spp. were part of the opportunistic collection.

Conservation status and distribution of taxa

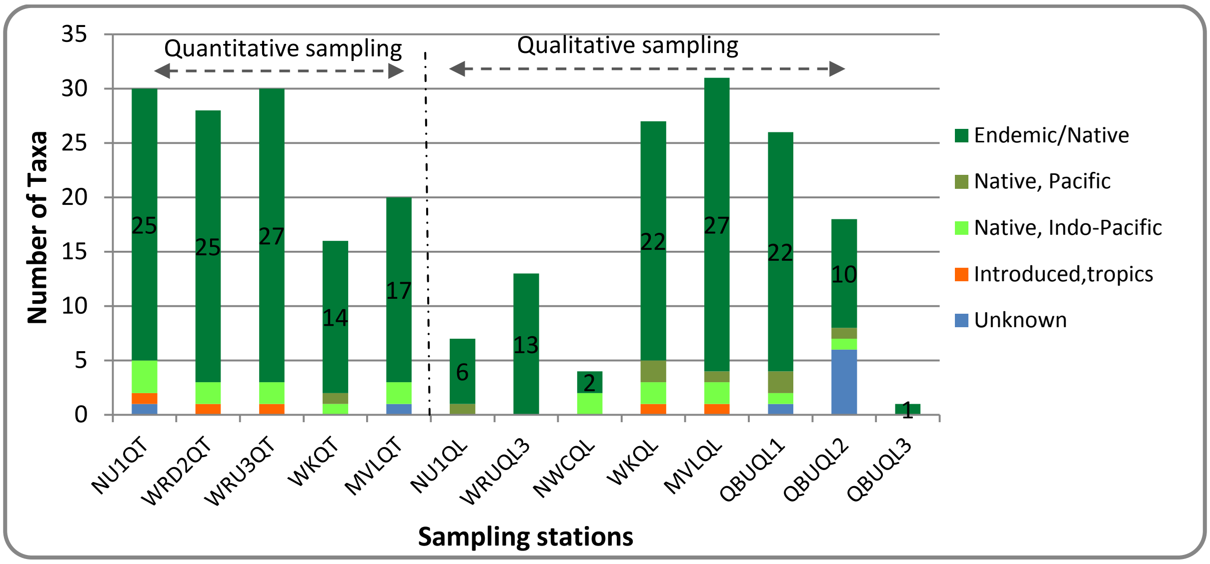
A total of 57 of the macroinvertebrate taxa recorded as part of the survey were endemic to Fiji and represented 75% of the total number of taxa recorded (Graph 4).



Graph 4. Status and distribution of taxa across all sites.

Apart from a few unique specimens (~15), many of the endemic taxa recorded are common throughout the headwaters of Fiji Island streams. The remaining 15% of taxa were either native to Fiji, the Pacific or the Indo-Pacific region, or introduced tropical species or unknown species.

Graph 5 shows the total number of taxa recorded at each sampling station and their status/distribution shown as a proportion of total taxa richness within each community. The number of endemic/native taxa recorded at sampling stations as part of quantitative survey ranged between 14 endemic/native taxa at Waikarakarawa stream (WKQT) to 27 at Wainirovurovu upstream (WRU3QT). This amounted to 88% and 90% of the total taxa per sites respectively; highlighting that endemic species are the dominant taxa at all sites. The majority of endemic/native taxa recorded were insects; inclusive of both qualitative and quantitative collection (53 taxa in total). Other endemic taxa recorded were the small (<4mm) snail *Fluviopupa* spp. and nereid and nematode worms. A single juvenile specimen of the introduced tropical snail *Melanoides tuberculata* was also found in riffle habitat at Nasa stream (NU1QT) of Tovatova catchment, although no adults were observed around the edges of streams during the qualitative survey. This could possibly be an inadvertent introduction into the stream via footwear worn by villagers/surveyors. This tropical snail was however present in adult and juvenile sizes along the sides of stream channel at Waikarakarawa stream and Wainasoba Creek. The common introduced mosquitoe larvae (Culicidae) was found at Wainirovurovu stream. These species are usually limited to stagnant waters (pools) in streams but due to the previous night's rainfall they might have been washed into the riffles.



Graph 5. Status and distribution of taxa across individual sites.

A lower number of endemic taxa were observed as part of the quantitative survey at Waikarakarawa Creek (WKQT) (14 taxa) and Wainasoba Creek (WSLQT) (17 taxa). The qualitative survey at both stations (WKQL & WSLQL) showed a high increase in endemic/native taxa. This is probably due to species becoming habitat specific with changing physical parameters such as an increase in flow with increasing elevation and steepness coupled with a decrease in channel width. Damselflies, shrimps and some caddisfly species were more abundant on the sides of the streams which supported slow flows, compared to riffles with swift flows. The sides of the streams also had mass fibrous roots extended into the channel that provided habitats for damselflies, shrimps, whirligig beetles and some caddisfly species.

Focal species / taxa of interest

Certain macroinvertebrate taxa that were recorded during the surveys and that may be of potential ecological interest are shown in Fig. 45 - Fig. 61. These highly sensitive species are typical of pristine streams draining intact watersheds. Furthermore, some of these taxa, such as *Fluviopupa* spp., *Nesobasis* “orangish”, the unknown moth larvae and the nematode worm, have a very high chance of being catchment endemic or localised endemic.

7.5 Discussion

Dense forest cover, intact riparian zone and highly stable banks along these rivers and their tributaries provide suitable conditions for a thriving freshwater macroinvertebrate community. Dense forests ensure enough volume and clear water entering the creeks and tributaries; maintaining a natural state of waterway hydrology to provide different habitats such as runs, riffles, pools and chutes coupled with appropriate streambed substrates and good water quality. Intact riparian vegetation acted as an excellent buffer zone for any sediment intrusion from land, thereby maintaining water quality. Adequate canopy cover along waterway edges provide for shade to control water temperature, leaf litter for nutrient cycle, sufficient light for algal cover (food for macroinvertebrates) on stream substrata, while native tree roots, shrubs, ferns and big boulders ensured bank stability. At Waikarakarawa Creek a few cases of natural landslides were observed, while Qalibovitu upstream had more than six cases of landslides. These landslides caused large trees to fall in the waterways which altered the waterway hydrology but also provided additional habitats via branches, leaf litter and twigs. The landslides also caused abrasion of stream banks resulting in the addition of sediment to the streambed. However, this impact is a temporary one.

The freshwater macroinvertebrate community of Emalu (in total 76 taxa) showed that the endemic taxa were the most dominant with insects making up the majority of the taxa. This is typical of pristine inland tropical riverine system headwaters. In comparison with other studies in pristine headwater catchments (by the author), 27 taxa were identified from Wainavadu Creek and the headwaters of the Waidina River in Namosi and Naitasiri Provinces, and 32 taxa were identified from the Wainibuka River headwaters in the Nakauvadra Range. Waterways in the Emalu area therefore supports much higher taxa richness (almost threefold more) than other creek/river headwaters that have been surveyed in Viti Levu.

A total of fourteen macroinvertebrate taxa collected as part of the survey may be of potential ecological interest. These include four species of mayfly nymphs (Ephemeroptera: two *Pseudocloeon* spp. and two *Cloeon* spp.), two species of damselfly nymphs (Odonata: *Nesobasis* "orangish" & *Nesobasis* "dark green"), four species of caddisfly larvae (Trichoptera: *Apsilochorema* "light green" , *Hydrobiosis* "pinkish" sp., *Hydrobiosis* sp. "green" and *Chimarra* sp.*)*, one Cranefly larvae (Tipulidae: *Tipula* sp.), one snail (*Fluviopupa* spp. (< 4mm), one nematode worm (Unknown 1 sp.) and one moth larvae (Lepidoptera: Unknown 2 sp.). These highly sensitive species are very good bioindicators. They are also typical of pristine streams draining intact watersheds. In addition special taxa such as rissooidean snails (*Fluviopupa* spp.), *Nesobasis* "orangish", the unknown moth larvae and the nematode worm are very likely to be catchment endemic or area endemic species. *Fluviopupa* snails, ten species of which are already known to be endemic to Fiji, have restricted distribution and are usually catchment endemic, inhabiting springs and small creeks or riffles (Haase *et al*., 2006).

The slender red headed (*Pseudocloeon* sp. A) and the dark brown (*Cloeon* sp. *A*) mayfly nymphs also have a high chance of being catchment endemic species. The nematode worm has only been found in the Wainrovurovu tributary and not in Nasa Creek, possibly due to the narrower stream channel and the difference in water depth. Since the catchment is unimpacted by cattle grazing, these worms have naturally been part of the freshwater macroinvertebrate community or may have been introduced by birds etc. The orangish damselfly nymph and the moth larvae (Black with orangish spots and prolegs) have been encountered for the first time. These two taxa have not been observed in any streams surveyed prior to this survey.

However, these are only the larval stage and have not been matched with the adult stage as yet. Therefore it cannot be confirmed if they are new species or not. In addition, the amphipod and the caridean shrimps (*Caridina* sp. B-F) found in Qalibovitu Creek QB1QL and QB2QL have a very great chance of being new species as they do not resemble the crustaceans described so far from Fiji or Asia.

CHAPTER 8: INVASIVE SPECIES

Isaac Rounds and Sarah Pene

8.1 Summary

Trapping and opportunistic surveys were used to record the presence and abundance of invasive plants and animals in the Nasa, Mavuvu and Waikarakarawa catchments of the mataqali Emalu forests, Viti Levu. The checklist of 26 invasive plants and eleven invasive animals recorded as present in the area includes thirteen species which are listed in the 100 most invasive species in the world, namely;

Plants: *Spathodea campanulata, Mikania micrantha, Leucaena leucocephala, Lantana camara, Imperata cylindrica, Arundo donax* and *Clidemia hirta*.
Animals: *Rattus rattus, Sus scrofa, Felis cattus, Pycnonotus cafer, Bufo marinus* and *Herpestes auropunctatus*.

In general the occurrence and abundance of invasive species in the Emalu boundary was associated with proximity to human habitation and to disturbed areas such as tracks, temporary campsites and cultivated areas. The invasive plant species were generally low in abundance, with the exception of *Piper aduncum* which was locally common, and *Clidemia hirta* and *Mikania micrantha* which were both widespread.

The faunal component of the invasive species was comprised primarily of the most common (and most serious) global invasives such as rats, mongooses, mynah birds and cane toads, as well as feral animals of domesticated species, such as cats, dogs and pigs. Some invasive animal species such as the Polynesian rat (*Rattus exulans*), the Norwegian rat (*Rattus norvegicus*) and the house mouse (*Mus musculus*) were not observed directly in the field but they were reported by the guides to be present in and around the villages in the area.

8.2 Introduction

Because of their isolation and relatively recent human occupation, Pacific islands are especially vulnerable to invasive species, to such an extent that invasive species are the primary cause of the extinction of island native species (Tye, 2009). Previous work from numerous authors has focussed on documenting their presence and to some extent their distribution and abundance within Fiji.

Pernetta and Watling (1978) compiled a list of native and introduced vertebrates which included reptiles. Since then monitoring of some of the major invasives have revealed new additions for example, a second mongoose species (Morley *et al*., 2007). Some species (rats, mongooses and goats) have also been the target of concerted eradication efforts on some smaller islands to protect native biodiversity.

In terms of invasive plants, 52 species have been identified as being present in Fiji (Meyer, 2000). These have been classified under three groups according to their degree of invasiveness, namely: thirteen dominant invaders, seventeen medium invaders and 22 potential invaders. For some of these individual species, such as *Mikania micrantha* (Macanawai *et al*. 2010) and *Spathodea campanulata* (Auld and Nagatalevu-Seniloli, 2003), research has focussed on their ecology and control.

Invasive species surveys have been a component of wider biodiversity assessments done in eastern Viti Levu (Morrison and Nawadra, 2009, Morrison *et al*., 2010, Morrison, 2003). This is however, the first survey of invasive species in the Emalu area.

8.3 Methodology

Rodent Survey

Traps were laid for rodents (rats and mice) on three consecutive nights during the July 2012 survey in the Nasa River catchment. Traps were baited with roasted coconuts and positioned in protected spots under hanging boulders, large tree bases and below fallen logs. The traps were laid in pairs along a transect, according to the established methodology of Cunningham and Moors (2006). The location of the three trapping transects is shown in Map 11.

A total of 88 traps were set over the 3-day period, each for one night.The nose-to-tail length and the weight of captured animals were measured using vernier calipers and a 1kg spring balance. The species and sex of each captured animal was recorded, along with an estimate of its age (based on body size).

Other Mammals

Opportunistic surveys were conducted to identify the presence of other invasive mammal species such mongooses, feral cats, cows, dogs, horses, cows and goats. This included simple visual surveys for individuals, or for traces such as footprints, scat, and feeding evidence. Information was also obtained from other teams conducting surveys in other parts of the forest study site. One of the guides used dogs to hunt feral pigs, and these captures were also recorded.

Invasive Plants

A checklist of all invasive plants sighted was compiled during the survey with notes taken as to their relative abundance and habitat preferences.

8.4 Results

A full checklist of all invasive and potentially invasive animals documented during the survey is provided in Appendix 20.

Rodent Trapping

A summary of the trapping results is provided in Appendix 21. The trapping transects only successfully captured one rat; a juvenile male black rat (*Rattus rattus*) that weighed 135g. This rat was captured on the first trap night in Transect 1.

Another individual of the same species (*Rattus rattus*) was caught opportunistically by one of the guides without a trap during the survey of the Waikarakarawa River catchment (Fig. 62). The other two species of rats, *Rattus exulans*, *Rattus norvegicus* and the mouse *Mus musculus* were not caught or observed during this trip, but it is highly likely that they are present in the area.

Other Animals

Pigs

Six pigs were caught with the use of hunting dogs, including one pregnant female. Descriptions of the pigs caught are given in Appendix 22. Numerous wild pig wallows were observed in the forest including resting areas such as large tree hollows. Plantations near the village of Navitilevu showed some evidence of pig damage, including the uprooting of root crops such as cassava, taro and giant taro.

Cats

A juvenile male feral cat (*Felis cattus*) was caught at the Tovatova base camp. The cat managed to escape but was seen around the camp several times looking for food. Cat scat was also found along one of the tracks. No cats or evidence of cats were found around the Waikarakarawa Creek base camp.

Horses

Due to the remoteness of the area and villagers depend greatly on their horses (*Equus caballus*) for transportation to their plantations or into the forest. Horses were used for transportation of equipment and supplies to the campsites in the Mavuvu and Waikarakarawa Creek catchments during this study (Fig. 63). There was no evidence of the presence of feral horses in the Emalu area.

Mongooses

Although no mongooses were observed within Emalu forest, according to the guides they are present in and around their villages. Since no individuals were sighted it is not known if both species of mongoose (*Herpestes auropunctatus, Herpestes fuscus*) are present in the area, or just one.

Cane toads

Cane toads (*Bufo marinus*) were present in the area, and several were caught and photographed (Fig. 64). They tended to be larger in size than those in urban areas.

Invasive Plants

A total of 26 invasive plant species were observed to be present within the area. Seven of these are currently listed in the top 100 of the World's Worst Invasive Alien Species (Lowe *et al*., 2000). The complete list of all invasive and potentially invasive plant species found in the Emalu forest is in Appendix 23.

The majority of species and the highest abundances were recorded in proximity to human habitation and to roads and agricultural land, with a much reduced number penetrating into the forest. Stream flats and embankments often had multiple invasive species in close proximity to each other (Fig. 65).

African tulip (*Spathodea campanulata*)

Spathodea campanulata, although one of the most problematic invasive plant species in Fiji, was recorded as only two individual trees within the forested area of the Nasa catchment. One other tree was found near the basecamp in the Waikarakarawa catchment. In and around villages and roadsides however this species was more common.

False kava (*Piper aduncum*)

Large monotypic stands of *Piper aduncum* were observed outside the Emalu boundary especially around Navitilevu Village, but within the Emalu site it is generally restricted to creek banks and disturbed open areas.

Mikania micrantha and *Clidemia hirta*

Although generally occurring at low densities within the forest, these two species are the most pervasive. Both were observed in higher altitudes, even in closed forest, above 700m and *Clidemia hirta* was also recorded in the cloud forest of Mt Vonolevu. Although both species are capable of growing in the low light conditions beneath canopy, they are found in much higher density in open and disturbed areas especially around tracks and stream banks.

Ornamentals

Several ornamentals plants introduced deliberately, probably as aboriginal introductions, were found in the area. These included species such as *Brugmansia suaveolens*, *Musa* x *paradisiaca*, *Saccharum edule*, *Citrus grandis, Bambusa vulgaris, Artocarpus altilis, Citrus limon, Derris malaccensis* and *Bischofia javanica.* Large terraces were observed within the Nasa and Waikarakarawa river catchments indicating that at one time the area was intensively farmed.

8.5 Discussion

In general the occurrence and abundance of invasive species in the Emalu forest was associated with proximity to human habitation and to disturbed areas such as tracks and past or present campsites, fallow land, old village sites, burnt out forest and cultivated areas.

A total of 26 invasive plants species were recorded during the trip including some ornamental plant species that have the potential to become invasive. The majority of the invasive plant species were found along stream banks, abandoned plantations and old village sites. Continuous clearing of forest for plantation will certainly facilitate the incursion of invasive plants into the forest. Disturbance and both human and animal traffic along tracks will also contribute to the spread of invasive plants into the interior of the forest.

Compared to invasive plants, invasive animals tend to have a more negative effect on the native fauna. Even though there is a high possibility that all rat species are present in the Nasa catchment of Emalu forest, the low trapping rate indicated either a low density of rodents or the need to improve trapping methods. It is possible that a grid system (Weihong *et al*., 1999) would have had a higher trapping success than the transect system. Trapping data suggest the rat abundances are not very significant but the presence of the black rat (*Rattus rattus*) is worrisome as they are a very agile and frequent climber and therefore can easily access nesting birds.

The presence of feral cats could have also impacted the number of rats caught. Some farms are located at a significant distance from villages and farmers prefer to build temporary shelter where they camp and tend to their farms during the week and return to the village during the weekend. Domestic animals such as cats and dogs can aggregate around such makeshift camps and in this way become feral. Feral cats in particular are a major threat to native birdlife.

Other invasive mammals observed during the trip included one juvenile feral cat and six wild pigs caught by guide Aporosa Maya. Wild pig wallows are common throughout the Emalu forest and according to the guides the wild pigs are a significant cause of crop damage. Pigs can also cause damage to native biodiversity, in particular through destroying seedlings, and contributing to soil erosion. Although mongooses were not directly observed within the Emalu Forest according to guides they can be seen around the villages, and it is likely there is incursion into the forest where, like cats they pose a significant threat to native birdlife.

8.6 Recommendations

In terms of the potential for further study of invasive species, the following have been identified as areas for further action:

1. Long-term monitoring of *Spathodea campanulata*. Emalu is an ideal site for long-term monitoring as this species is considered highly invasive, but currently has very low abundance in the area. Assessing its spread in relation to disturbances or other ecological factors over time would elucidate further information as to its invasiveness potential in Fiji.
2. A dedicated mongoose-trapping study over a longer time period is needed to definitively establish if one or both of the two mongoose species in Fiji are present in the Emalus area.

Some general control measures which would help lessen the damage done by invasive species, and on which there needs to be awareness-raising in the villages are:

3. Control of feral pig populations through de-sexing of alpha male pigs, and a bounty system for pig hunters.
4. Limitation of the establishment of new farms to reduce encroachment on grassland and secondary forest.

CHAPTER 9: ARCHAEOLOGICAL SURVEY

Elia Nakoro and Sakiusa Kataiwai

9.1 Summary

The land belonging to the mataqali Emalu is rich in historical and cultural material remains that have not been documented until this survey. The historical remains are scattered all throughout the mataqali land, a widespread distribution of elaborate hilltop and lowland settlement and fortifications some of which are associated with sophisticated irrigation systems for terrace agriculture.

The general physical setup of settlements depicts various forms of insecurity in the past, a time of great rivalry and competition. Supporting evidence for this can be found in some of the structures of the hill fortifications that were encountered. Constructing on high elevation is a survival strategy whereby communities used their natural environment and rugged terrain to provide security.

Further evidence to support the notion that the area was densely populated was given by the series of large intricate irrigation systems discovered during this survey. The discovery of these elaborate channels suggests larger populations to implement and maintain this agricultural system. The study of the cultural footprints within the Emalu study area is vital in understanding why the people of Emalu chose to live in such remoteness and rugged terrain, as well as their socio-cultural relations and their responses to altering natural and climatic conditions.

Generally, the archaeological finds during this survey have considerable cultural value to the local community as well as at the national level. The significance of these sites can be determined and derived by deconstructing the value of the individual sites into the following components; aesthetic, symbolic, social, historic, authenticity and spiritual values.

9.2 Introduction

A collaborative archaeological survey was undertaken to outline the cultural connection the land has to the people of the mataqali Emalu and surrounding communities with an emphasis on identifying and describing cultural sites of significance for which there is tangible evidence.

The mataqali Emalu, from the village of Draubuta, possesses a rich historical background with ancestral ties and links connected to the Emalu forest in which their generational history and cultural livelihood have been strongly maintained. The Emalu forest plays a primary role in the cultural identity and history of the mataqali, as their forefathers inhabited the area utilizing its resources and settling extensively throughout the land as highlighted in this extract by A. Brewster, the Commissioner of Colo North and East provinces in the late 1800s:

At the time when the ancestral gods were sent forth, Qicatabua went to Qamo, which is near to Serua. Having arrived there, he disliked being on the sea coast, and made up his mind to proceed into the hills in the interior, and so departing thence he went upwards to Vautabu and came to the Wailevu, which he followed down to Navua and then he arrived at Busa Levu. (Note: The great plateau of moorland and swamp in which rises the Wainisavulevu or River of the great falls, a feeder of the Wainimala head of the Rewa. North of the Busa Levu is the valley of the Sigatoka River and south west of the Navua River. This plateau is very nearly in the centre of Viti Levu. A.B.B.) He followed the plateau up until he came to a hill, which he called ***Emalu*** *and thought that he would build his village there. He did build houses and made* ***clearings for gardens*** *but he took a dislike to it, and arising he went on his way. He followed the* ***Mavuvu River*** *(a tributary of the Navua) until he came to Veinuqa, afterwards arriving at a place called Nasaqaruku. Some of his men who were with him said they would like to remain there and Qicatabua gave them permission to do so, and they built some houses there at Nasaqaruku. Now the name of the clan who remained at that place is Nataritale. Then he went upstream to Toluga, and then some more of his followers said they would stop there. Then he went on to another place called Nasakikisaqora. There stayed his priest, Siliece. Then he went on to Sirowala, and there stopped another of his followers whose name was Vadra. Then he went along the ridge at Naonou and descending followed another ridge, Naraiyawa, then he got down to the river (the Sigatoka River) and got to a place called Nakavu, and there stayed another of his young men by the name Quna. Then he came to another stream, the Wainimosi, which he followed up to a marsh called Nabudoi. Then he ascended a ridge and he said he would rest there, and called the place* ***Emalu…***
(Brewster, 1921)

9.3 Methodology

With the assistance of village guides through collaboration of oral history and correspondence, areas of interest were identified and located in the study area. Location data of each site was captured utilising a GPS unit (Garmin GPSmap 76CSx). Site notation was carried out and photographic documentation of sites was made with a camera (Practica Luxmedia 14-Z4).

9.4 Results

During the field survey, a total of 77 sites were documented. Their locations are shown in Map 12 and Map 13 and a brief description of each site is given in Appendix 24. Photographs of some of the sites are shown in Fig. 68 - Fig. 97.

9.4.1 Sites of interest

Seven of the most interesting sites are described in detail below.

M28-0008

Extending along a flatland situated in lowland forest, the site displayed identified features approximately within a 20m length zone from the first identified feature to the furthest. Altogether, three evident house mound features were identified: the first of which exuded significance in structure as the mound was more elevated than usual, at a height of about 3m, containing a stone alignment that was demonstrated along a portion of the mound surface. According to locals, this significant mound may be the remains of a temple mound or burekalou indicated by the elevation in the structure. The remaining identified features were two house mounds which were sufficiently preserved, displaying a vague structure that demonstrated an adequate appearance of its original formation.

M28-0016

This is a significant site of sentimental value to the mataqali Emalu as it represents an aspect linked directly to the ancestral relations, background, oral accounts and values that define and verify the mataqali and its cultural affiliations. The site is demarcated by a pool, in which flows the Nasa Creek. According to the local oral narrative, the pool is the final resting place for the endemic cicada, locally known as nanai (*Raiateana knowlesi*). In the final stages of their life cycle, the cicadas flock to this pool to perish, an event that occurs every eight years. The nanai is the traditional manumanu or animal totem of the mataqali Emalu and through this site identification, a considerable part of the historical link the mataqali Emalu has with the land or vanua of Emalu, was established.

M28-0055

The site is quite extensive, covering a large area along the ridgeline with a total of nine house mounds identified among two platforms that are conjoined, forming a terrace-like construction over an extensive distance, as the landscape descends towards the west. The first identified platform is situated at the initial area of inspection on the east side of the site area. This platform reached a total length of 50m from either end with an identified width of 30m accommodating much of the identified cultural features belonging to this site.

The first identified mound is rectangular in structure, 8.5 x 6.5m and is highly raised compared to associated mounds-at least a meter above the ground. Due to its elevated structure, this mound feature may represent a rank or status associated in cultural communities. The second identified mound has a diameter of 8m and is raised at 60cm from the ground displaying a well-preserved structure of its original form. The third mound is circular and has a diameter of 8m with height raised at 60cm. The fourth mound is the largest mound feature identified in the area and is centrally located. The mound is rectangular structured, having a length of 9m with a width of 7.5m. The fifth house mound is identified as circular with a diameter of 7m and a height of 150cm, well preserved. The sixth identified house mound is situated on the western edge as the landscape descends to the second identified platform. The mound is circular structured with a diameter of 7.5m and raised at 50cm, however, closer inspection revealed that this mound has undergone disturbance through erosion processes. At the edge of the northern wall of the platform, the team identified the seventh house mound that was conjoined to the platform unlike the associated mounds which were situated upon the platform. This mound is circular structured and extends outwards from the platform. The platform is elevated 40cm higher than the mound feature, creating a terrace-like structure. The mound has a diameter of 7m and is raised 60cm from ground level.

As inspection continued towards the west, the team descended onto a second platform that accommodated two house mounds. The initial identified mound on this platform is the eighth house mound. This mound is circular structured with a diameter of 7m and raised at 50cm. Along with this mound is the ninth identified feature of another circular mound with a diameter of 6.5m and raised at 60cm. Both mounds are situated on this second platform on the west section of the site area. This platform extends 12 x 9.5m and is thickly vegetated with little undergrowth.

M28-0059 – Nanaga

This site has been designated for site monitoring due to cultural material remains in the form of stone alignment which are quite intact. The site is bordered by the Mavuvu Creek which borders the east and south of the unique study area. The site is elevated from the banks of the Mavuvu Creek and is quite extensive covering an area of about 70m in a north to south orientation and a width of 65m along an east to west orientation however, areas beyond may be included but could not be surveyed as dense vegetation and thickets limited access to these areas.

The site consisted of well-preserved cultural features that may define traditions that were once practiced in the past. Upon inspection, the team identified rock walls or baivatu, which were constructed elaborately around the site area. These rock walls were measured at 1.2m wide and constructed in a circular manner with a portion of the rock wall redirected from its key route to form another parallel formation along the east side of the rock wall system. This parallel formation of the outer rock wall extended to about 15m in a north-east orientation, ending at the eastern edge of the elevated platform which the site is situated upon. The rock wall system encircles until it ends as a three-quarter circle formation as a portion of the remainder has undergone disturbance. A protruding rock wall formation projects southwards from the main system extending to about 10m. At the centre of the surrounding rock wall is a hollow area with the surface dipping gradually. The vegetation of the area is predominately covered with bamboo and some moli kana (*Citrus grandis*), yasiyasi (*Syzygium fijiense*), makita (*Parinari glaberrima*), sawira (*Dysoxylum richii*) and sago palm shoots, locally known as soga.

Several researchers have conducted thorough studies on the ceremonial use of the remarkable stone enclosure known as nanaga sites. The extent of these sites is confined to a small area- less than a third of Viti Levu. These are the provinces of Serua and Navosa with two sites in the upper Wainimala River, Narokorokoyawa area, Naitasiri and appear to have been used up until 1876 during the end of the Colo (highland) rebellion and the acceptance of Christianity caused them to fall into disuse (Palmer, 1971). According to Palmer (1971), the nanaga sites are an archaeological manifestation pertaining to certain Fijian ceremonials marking their New Year about the end of October or the beginning of November. Palmer's research sufficiently connects the use of the nanaga sites with initiation, circumcision, pig worship and perhaps preparations for warfare.

Considered a cult or a secret religious society bound together by the common link of initiation resembling certain Australian and Melanesian rites, the nanaga was the "bed" of the ancestors, that is where their descendants might hold communion with them; the baki were the rites celebrated in the nanaga, from the initiation of youths or presenting the first fruits, recovering the sick, or winning charms against wounds in battle (Thomson, 1908).

M28-0065

This is the most extensive old village site that was recorded within the mataqali Emalu boundary. The site is known as Nasaqaruku and was documented by Brewster (1921) in his records of the migration of the mataqali Emalu.

The site begins on a stretch of flat land and includes a nearby ridge. Nasaqaruku contains 30 identified house mounds and more would have been uncovered if the lush vegetation cover was cleared. The level of erosion in the area is high and could also contribute to the loss of several house mound features at the foot of the ridge. Most of the house mounds are aligned with stones and have been displaced over time by surface runoff. Similarly, wild pig trails and human harvesting of wild yams are widely evident. On the south-western side of the settlement and along the ridge stands a house mound 3m high and has a diameter of 6m. The structure is typical of a traditional temple or burekalou and constructed on a platform so that it is higher above all the other house mounds. The structure is raised earthen material and has withstood the devastating forces of natural elements. Apart from the evidence of house mounds, other cultural remains include plain pottery sherds found scattered in some parts of the area, and the culturally introduced plant indicators such as *moli kana*, *vasili*, *saqiwa* and *kavika*.

M28-0066

This is a fortified settlement strategically constructed on a hill east-southeast of the rock shelter site M28-00071. The hill fortification is immense and contains several exceptional features that are well preserved. Outlined in a north-northwest to south-

southeast direction, the site runs along a ridge. Habitational platforms are carved onto the surface and accommodated four house mounds. Each house mound is embedded with stone lining some of which have been displaced due to natural causes.

As the ridge line drops on the south-southeast end of the site, rocks are piled in a heap up to 2.5m high. The stones are piled as if to await adversaries and probably were never used, as the stones are stacked in a dome like structure. Further down the slope two defensive pits are dug deep into the floor of the ground separated by a 1m wide causeway. The pits are about 2.5m long and about 1.5m wide and dug following the direction of the ridge line. As the relief begins to ascend to the next ridge level another set of stones piled up to form a defensive wall that is about 2.5m high, half a meter wide and about 4m long. At the end of the stone wall are two huge rock outcrops to strengthen the western corner of the wall aided with a steep slope, leaving no room for safe passage through. The vegetation of the area is that of scattered secondary vegetation cover of huge trees like dakua makadre (*Agathis macrophylla*), baka (*Ficus obliqua*), and marasa (*Elattostachys falcata*). The stone features are cloaked with thickets of vines that have held the stones in place over the years.

M28-0068

Similar to Nasaqaruku old village site (M28-0065), the footprint of this cultural relic is extensive and stretches approximately 530m along a ridgeline southwest of the site described above. A total of 26 house remains were surveyed with sizes that vary all throughout the site. The average size of the house mounds is 6.8m to 8.6m.

In different parts of the site there are massive platforms upon which several house mounds are constructed. The eastern corner contains an oval platform that is 5m high, 30m long, 16m wide and holds three house mounds. The foot of the platform is enclosed with a 15m flat area where four house mounds can be found on the east of the platform. This is the only portion of the site where the mounds and the platform are symmetrical. The mid-section of the site contains three platforms each more than 30m long and highly raised well above 3m. The first platform is separated from the next by a ditch that is 2.5m deep and 4m wide. Several obvious house mounds of raised earthen materials are constructed on these platforms. The house mounds are well intact with slow erosion seen on the edges. The thick canopy cover and floor vegetation preserved the cultural remains from heavy downpour.

Towards the west of the settlement, the ridge runs southwest and the cultural remains continues for another 121m consisting of a platform that is almost 30m long, 9m wide and raised 5m from the ground surface. The platform holds four house mounds while several more were constructed on the lower elevation. A 5m wide ditch seals off the end of the settlement as the ridge begins to slope downward to the lower reaches of the hill.

9.4.2 Monitoring sites

The increasingly intensive use and modification of the landscape resulting from modern demands for efficient infrastructure and land use (agricultural production, mining, energy sources, logging, etc.) exerts growing pressure on cultural heritage in the landscape. A summary of the threats and disturbances affecting the sites is provided in Table 2.

Table 2. Site disturbance factors and threats within Emalu.

Type of disturbance/threat	Disturbance/threat description	Sites affected
Nature	These threats occur naturally and cause irreversible damage - tropical cyclones, earthquakes, heavy rain and erosion processes contribute to changing and shaping the natural and cultural landscape.	All the sites documented the effects of natural events on the remains of cultural heritage site features. The dominant natural element affecting the structures is heavy rain which leads to the erosion of the edges of the house mounds, infilling of fortification ditches and causeways. Heavy rain also results in fluvial formation of rills and gullies thus displacing stone alignment and washing away the material remains.
Human	These are threats that are caused or related to human inhabitance & activities in and around the area of study.	About 95% of the sites identified contained human trails either travelling between provinces but mostly from hunting and gathering.
Animal	These are threats that are caused or related to animals-grazing, breeding and inhabitation activities specifically wild pigs	Pig hooves and snout trails covered about 60-70% of the sites surveyed. Dog trails were also encountered but pose little threat to the sites.

The 77 culturally significant sites encountered and documented during this survey are widely distributed across the study area. Since the Emalu land boundary is vast and accessibility is hindered by rugged terrain, the Archaeology team recommends that two sites, M28-0059 and M28-0046, be used for monitoring purposes. A summary of the framework within which this monitoring could occur is presented in Table 3.

Site M28-0059 can be easily accessed from either Navitilevu Village or Draubuta Village, both in the province of Navosa and located on the valley flats along Mavuvu Creek. However, site M28-0046 is located upland and results from the assessment will be used for comparison of threats that affect cultural heritage sites. These sites are most suitable for such a study given the outstanding cultural remains found here. The degradation of the site will be examined every two years by using traditional methods of site visitation and capturing still images of the area during the period of the REDD+ program. Data from other teams such as aerial/satellite images of the forest cover can also be a tool used for the process depending on data availability.

Table 3. Indicators and monitoring plan for cultural sites in Emalu.

Theme	Indicators	Monitoring Tool	Reporting
Cultural heritage sites	State of the sites	Assessing the current state of the sites and monitor the changes through time	Assessment report every two years
	Threats to the sites	Identifying the threats that affect the state of the sites	
	Access to the sites	Choosing two sites for the assessment of the above variables with access to the site as comparison	
	Cultural valuation of the sites	The two sites differ in cultural value	

Remote sensing even though costly, could also be a useful tool to map out the changes in the monitoring site by using laser-based sensors and radar in particular Synthetic Aperture Radar to see the ground or surface changes or even identify subsurface remains.

9.5 Conclusion

The land belonging to the mataqali Emalu is rich in historical cultural material remains that have never been documented. The historical remains are scattered all throughout the mataqali land, a widespread distribution of elaborate hilltop and lowland settlement and fortifications some of which are associated with the sophisticated irrigation systems for terrace agriculture.

The cultural footprints indicate the vast number of activities at one stage in history occurring in the remote highlands of Navosa. It also demonstrates the dense populations of the area where the sites occur close to each other and are mostly constructed along the ridgeline. The general physical setup of settlements depicts various forms of insecurity at that time-a time of great rivalry and competition. Supporting evidence can be found in some of the structures of the hill fortifications that were encountered. Constructing on high elevation is a survival strategy whereby communities used their natural environment and rugged terrain to provide security.

Further evidence to support the notion that the area was densely populated was given by the series of large intricate irrigation systems discovered during this survey. The discovery of these elaborate channels suggests larger populations to implement and maintain this agricultural system. However the drive and intentions of the local people related to the social structure and hierarchy in Fijian communities still remain undefined.

The study of the cultural footprints within the Emalu study area is vital in understanding the patterns and motivational factors related to inland migration: why the people of Emalu chose to live in such remoteness and rugged terrain, socio-cultural relations and their responses to altering natural and climatic conditions.

Generally, the archaeological finds during this survey have considerable cultural value to the local community and at national level. The significance of these sites can be determined and derived by deconstructing the value of the individual sites into the following components; aesthetic, symbolic, social, historic, authenticity and spiritual values. All the sites identified include one of these values while some may incorporate all, however an absent values does not lessen the significance of a site as it holds the ancestral history of the hill tribes of Fiji.

9.6 Conservation recommendations

Fiji has an ancient, complex and unique cultural heritage preserved in its archaeological sites. Unfortunately much of this record has been carelessly destroyed through human activity. The large scale of current and planned land development activity in Fiji poses a great threat to remaining sites, thus preservation activities are crucial to saving Fiji's archaeological heritage. Fiji's archaeological environment represents a valuable and irreplaceable record of the nation's cultural and social development. For this reason alone it is important that these sites be maintained well. In addition to its historical, cultural and archaeological merits the historic heritage also forms a readily available resource of considerable amenity, education, scientific, recreational and tourism value to the people of Fiji and visitors alike.

The archaeological assessment revealed valuable information pertaining to the mataqali Emalu and neighbouring communities historically linked to the land. Various findings of cultural assets were able to ascertain that these ancestral sites conveyed immeasurable knowledge and understanding of the history pertaining to traditional and cultural developments, linked closely to the identity of its people. It depicts the movement and settlement patterns of their ancestors and the forms of survival which defined their everyday lives.

Such history must be preserved whether tangible or intangible, however, various threats and disturbances of these cultural sites have, to an extent, altered important aspects of material history of the vanua of Emalu. All the sites identified are protected in Fiji under the Preservation of Objects of Archaeological and Palaeontological Interest Act (1940).

Recommendations are:

- that proper documentation of the assessment and oral history be undertaken to avoid the loss of traditional knowledge and history of the study area,

- the Fiji Museum Archaeology department is included in any future surveys to allow for completion of assessments of areas that have been overlooked, namely, the area on the southwest of the land boundary,
- a presentation of significant findings be done to raise awareness in the region, an activity for which the Fiji Museum is available.

APPENDICES

Appendix 1. Species checklist of the non-vascular flora and lichens

Family	Species
Hornworts	
Anthocerotaceae	*Folioceros amboinensis* (Schiffn.) Piippo
Anthocerotaceae	*Folioceros fuciformis* (Mont.) D.C.Bharadwaj
Anthocerotaceae	*Folioceros gladulosus* (Lehm. et Lindenb.) D.C.Bharadwaj
Anthocerotaceae	*Folioceros pinnilobus* (Steph.) D.C.Bharadwaj
Dendrocerotaceae	*Dendroceros cavernosus* J.Haseg.
Dendrocerotaceae	*Dendroceros granulatus* Mitt.
Dendrocerotaceae	*Dendroceros javanicus* (Nees) Nees
Dendrocerotaceae	*Megaceros flagellaris* (Mitt.) Steph.
Notothyladaceae	*Phaeoceros carolinianus* (Michx.) Prosk.
Liverworts	
Anastrophyllaceae	*Plicanthus birmensis* (Steph.) R.M.Schust.
Anastrophyllaceae	*Plicanthus hirtellus* (F.Weber) R.M.Schust.
Aneuraceae	*Aneura maxima* (Schiffn.) Steph.
Aneuraceae	*Lobatiriccardia coronopus* (De Not. Ex Steph.) Furuki
Aneuraceae	*Riccardia alba* (Colenso) E.A.Br.
Aneuraceae	*Riccardia graeffei* (Steph.) Hewson
Dumortieraceae	*Dumortiera hirsuta* (Sw.) Nees
Geocalycaceae	*Heteroscyphus argutus* (Reinw., Blume et Nees) Schiffn
Geocalycaceae	*Heteroscyphus aselliformis* (Reinw., Blume et Nees) Schiffn
Geocalycaceae	*Heteroscyphus coalitus* (Hook.) Schiffn.
Geocalycaceae	*Heteroscyphus succulentus* (Gottsche) Schiffn.
Geocalycaceae	*Notoscyphus lutescens* (Lehm. et Lindenb.) Mitt.
Hymenophytaceae	*Hymentophyton flabellatum* (Labill.) Dumort. ex. Trevis.
Jamesoniellaceae	*Cuspidatula contracta* (Reinw., Blume et Nees) Steph.
Jamesoniellaceae	*Denotarisia linguifolia* (De Not.) Grolle
Jubulaceae	*Frullania apiculata* (Reinw., Blume et Nees) Nees
Jubulaceae	*Frullania arecae* (Spreng.) Gottsche var. arecae
Jubulaceae	*Frullania cf. capillaris*
Jubulaceae	*Frullania chevalieri* (R.M.Schust.) R.M.Schust.
Jubulaceae	*Frullania cordistipula* (Reinw., Blume et Nees) Dumort.
Jubulaceae	*Frullania ericoides* (Nees) Mont.
Jubulaceae	*Frullania f. intermedia*
Jubulaceae	*Frullania f. intesmed*
Jubulaceae	*Frullania gaudichaudii* (Nees et Mont.) Nees et Mont.
Jubulaceae	*Frullania gracilis* (Reinw., Blume et Nees) Gottsche, Lindenb. et Nees
Jubulaceae	*Frullania intermedia* (Reinw., Blume et Nees) Gottsche, Lindenb. et Nees Dumort.
Jubulaceae	*Frullania meyeniana* Lindenb.
Jubulaceae	*Frullania neurota* Taylor
Jubulaceae	*Frullania nodulosa* (Reinw., Blume et Nees) Nees
Jubulaceae	*Frullania ramuligera* (Nees) Mont.
Jubulaceae	*Frullania ternatensis* Gottsche
Jungermanniaceae	*Conoscyphus trapezioides* (Sande Lac.) Schiffn.
Jungermanniaceae	*Jamesoniella flexicaulis* (Nees) Schiffn.
Lejeuneaceae	*Acrolejeunea pycnoclada* (Taylor) Schiffn.
Lejeuneaceae	*Archilejeunea planiuscula* (Mitt.) Steph.
Lejeuneaceae	*Caudalejeunea reniloba* (Gottsche) Steph.

Family	Species
Lejeuneaceae	*Ceratolejeunea belangeriana* (Gottsche) Steph.
Lejeuneaceae	*Ceratolejeunea vitiensis* Steph.
Lejeuneaceae	*Cheilolejeunea decursiva* Steph.
Lejeuneaceae	*Cheilolejeunea falsinervis* (Sande Lac.) R.M.Schust. et Kachroo
Lejeuneaceae	*Cheilolejeunea intertexta* (Lindenb.) Steph.
Lejeuneaceae	*Cheilolejeunea lindenbergii* (Gottsche) Mizut.
Lejeuneaceae	*Cheilolejeunea trapezia* (Nees, Lindenb. Et. Gottsche) R.M.Schutst et Kachroo
Lejeuneaceae	*Cheilolejeunea trifaria* (Reinw., Blume et Nees) Mizut.
Lejeuneaceae	*Cololejeunea aequabilis* (Sande Lac.) Schiffn.
Lejeuneaceae	*Cololejeunea amphibola* B. Thiers
Lejeuneaceae	*Cololejeunea augustiflora* (Steph.) Mizut.
Lejeuneaceae	*Cololejeunea cardiocarpa* (Mont.) A.Evans
Lejeuneaceae	*Cololejeunea cocoscola* (Angstr.) Steph.
Lejeuneaceae	*Cololejeunea diaphana* A.Evans
Lejeuneaceae	*Cololejeunea equialbi* Tixier
Lejeuneaceae	*Cololejeunea falcata* (Horik.) Benedix
Lejeuneaceae	*Cololejeunea floccosa* (Lehm.et Lindenb.) Schiffn.
Lejeuneaceae	*Cololejeunea huerlimannii* (Austin) Steph.
Lejeuneaceae	*Cololejeunea inflectens* Tixier
Lejeuneaceae	*Cololejeunea kulenensis* (Mitt.) Benedix
Lejeuneaceae	*Cololejeunea longifolia* (Mitt.) Benedix ex Mizut.
Lejeuneaceae	*Cololejeunea metzgeriopsis* (K.I.Goebel) Gradst., R.Wilson, Ilk.-Borg. et Heinrichs
Lejeuneaceae	*Cololejeunea minutissima* (Sm.) Schiffn.
Lejeuneaceae	*Cololejeunea obliqua* (Nees et Mont.) Schiffn.
Lejeuneaceae	*Cololejeunea peraffinis (Schiffn.) Schiffn.*
Lejeuneaceae	*Cololejeunea pseudoserrata* Tixier
Lejeuneaceae	*Cololejeunea raduliloba* Steph.
Lejeuneaceae	*Cololejeunea schmidtii* Steph.
Lejeuneaceae	*Cololejeunea sintenisii* (Steph.) Pocs
Lejeuneaceae	*Cololejeunea societatis* Tixier
Lejeuneaceae	*Cololejeunea stylosa* (Steph.) Steph.ex Mizut.
Lejeuneaceae	*Cololejeunea wightii* Steph.
Lejeuneaceae	*Colura acroloba* (Mont. ex Steph.) Ast
Lejeuneaceae	*Colura ari* (Steph.) Steph.
Lejeuneaceae	*Colura brevistyla* Herzog
Lejeuneaceae	*Colura conica* (Sande Lac.) K.I.Goebel
Lejeuneaceae	*Colura corynophora* (Nees, Lindeb. Et.Gottsche) Trevis.
Lejeuneaceae	*Colura crispiloba* Ast
Lejeuneaceae	*Colura cristata* Ast
Lejeuneaceae	*Colura leratii* Ast
Lejeuneaceae	*Colura pluridentata* Ast
Lejeuneaceae	*Colura queenslandica* B.M.Thiers
Lejeuneaceae	*Colura superba* (Mont.) Steph.
Lejeuneaceae	*Colura tenuicornis* (A.Evans) Steph.
Lejeuneaceae	*Colura vitiensis* Pocs et J.Eggers
Lejeuneaceae	*Dendrolejeunea fruticosa* (Lindenb. Et Gottsche) Lacout.
Lejeuneaceae	*Diplasiolejeunea cavifolia* Steph.
Lejeuneaceae	*Drepanolejeunea angustifolia* (Mitt.) Grolle
Lejeuneaceae	*Drepanolejeunea dactylophora* (Nees, Lindend. et Gottsche) Schiffn.
Lejeuneaceae	*Drepanolejeunea ternatensis* (Gottsche) Spruce ex Schiffn.
Lejeuneaceae	*Drepanolejeunea vesiculosa* (Mitt.) Steph.
Lejeuneaceae	*Harpalejeunea filicuspis* (Steph.) Mizut.
Lejeuneaceae	*Lejeunea alata* Gottsche

Family	Species
Lejeuneaceae	*Lejeunea anisophylla* Mont.
Lejeuneaceae	*Lejeunea capensis* Gottsche
Lejeuneaceae	*Lejeunea discreta* Lindenb.
Lejeuneaceae	*Lejeunea exilis* (Reinw., Blume et Nees) Grolle
Lejeuneaceae	*Lejeunea flava* (Sw.) Nees
Lejeuneaceae	*Lejeunea lumbricoides* (Nees) Nees
Lejeuneaceae	*Lejeunea sordida* (Nees) Nees
Lejeuneaceae	*Lejeunea umbilicata* (Nees) Nees
Lejeuneaceae	*Lepidolejeunea bidentula* (Steph.) R.M.Schust.
Lejeuneaceae	*Lepidolejeunea borneensis* (Steph.) R.M.Schust.
Lejeuneaceae	*Lepidolejeunea graeffei* (J.B.Jack et Steph.) R.M.Schust.
Lejeuneaceae	*Lepidolejeunea integristipula* (J.B.Jack et Steph.) R.M.Schust.
Lejeuneaceae	*Lepidolejeunea involuta* (Gottsche) Grolle
Lejeuneaceae	*Leptolejeunea elliptica* (Lehm. Et Lindenb.) Schiffn.
Lejeuneaceae	*Leptolejeunea epiphylla* (Mitt.) Steph.
Lejeuneaceae	*Lopholejeunea eulopha* (Taylor) Schiffn.
Lejeuneaceae	*Lopholejeunea hispidissima* Steph.
Lejeuneaceae	*Lopholejeunea nigricans* (Lindenb.) Schiffn.
Lejeuneaceae	*Lopholejeunea subfusca* (Nees) Schiffn.
Lejeuneaceae	*Lopholejeunea zollingeri* (Steph.) Schiffn.
Lejeuneaceae	*Mastigolejeunea auriculata* (Wilson) Schiffn.
Lejeuneaceae	*Mastigolejeunea calcarata* (Mitt. ex Steph.) Verd.
Lejeuneaceae	*Metalejeunea cucullata* (Reinw., Blume et Nees) Grolle
Lejeuneaceae	*Phaeolejeunea amicorum* (Hurl.) Pocs
Lejeuneaceae	*Ptychanthus striatus* (Lehm. Et Lindenb.) Nees
Lejeuneaceae	*Spruceanthus polymorphus* (Sande Lac.) Verd.
Lejeuneaceae	*Thysananthus retusus* (Reinw., Blume et Nees) B.M.Thiers et Gradst.
Lepicoleaceae	*Lepicolea rara* (Steph.) R.M.Schust.
Lepicoleaceae	*Mastigophora diclados* (Brid. Ex F.Weber) Nees
Lepidoziaceae	*Bazzania erosa* (Reinw.Blume et Nees) Trevis.
Lepidoziaceae	*Bazzania tridens*(Reinw.Blume et Nees) Trevis.
Lepidoziaceae	*Bazzania unicegera*(Reinw.Blume et Nees) Trevis.
Lepidoziaceae	*Bazzania vittata* (Gottsche) Trevis
Lepidoziaceae	*Kurzia gonyotricha* (Sande Lac.) Grolle
Lepidoziaceae	*Psiloclada clandestina* Mitt.
Lepidoziaceae	*Telaranea lindenbergii* (Gottsche) J.J.Engel et G.L.Merr.
Lepidoziaceae	*Telaranea pruinosa* (Herzog) J.J.Engel et G.L.Merr.
Lepidoziaceae	*Telaranea rosarioana* H.A.Mill.
Lepidoziaceae	*Zoopsidella caledonica* (Steph.) R.M.Schust.
Marchantiaceae	*Marchantia vitiensis* Steph.
Metzgeriaceae	*Metzgeria ciliata* Raddi
Metzgeriaceae	*Metzgeria furcata* (L.) Corda
Metzgeriaceae	*Metzgeria leptoneura* Spruce
Pallaviciniaceae	*Pallavicinia lyellii* (Hook.) Carruth.
Pallaviciniaceae	*Symphyogynopsis gottscheana* (Mont. Et Nees) Grolle
Plagiochilaceae	*Chiastocaulon dendroides* (Nees) Carl
Plagiochilaceae	*Chiloscyphus muricatus* (Lehm.) J.J.Engel et R.M.Schust.
Plagiochilaceae	*Plagiochila abietina* (Nees) Nees et Mont.
Plagiochilaceae	*Plagiochila arbuscula* (Brid. ex Lehm. et Lindenb.) Lindenb.
Plagiochilaceae	*Plagiochila bantamensis* (Reinw., Blume et Nees) Mont.
Plagiochilaceae	*Plagiochila hampenana* Gottsche
Plagiochilaceae	*Plagiochila javanica* (Sw.) Nees et Mont.
Plagiochilaceae	*Plagiochila oppositum* Dozy ex Sande Lac

Family	Species
Plagiochilaceae	*Plagiochila sandei* Sande
Plagiochilaceae	*Plagiochila teysmannii* Sande
Plagiochilaceae	*Plagiochilion braunianum* (Nees) S.Hatt.
Pleuroziaceae	*Pleurozia conchifolia* (Hook. Et Arn.) Austin
Pleuroziaceae	*Pleurozia gigantea* (F.Weber) Lindb.
Porellaceae	*Porella elegantula* (Mont.) E.A.Hodgs.
Pseudolepicoleaceae	*Temnoma setigerum* (Lindenb.) R.M.Schust.
Radulaceae	*Radula amentulosa* Mitt.
Radulaceae	*Radula campanigera* Mont.
Radulaceae	*Radula decurrens* Mitt.
Radulaceae	*Radula formosa* (C.F.W.Meissn. Ex Spreng.) Nees
Radulaceae	*Radula javanica* Gottsche
Radulaceae	*Radula lingulata* Gottsche
Radulaceae	*Radula protensa* Lindenb.
Radulaceae	*Radula reflexa* Nees et Mont.
Radulaceae	*Radula retroflexa* Taylor
Radulaceae	*Radula scariosa* Mitt.
Radulaceae	*Radula tjibodensis* K.I.Goebel
Schistochilaceae	*Schistochila aligera* (Nees et Blume) J.B.Jack et Steph.
Schistochilaceae	*Schistochila blumei* (Nees) Trevis
Schistochilaceae	*Schistochila caledonica* Steph.
Schistochilaceae	*Schistochila fijiensis* H.Buch et Herzog
Schistochilaceae	*Schistochila repleta* (Hook.f.et Taylor) Steph
Schistochilaceae	*Schistochila sciurea* (Nees) Schiffn.
Solenostomataceae	*Solenostoma ariadne* (Taylor ex Lehm.) R.M.Schust. ex Vana et D.G.Long
Solenostomataceae	*Solenostoma haskarlianum* (Nees) R.M.Schust. ex Vana et D.G.Long
Solenostomataceae	*Solenostoma tetragonum* (Lindenb.) R.M.Schust. ex Vana
Solenostomataceae	*Solenostoma truncatum* (Nees) R.M.Schust. Ex Vana et D.G.Long
Treubiaceae	*Treubia lacunosa* (Colenso) Prosk.
Trichocoleaceae	*Trichocolea tomentella* (Ehrh.) Dumort.
Mosses	
?	*Cyclodictyum blumeanum*
Calymperaceae	*Calymperes* sp.
Calymperaceae	*Mitthyridium luteum* (Mitt.) H. Rob.
Calymperaceae	*Mitthyridium obtusifolium* (Lindb.) H. Rob.
Calymperaceae	*Mitthyridium* sp.
Calymperaceae	*Syrrhopodon* sp.
Calymperaceae	*Syrrhopodon tristichus* Nees ex Schwägr.
Daltoniaceae	*Bryobrothera crenulata* (Broth. & Paris) Thér.
Dicranaceae	*Campylopodium euphorocladum* (Müll. Hal.) Besch.
Dicranaceae	*Campylopus introflexus* (Hedw.) Brid.
Dicranaceae	*Campylopus umbellatus* (Schwägr. & Gaudich. ex Arn.) Paris
Dicranaceae	*Leucoloma* sp.
Dicranaceae	*Leucoloma tenuifolium* Mitt.
Entodontaceae	*Entodon solanderi* (Ångström) A. Jaeger
Fissidentaceae	*Fissidens* sp.
Garovagliaceae	*Euptychium setigerum* (Sull.) Broth.
Garovagliaceae	*Euptychium vitiense* Dixon
Hookeriaceae	*Cyathophorum* sp.
Hookeriaceae	*Cyathophorum tahitense* Besch.
Hookeriaceae	*Daltonia contorta* Müll. Hal.
Hookeriaceae	*Distichophyllum cuspidatum* (Dozy & Molk.) Dozy & Molk.
Hookeriaceae	*Distichophyllum* sp.

Family	Species
Hookeriaceae	*Distichophyllum vitianum* (Sull.) Mitt.
Hypnaceae	*Ectropothecium sp.*
Hypnaceae	*Hypnum* sp.
Hypnodendraceae	*Bescherellia cryphaeoides* (Müll. Hal.) M. Fleisch.
Hypnodendraceae	*Hypnodendron dendroides* (Brid.) Touw
Hypopterygiaceae	*Hypopterygium vriesei* Bosch & Sande Lac.
Lembophyllaceae	*Camptochaete porotrichoides* (Besch.) Broth.
Lembophyllaceae	*Camptochaete subporotrichoides* (Broth. & Geh.) Broth.
Leucobryaceae	*Leucobrym sanctum* (Brid.) Hampe
Leucobryaceae	*Leucobryum aduncum* Dozy & Molk.
Leucobryaceae	*Leucobryum candidum* (Brid. ex P. Beauv.) Wilson
Leucobryaceae	*Leucobryum scalare* Müll. Hal. ex M. Fleisch.
Meteoriaceae	*Aerobryopsis longistima* (Dozy & Molk.) M.Fleisch.
Meteoriaceae	*Aerobryopsis vitiana* (Sull.) M. Fleisch.
Meteoriaceae	*Aerobryopsis wallichii* (Brid.) M. Fleisch.
Meteoriaceae	*Floribundaria aeruginosa* (Mitt.) M. Fleisch.
Meteoriaceae	*Papillaria helictophylla* (Mont.) Broth.
Meteoriaceae	*Papillaria leuconeura* (Müll. Hal.) A. Jaeger
Neckeraceae	*Himantocladium plumula* (Nees) M. Fleisch.
Neckeraceae	*Homaliodendron flabellatum* (Sm.) M. Fleisch.
Neckeraceae	*Neckeropsis lepineana* (Mont.) M. Fleisch.
Neckeraceae	*Nedceropsis* sp.
Neckeraceae	*Pinnatella* ct. *ambigua*
Neckeraceae	*Pinnatella kuehliana* (Bosch & Sande Lac.) M. Fleisch.
Neckeraceae	*Pinnatella* sp.
Orthorrhynchiaceae	*Orthorrhynchium elegans* (Hook. f. & Wilson) Reichardt
Orthotrichaceae	*Macromitrium angulatum* Mitt.
Orthotrichaceae	*Macromitrium incurvifolium* (Hook. & Grev.) Schwägr.
Orthotrichaceae	*Macromitrium involutifolium* (Hook. & Grev.) Schwägr.
Pallaviciniaceae	*Pallavicinia* sp.
Pleuroziaceae	*Pleurozia gigantea* (F. Weber) Lindb.
Pterobryaceae	*Calyptothecium seminerve* E.B. Bartram is an unresolved name
Pterobryaceae	*Garovaglia elegans* (Dozy & Molk.) Hampe ex Bosch & Sande Lac.
Pterobryaceae	*Garovaglia powellii* Mitt.
Pterobryaceae	*Symphysodon vitianus* (Sull.) Broth.
Pterobryaceae	*Symphysodontella cylindracea* (Mont.) M. Fleisch.
Ptychomniaceae	*Ptychomnion aciculare* (Brid.) Mitt.
Racopilaceae	*Racopilum* sp.
Rhizogoniaceae	*Pyrrhobryum* sp.
Rhizogoniaceae	*Pyrrhobryum spiniforme* (Hedw.) Mitt.
Rhizogoniaceae	*Rhizogonium graeffeanum* (Müll. Hal.) A. Jaeger
Sematophyllaceae	*Acroporium sp.*
Sematophyllaceae	*Meiothecium hamatum* (Müll. Hal.) Broth.
Spiridentaceae	*Spiridens aristifolius* Mitt.
Thuidiaceae	*Thuidium* sp.
Lichen	
Baeomycetaceae	*Baemyces heteromorphus* Nyl.ex C.Bab.&Mitt.
Baeomycetaceae	*Dibaeis absoluta* Kalb & Gierl
Baeomycetaceae	*Dibaeis sorediata* Kalb & Gierl
Brigantiaceae	*Brigantiaea leucoxantha* (Spreng.)R. Sant. & Hafellner
Chrysotrichaceae	*Chrysothrix xanthina* (Vain.)Kalb
Cladoniaceae	*Cladonia macilenta* Hoffm.
Coccocarpiaceae	*Coccocarpis glaucina* Kremp.

Family	Species
Coccotremataceae	*Coccotrema cucurbitula* (Mont.) Mull.Arg.
Coenogoniaceae	*Coenogonium congense* Dodge
Gomphillaceae	*Calenia depressa* Mull.Arg.
Gomphillaceae	*Gyalectidium filicinum* Mull.Arg.
Gomphillaceae	*Gyalectidium imperfectum* Vezda
Gomphillaceae	*Gyalideopsis intermedia* Lucking
Graphidaceae	*Fissurina dumastioides* (Fink) Staiger
Graphidaceae	*Graphis duplicata* Vain
Graphidaceae	*Leucodecton albidulum* (Nyl.) Mangold
Graphidaceae	*Leucodecton phaeosporum* (Nyl.) Rivas
Graphidaceae	*Thelotrema circumscriptum* C.Knight
Graphidaceae	*Thelotrema defossum* (Mull.Arg.) Mangold
Graphidaceae	*Thelotrema pachysporum* Nyl.
Graphidaceae	*Thelotrema porinaceum* Mull.Arg.
Graphidaceae	*Thelotrema porinoides* (Mont. & Bosh)
? Hymenochaetales	*Cyphellostereum pusiolum* (Berk.&M.A.Curtis) D.A.Reid
Megalosporaceae	*Megalospora sulphurata* Meyen
Meruliaceae	*Dictyonema irpicinum* (Mont.) Nyl.
Pannariaceae	*Pannaria tavaresii* P.M.Jorg
Parmeliaceae	*Hypotrachyna imbricatula (*Zahlbr.) Hale
Parmeliaceae	*Parmotrema abessinicum* (Nyl.ex Kremp.) Hale
Parmeliaceae	*Relicina abstrusa* (Vain.) Hale
Peltigeraceae	*Peltigera sumatrana* Gyeln.
Physciaceae	*Heterodermia incana* (Stirt.) D.D.Awasthi
Piliocarpaceae	*Badimia elegans* (Vain.) Vezda
Pilocarpaceae	*Byssoloma leucoblepharum* (Nyl.)Vain.
Porinaceae	*Porina brisbanensis* Mull.Arg.
Pyrenulaceae	*Pyrenula kurzii* Ajay Singh & Upreti
Stereocaulaceae	*Lepraria lobificans* Nyl.
Strigulaceae	*Strigula maculata* (Cooke & Massee)
Thelotremateae	*Melanotopelia rugosa* (Kantvilas & Vezda) Mangold & Lumbsch
SUMMARY: 72 Families, 133 Genera	

Appendix 2. Annotated checklist of the vascular flora of Emalu.

Family	Scientific Name	Local name	Distribution
indg.=indigenous, nat.=native, end.=endemic, cmm=common, intr.-introduced, cult.-cultivated, edv.=adventive			
Angiosperm – Dicotyledons			
Alangiaceae	*Alangium vitiense* (A.Gray) Baill. ex Harms	dalovoci, dokonisau	Indg., nat., end.
Anacardiaceae	*Buchanania attenuata* A.C.Smith	Kaukaro	Indg., nat., poss.end
Anacardiaceae	*Buchanania vitiensis* Engl.	maqo ni veikau	Indg., nat., end.
Anacardiaceae	*Dracontomelon vitiense* Engl.	Tarawau	Indg.pres.
Anacardiaceae	*Pleiogynium timoriense* (DC.) Leenh.	tarawau	Intrd., cult.
Anacardiaceae	*Rhus simarubifolia* A.Gray		Indg., nat., cmm.
Anacardiaceae	*Semecarpus vitiensis* (A.Gray) Engl.	Kaukaro	Indg., nat., cmm.
Annonaceae	*Cananga odorata* (Lam.) Hook.f.& Thoms.	Makosoi	Indg.pres.
Annonaceae	*Cyathocalyx cf. insularis*	Mako	Indg., nat., end.
Annonaceae	*Cyathocalyx insularis* A.C.Sm.	makosoi ni veikau	Indg., nat., end.
Annonaceae	*Cyathocalyx sp.*	dulewa, makosoi ni veikau	Indg., nat., end.
Annonaceae	*Polyalthia laddiana* A.C.Smith		Indg., nat., end.
Annonaceae	*Xylopia sp.*	dulewa	Indg., nat., end.
Apiaceae	*Centella asiatica* (L.) Urb.		Indg., poss.nat.
Apocynaceae	*Alstonia montana* Turrill	sorua	Indg., nat., cmm.
Apocynaceae	*Alstonia pacifica* (Seem.) A.C.Smith	sorua lailai	Indg., nat., cmm.
Apocynaceae	*Alstonia vitiensis* Seem.	sorua levu	Indg., nat., end.
Apocynaceae	*Alyxia sp.*		Indg., nat., cmm.
Apocynaceae	*Cerbera manghas* L.	vasa	Indg., nat., cmm.
Araliaceae	*Plerandra insolita* A.C.Sm.	sole	Indg., nat., end.
Araliaceae	*Plerandra pickeringii* A.Gray	sole	Indg., nat., end.
Araliaceae	*Polyscias joskei* Gibbs	sole	Indg., nat., end.
Araliaceae	*Polyscias multijuga* (A.Gray) Harms	danidani	Indg., nat., cmm.
Araliaceae	*Schefflera vitiensis* (A.Gray) Seem.	sole	Indg., nat., end.
Araucariaceae	*Agathis macrophylla* (Lindl.) Mast.	dakua makadre	Intrd., cult.
Asclepiadaceae	*Hoya australis* R.Br.	hoya	Intrd., poss.cult.
Asteraceae	*Ageratum conyzoides* L.	botebotekoro	Intrd., cult.
Asteraceae	*Conyza bonariensis* (L.) Cronquist		Intrd., cult.
Asteraceae	*Crassocephalum crepidioides* (Benth.) S.Moore		Indg., nat., cmm.
Asteraceae	*Cyanthillium cinereum* (L.) H.Rob.	ironweed	Indg., nat., cmm.
Asteraceae	*Elephantopus mollis* H.B.K.		Intrd., cult.

Family	Scientific Name	Local name	Distribution
indg.=indigenous, nat.=native, end.=endemic, cmm=common, intr.-introduced, cult.-cultivated, edv.=adventive			
Asteraceae	*Emilia sonchifolia* (L.) DC.		Indg., nat., cmm.
Asteraceae	*Mikania micrantha* H.B.K.	mile a minute	Intrd., cult.
Asteraceae	*Pseudelephantopus spicatus* (B.Juss. ex Aubl.) C.F.Baker		Intrd., cult.
Asteraceae	*Synedrella nodiflora* (L.) Gaertn.		Intrd., cult.
Asteraceae	*Vernonia cinerea* (L.) Less.	ironweed	Indg.pres.
Asteraceae	*Wedelia trilobata* (L.) Hitchc.		Intrd., adv.
Asteraceae	*Wollastonia biflora* (L.) DC.		Indg., nat., cmm.
Balanophoraceae	*Balanophora fungosa* J.R.&G.Forst.		Indg., nat., cmm.
Barringtoniaceae	*Barringtonia sp.*	vutu	Indg., nat., cmm.
Burseraceae	*Canarium harveyi* Seem.	kaunicina, kaunigai	Indg., nat., cmm.
Burseraceae	*Canarium vanikoroense* Leenh.	kaunisiga	Indg., nat., cmm.
Burseraceae	*Canarium vitiense* A.Gray	kaunicina B	Indg., nat., cmm.
Burseraceae	*Haplolobus floribundus* (K.Schum) Lam	kaunigai, kaunigai	Indg., nat., cmm.
Caesalpiniaceae	*Caesalpinia major* (Medik.) Dandy & Exell	soni	Indg., nat., cmm.
Caesalpiniaceae	*Chamaecrista nictitans* (L.) Moench		Intrd., cult.
Caesalpiniaceae	*Cynometra falcata* A.Gray	moivi	Indg., nat., end.
Caesalpiniaceae	*Cynometra insularis* A.C.Sm.	moivi	Indg., nat., end.
Caesalpiniaceae	*Kingiodendron platycarpum* B.L.Burtt	moivi	Indg., nat., end.
Caesalpiniaceae	*Maniltoa grandiflora* (A.Gray) Scheffer	cibicibi, moivi	Indg., nat., cmm.
Caesalpiniaceae	*Senna occidentalis* (L.) Link		Indg., nat., cmm.
Caesalpiniaceae	*Senna tora* (L.) Roxb.		Intrd., cult.
Caesalpiniaceae	*Storckiella vitiensis* Seem.	marasa	Indg., nat., end.
Cassythaceae	*Cassytha filiformis* L.		Indg., nat., cmm.
Casuarinaceae	*Casuarina equisetifolia* J.R.& G.Forst.	nokonoko	Indg., nat., cmm.
Casuarinaceae	*Gymnostoma vitiense* L.A.S.Johnson	velau	Indg., nat., end.
Ceasalpiniaceae	*Maniltoa floribunda* A.C.Smith	cibicibi	Indg., nat., end.
Chrysobalanaceae	*Parinari insularum* A.Gray	Sea/sa	Indg., nat., cmm.
Clusiaceae	*Calophyllum ambiphyllum* A.C.Smith & S.Darwin	damanu dilodilo	Indg., nat., end.
Clusiaceae	*Calophyllum cerasiferum* Vesque	damanu draulevu	Indg., nat., end.
Clusiaceae	*Calophyllum inophyllum* L.	damanu (lailai)	Indg., nat., cmm.
Clusiaceae	*Calophyllum leptocladum* A.C.Sm. & S.P.Darwin	damanu draulailai	Indg., nat., end.
Clusiaceae	*Calophyllum neo-ebudicum* Guillaumin	damanu kula	Indg., nat., cmm.
Clusiaceae	*Calophyllum vitiensis* Turrill	damanu	Indg., nat., end.
Clusiaceae	*Garcinia adinantha* A.C.Sm. & S.P.Darwin	bulu	Indg., nat., end.

Family	Scientific Name	Local name	Distribution
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Clusiaceae	*Garcinia myrtifolia* A.C.Smith	bulu	Indg., nat., cmm.
Clusiaceae	*Garcinia pseudoguttifera* Seem.	bulu m, laubu	Indg., nat., cmm.
Clusiaceae	*Garcinia sessilis* (Forst.f.) Seem.		Indg., nat., cmm.
Clusiaceae	*Garcinia vitiensis* (A.Gray) Seem.	bulu wai	Indg., nat., cmm.
Combretaceae	*Terminalia catappa* L.	tavola	Intrd., cult.
Connaraceae	*Connarus pickeringii* A.Gray		Indg., nat., end.
Crassulaceae	*Kalanchöe pinnata* (Lam.) Pers.		Intrd., adv.
Cucubitaceae	*Momordica charantia* L.		Intrd., adv.
Cunoniaceae	*Geissois ternata* A.Gray	vure	Indg., nat., end.
Cunoniaceae	*Weinmannia vitiensis* Seem.		Indg., nat., end.
Degeneriaceae	*Degeneria vitiensis* I.W.Bailey & A.C.Smith	masiratu/vavaloa	Indg., nat., end.
Dichapetalaceae	*Dichapetalum vitiense* (Seem.) Engl.		Indg., nat., cmm.
Dioscoreaceae	*Dioscorea bulbifera* L.	kaile	Intrd., cult.
Ebenaceae	*Diospyros elliptica* (J.R.&G.Forst) P.S.Green		Indg., nat., cmm.
Ebenaceae	*Diospyros foliosa* (Rich ex A.Gray) Bakh.	kauloa	Indg., nat., end.
Ebenaceae	*Diospyros major* (G.Forst.) Bakh.	kauloa	Indg., nat., cmm.
Ebenaceae	*Diospyros sp.*	kauloa	Indg., nat., cmm.
Elaeocarpaceae	*Elaeocarpus chelonimorphus* Gillespie	kabi	Indg., nat., cmm.
Elaeocarpaceae	*Elaeocarpus kambi* Gibbs.	kabi	Indg., nat., end.
Euphorbiaceae	*Acalypha insulana* Müll.Arg.		Indg., nat., cmm.
Euphorbiaceae	*Acalypha repanda* Müll.Arg.		Indg., nat., cmm.
Euphorbiaceae	*Acalypha rivularis* Seem.		Indg., nat., end.
Euphorbiaceae	*Acalypha sp.*	kalabuci	Indg., nat., cmm.
Euphorbiaceae	*Aleurites moluccana* (L.) Willd.	lauci	Indg., nat., cmm.
Euphorbiaceae	*Antidesma elassophyllum* A.C.Sm.	molau	Indg., nat., end.
Euphorbiaceae	*Baccaurea pulvinata* A.C.Sm.	midra	Indg., nat., end.
Euphorbiaceae	*Baccaurea sp.*	midra	Indg., nat., end.
Euphorbiaceae	*Bischoffia javanica* Blume	koka	Intrd., adv.
Euphorbiaceae	*Croton microtiglium* Burkill	danidani	Indg., nat., cmm.
Euphorbiaceae	*Drypetes vitiensis* Croizat		Indg., nat., cmm.
Euphorbiaceae	*Endospermum macrophyllum* (Muell.Arg.) Pax & Hoffm.	kauvula	Indg., nat., end.
Euphorbiaceae	*Euphorbia cyathophora* Murray		Indg., nat., cmm.
Euphorbiaceae	*Glochidion anfractuosum* Gibbs	makovatu	Indg., nat., end.
Euphorbiaceae	*Glochidion concolor* Müll.Arg.	molau	Indg., nat., cmm.

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Euphorbiaceae	*Glochidion vitiense* (Müll.Arg.) Gillespie	molau	Indg., nat., end.
Euphorbiaceae	*Homalanthus nutans* (G.Forst.) Guill.	tadano	Intrd., adv.
Euphorbiaceae	*Macaranga graeffeana* Pax & K.Hoffm.	gadoa	Indg., nat., end.
Euphorbiaceae	*Macaranga harveyana* (Muell.Arg.) Muell.	dava	Indg., nat., cmm.
Euphorbiaceae	*Macaranga seemannii* (Muell.Arg.) Muell.		Indg., nat., cmm.
Euphorbiaceae	*Phyllanthus sp.*		Indg., nat., cmm.
Fabaceae	*Crotalaria pallida* Ait.		Intrd., cult.
Fabaceae	*Derris trifoliata* Lour.	duva	Indg., poss.nat.
Fabaceae	*Milletia elliptica* (Roxb.) Steud.	vesi wai	Intrd., adv.
Fabaceae	*Mucuna* cf. *platyphylla*		Indg., nat., cmm.
Fabaceae	*Mucuna gigantea* (Willd.) DC.		Indg., nat., cmm.
Flacourtiaceae	*Flacourtia sp.?*		Indg., nat., end.
Flacourtiaceae	*Homalium pallidum* A.C.Smith	molaca	Indg., nat., end.
Flacourtiaceae	*Homalium vitiense* Benth.		Indg., nat., end.
Gonystylaceae	*Gonystylus punctatus* A.C.Sm.	mavota	Indg., nat., end.
Goodeniaceae	*Scaevola floribunda* A.Gray		Indg., nat., end.
Hernandiaceae	*Hernandia olivacea* Gillespie	dalovoci, duvula	Indg., nat., end.
Icacinaceae	*Citronella vitiensis* R.Howard	nuqanuqa	Indg., nat., end.
Icacinaceae	*Medusanthera vitiensis* Seem.	duvu	Indg., nat., end.
Lamiaceae	*Hyptis pectinata* (L.) Poit.		Intrd., cult.
Lauraceae	*Cryptocarya sp.*	damabi	Indg., nat., cmm.
Lauraceae	*Cryptocarya turrilliana* A.C.Sm.	lidi	Indg., nat., end.
Lauraceae	*Endiandra elaeocarpa* Gillespie	damabi	Indg., nat., cmm.
Lauraceae	*Endiandra gillespiei* A.C.Sm.	diriniu	Indg., nat., end.
Lauraceae	*Endiandra monticola* A.C.Sm.	damabi	Indg., nat., end.
Lauraceae	*Endiandra sp.*		Indg., nat., cmm.
Lauraceae	*Litsea sp.*		Indg., nat., cmm.
Loganiaceae	*Geniostoma macrophyllum* Gillespie	boiboida	Indg., nat., end.
Loganiaceae	*Geniostoma vitiense* Gilg & Benedict	boiboida lailai	Indg., nat., cmm.
Loganiaceae	*Neuburgia corynocarpa* (A. Gray) Leenh.	bo	Indg., nat., cmm.
Malvaceae	*Grewia sp.*	siti	Indg., nat., cmm.
Malvaceae	*Hibiscus tiliaceus* L.	vau	Intrd., adv.
Malvaceae	*Sida acuta* Burm.f.Fl.		Indg., nat., cmm.
Malvaceae	*Sida rhombifolia* L.		Indg., nat., cmm.

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Malvaceae	*Urena lobata* L.		Indg., nat., cmm.
Melastomaceae	*Astronidium confertiflorum* (A.Gray) Markgraf	dava	Indg., nat., end.
Melastomaceae	*Astronidium degeneri* A.C.Sm.	astronidium	Indg., nat., end.
Melastomaceae	*Astronidium inflatum* (A.C.Smith) A.C.Smith	astronidium	Indg., nat., end.
Melastomaceae	*Astronidium macranthum* (A.C.Smith) A.C.Smith	astronidium	Indg., nat., end.
Melastomaceae	*Astronidium parviflorum* A.Gray	astronidium	Indg., nat., end.
Melastomaceae	*Astronidium robustum* (Seem.) A.C.Smith	astronidium	Indg., nat., end.
Melastomaceae	*Astronidium sessile* (A.C.Smith) A.C.Smith	astronidium	Indg., nat., end.
Melastomaceae	*Astronidium sp.*	dava	Indg., nat., cmm.
Melastomaceae	*Astronidium storckii* Seem.	astronidium	Indg., nat., end.
Melastomaceae	*Astronidium tomentosum* (Seem.) A.C.Smith	astronidium	Indg., nat., end.
Melastomaceae	*Clidemia hirta* (L.)D.	koster's curse	Indg., nat., cmm.
Melastomaceae	*Melastoma denticulatum* Labill.		Indg., nat., cmm.
Meliaceae	*Aglaia achiboldiana*	kautoa	Indg., nat., end.
Meliaceae	*Aglaia elegans* Gillespie	kautoa	Indg., nat., end.
Meliaceae	*Aglaia sp.*	kautoa levu	Indg., nat., cmm.
Meliaceae	*Aglaia vitiensis* A.C.Sm.	mala	Indg., nat., end.
Meliaceae	*Dysoxylum lenticellare* Gillespie	malamala	Indg., nat., end.
Meliaceae	*Dysoxylum quercifolium* (Seem.) A.C.Smith	mala	Indg., nat., end.
Meliaceae	*Dysoxylum richii* (A.Gray) C.DC.	tarawau kei rakaka	Indg., nat., end.
Meliaceae	*Dysoxylum seemannii* Gillespie		Indg., nat., end.
Meliaceae	*Dysoxylum sp.*	malamala	Indg., nat., end.
Meliaceae	*Swietenia macrophylla* King	mahogany	Intrd., cult.
Meliaceae	*Swietenia mahagoni* (L.) Jacq.	mahogany	Intrd., cult.
Meliaceae	*Vavaea amicorum* Benth.	cevua	Indg., nat., cmm.
Meliaceae	*Vavaea degeneri* A.C.Sm.	cevua	Indg., nat., end.
Meliaceae	*Vavaea harveyi* Seem.	cevua	Indg., nat., end.
Meliaceae	*Vavaea megaphylla* C.H.Wright	cevua draulevu	Indg., nat., end.
Mimosaceae	*Albizia lebbek* (L.) Benth.		Intrd., adv.
Mimosaceae	*Entada phaseoioides* (L.) Merr.	walai	Indg., nat., cmm.
Mimosaceae	*Leucaena leucocephala* (Lam.) de Wit	vaivai	Indg., nat., cmm.
Mimosaceae	*Mimosa pudica* L.		Intrd., adv.
Mimosaceae	*Samanea saman* (Jacq.) Merr.	raintree	Intrd., adv.
Moraceae	*Ficus barclayana* (Miq.) Miq.	ai masi	Indg., nat., end.

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Moraceae	*Ficus fulvopilosa* Summerh.	ai masi	Indg., nat., end.
Moraceae	*Ficus greenwoodii* Summerhayes		Indg., nat., end.
Moraceae	*Ficus masonii* Horne ex Baker	ai masi	Indg., nat., end.
Moraceae	*Ficus obliqua* Forst.f.Fl.	ai masi/baka ni viti	Indg., nat., cmm.
Moraceae	*Ficus pritchardii* Seem.	ai masi	Indg., nat., end.
Moraceae	*Ficus smithii* Horne ex Baker		Indg., nat., cmm.
Moraceae	*Ficus sp.*	lololo/losilosi	Indg., nat., cmm.
Moraceae	*Ficus storckii* (scabrous) Seem.	ai masi, nunu	Indg., nat., cmm.
Moraceae	*Ficus tinctoria* Forst.f.Fl.		Indg., nat., cmm.
Moraceae	*Ficus vitiensis* Seem.	ai masi/lolo/lololo	Indg., nat., end.
Moraceae	*Malaisia scandens* (Lour.) Plaunch.		Indg., nat., cmm.
Moraceae	*Streblus anthropophagorum* (Seem.) Corner		Indg., nat., cmm.
Myrisinaceae	*Rapanea myricifolia* (A.Gray) Mez		Indg., nat., cmm.
Myrisinaceae	*Tapeinosperma sp.*		Indg., nat., cmm.
Myristicaceae	*Myristica castaneifolia* A.Gray	kaudamu	Indg., nat., end.
Myristicaceae	*Myristica chartacea* Gillespie	kaudamu draulailai	Indg., nat., end.
Myristicaceae	*Myristica gillespieana* A.C.Smith	kaudamu male	Indg., nat., end.
Myristicaceae	*Myristica grandifolia* A.DC.	kaudamu	Indg., nat., end.
Myristicaceae	*Myristica macarantha* A.C.Smith	male waqa	Indg., nat., end.
Myrsinaceae	*Tapeinosperma hornei* Mez	dasia	Indg., nat., end.
Myrtaceae	*Decaspermum vitiense* (A.Gray) Niedenzu	nuqa	Indg., nat., end.
Myrtaceae	*Metrosideros collina* (J.R.Forst. & G.Forst.) A.Gray	vuga	Indg., nat., cmm.
Myrtaceae	*Psidium guajava* L.	quawa	Intrd., cult.
Myrtaceae	*Syzygium amicorum* (A.Gray) Müll.Stuttg.	yasiyasi	Indg., nat., end.
Myrtaceae	*Syzygium confertiflorum* (A.Gray) Müll.Stuttg.	yasiyasi	Indg., nat., end.
Myrtaceae	*Syzygium corynocarpum* (A.Gray) Müll.Stuttg.	yasiyasi	Indg., nat., end.
Myrtaceae	*Syzygium curvistylum* (Gillespie) Merr. & L.M.Perry	yasiyasi	Indg., nat., end.
Myrtaceae	*Syzygium diffusum* (Turrill) Merr. & L.M.Perry	yasiyasi	Indg., nat., end.
Myrtaceae	*Syzygium dubium* (L.M.Perry) A.C.Sm.	yasiyasi	Indg., nat., end.
Myrtaceae	*Syzygium effusum* (A.Gray) Müll.Stuttg.	yasiyasi	Indg., nat., end.
Myrtaceae	*Syzygium fijiense* Perry	yasidravu	Indg., nat., end.
Myrtaceae	*Syzygium gillespiei* Merr. & L.M.Perry	yasiyasi	Indg., nat., end.
Myrtaceae	*Syzygium gracilipes* (A.Gray) Merr. & L.M.Perry	yasiyasi	Indg., nat., end.
Myrtaceae	*Syzygium grayi* (Seem.) Merr. & L.M.Perry	yasiyasi	Indg., nat., end.

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Myrtaceae	*Syzygium jambos* (L.) Alston	yasiyasi	Intrd., cult.
Myrtaceae	*Syzygium leucanthum* L.M.Perry	yasiyasi	Indg., nat., end.
Myrtaceae	*Syzygium malaccense* (L.) Merr. & Perry	kavika	Intrd., cult.
Myrtaceae	*Syzygium minus* A.C.Sm.	yasiyasi	Indg., nat., end.
Myrtaceae	*Syzygium neurocalyx* (A.Gray) Christoph.	yasiyasi	Indg., nat., end.
Myrtaceae	*Syzygium nidie* Guillaumin	yasiyasi	Indg., nat., end.
Myrtaceae	*Syzygium oblongifolium* (Gillespie) Merr. & L.M.Perry	yasiyasi	Indg., nat., end.
Myrtaceae	*Syzygium phaeophyllum* Merr. & L.M.Perry	yasiyasi	Indg., nat., end.
Myrtaceae	*Syzygium purpureum* (L.M.Perry) A.C.Sm.	yasiyasi	Indg., nat., end.
Myrtaceae	*Syzygium quadrangulatum* (A.Gray) Merr. & Perry		Indg., nat., cmm.
Myrtaceae	*Syzygium seemannianum* Merr. & L.M.Perry	yasiyasi	Indg., nat., end.
Myrtaceae	*Syzygium sp.*		Indg., nat., cmm.
Myrtaceae	*Syzygium tetrapleurum* L.M.Perry	yasiyasi	Indg., nat., end.
Myrtaceae	*Syzygium wolfii* (Gillespie) Merr. & L.M.Perry	yasiyasi	Indg., nat., end.
Nyctaginaceae	*Pisonia umbellifera* (J.R. Forst. & G. Forst.) Seem.	roro	Indg., nat., cmm.
Olacaceae	*Anacolosa lutea* Gillespie	kaukau makita	Indg., nat., cmm.
Oleaceae	*Jasminum didymum* G.Forst.		Indg., nat., cmm.
Oleaceae	*Jasminum simplicifolium* G.Forst.		Indg., nat., cmm.
Oleaceae	*Jasminum sp.*	nuqanuqa	Indg., nat., cmm.
Onagraceae	*Ludwigia octovalvis* (Jacq.) P.H.Raven		Intrd., adv.
Oxalidaceae	*Oxalis corniculata* L.		Intrd., cult.
Passifloraceae	*Passiflora foetida* L.var.*hispida* (DC.ex Triana & Planch.) Killip		Intrd., adv.
Passifloraceae	*Passiflora suberosa* L.		Intrd., cult.
Phytolaccaceae	*Rivina humilis* L.		Indg., nat., cmm.
Piperaceae	*Peperomia lasiostigma var. carnosa* C.DC.		Indg., nat., end.
Piperaceae	*Peperomia subroseispica* C.DC.		Indg., nat., end.
Piperaceae	*Piper aduncum* L.	honulu	Indg., nat., cmm.
Piperaceae	*Piper insectifugum* C.DC. ex Seem.		Indg., nat., end.
Pittosporaceae	*Pittosporum arborescens* Rich ex A.Gray		Indg., nat., end.
Pittosporaceae	*Pittosporum pickeringii* A.Gray	duva ni veikau	Indg., nat., end.
Pittosporaceae	*Pittosporum rhytidocarpum* A.Gray		Indg., nat., end.
Polygalaceae	*Polygala paniculata* L.		Intrd., adv.
Proteaceae	*Turrillia ferruginea* (A.C.Sm.) A.C.Sm.	kauceuti, tivi	Indg., nat., end.
Proteaceae	*Turrillia vitiensis* (Turrill) A.C. Sm., comb.nov.	kauceuti	Indg., nat., end.

Family	Scientific Name	Local name	Distribution
indg.=indigenous, nat.=native, end.=endemic, cmm=common, intr.-introduced, cult.-cultivated, edv.=adventive			
Rhamnaceae	*Alphitonia franguloides* A.Gray	doi	Indg., nat., end.
Rhamnaceae	*Alphitonia zizyphoides* (Spreng.) A.Gray	doi	Indg., nat., cmm.
Rhizophoraceae	*Crossostylis harveyi* Benth.		Indg., nat., end.
Rubiaceae	*Dolicholobium latifolium* A.Gray	soso ni ura	Indg., nat., end.
Rubiaceae	*Dolicholobium macgregorii* Horne ex Baker	soso ni ura levu	Indg., nat., end.
Rubiaceae	*Dolicholobium oblongifolium* A.Gray	soso ni ura	Indg., nat., end.
Rubiaceae	*Gardenia taitensis DC.*	jale ni veikau	Indg., nat., cmm.
Rubiaceae	*Hedyotis* sp.		Indg., nat., cmm.
Rubiaceae	*Mastixiodendron sp.*	duvula	Indg., nat., end.
Rubiaceae	*Morinda citrifolia* L.	kura	Intrd., cult.
Rubiaceae	*Morinda myrtifolia* A.Gray		Indg., nat., cmm.
Rubiaceae	*Mussaenda raiateensis* J.W.Moore		Indg., nat., cmm.
Rubiaceae	*Ophiorrhiza peploides* A.Gray		Indg., nat., end.
Rubiaceae	*Psychotria ampullacea* A.C.Sm.	psychotria	Indg., nat., end.
Rubiaceae	*Psychotria argantha* A.C.Sm.	psychotria	Indg., nat., end.
Rubiaceae	*Psychotria confertiloba* A.C.Sm.	psychotria	Indg., nat., end.
Rubiaceae	*Psychotria eumorphanthus* Fosberg	psychotria	Indg., nat., end.
Rubiaceae	*Psychotria glabra* (Turrill) Fosberg	psychotria	Indg., nat., end.
Rubiaceae	*Psychotria gracilior* A.C.Sm.	psychotria	Indg., nat., end.
Rubiaceae	*Psychotria leptantha* A.C.Sm.	psychotria	Indg., nat., end.
Rubiaceae	*Psychotria roseata* (Fosberg) A.C.Sm.	psychotria	Indg., nat., end.
Rubiaceae	*Psychotria sp.*	degedege, tabulina	Indg., nat., end.
Rubiaceae	*Psychotria turbinata* A.Gray	soso ni ura levu	Indg., nat., end.
Rubiaceae	*Psychotria vitiensis* Fosberg	psychotria	Indg., nat., end.
Rubiaceae	*Psydrax odorata* (Forst.f.) A.C.Smith & S.Darwin		Indg., nat., cmm.
Rubiaceae	*Spermacoce* sp.		Intrd., cult.
Rubiaceae	*Tarenna sambucina* (G.Forst.) T.Durand ex Drake	vakarube ni davui	Intrd., adv.
Rubiaceae	*Timonius affinis* A.Gray	dogo ni vanua/dogo ni veikau	Intrd., adv.
Rutaceae	*Citrus grandis* (L.) Osbeck	moli kana	Intrd., cult.
Rutaceae	*Citrus maxima* (Burm.) Osbeck	moli kana	Intrd., cult.
Rutaceae	*Euodia hortensis* J.R. Forst. & G. Forst.	uci	Intrd., cult.
Rutaceae	*Melicope cucullata* (Gillespie) A.C.Smith	drautolu	Indg., nat., end.
Rutaceae	*Melicope vitiensis* (A.C.Sm.) comb.nov.	drautolu	Indg., nat., end.
Rutaceae	*Micromelum minutum*(Forst.f.)Seem.	qiqila	Intrd., adv.

Family	Scientific Name	Local name	Distribution
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Sapindaceae	*Cardiospermum halicacabum* L.		Indg., nat., cmm.
Sapindaceae	*Dodonaea viscosa* (L.) Jacq.	usi	Indg., nat., cmm.
Sapindaceae	*Elattostachys falcata* (A.Gray) Radlk.	vure/marasa	Indg., nat., cmm.
Sapindaceae	*Guioa sp.*		Indg., nat., cmm.
Sapindaceae	*Koelreuteria elegans* (Seem.) A.C.Smith	manawi	Indg., nat., end.
Sapindaceae	*Pometia pinnata* J.R. Forst. & G. Forst.	dawa	Intrd., adv.
Sapindaceae	*Sapindus sp.*		Indg., nat., cmm.
Sapindaceae	*Sapindus vitiensis* A.Gray		Indg., nat., cmm.
Sapotaceae	*Burckella fijiensis* (Hemsl.) A.C.Sm. & S.P.Darwin	bau	Indg., nat., end.
Sapotaceae	*Burckella richii* (A.Gray) H.J.Lam		Indg., nat., poss.end.
Sapotaceae	*Burckella sp.*	bau	Indg., nat., poss.end.
Sapotaceae	*Palaquium fidjiense* Pierre ex Dubard	bau	Indg., nat., end.
Sapotaceae	*Palaquium hornei* (Hartog ex Baker) Dubard	cevua, sacau	Indg., nat., end.
Sapotaceae	*Palaquium porphyreum* A.C.Sm. & S.P.Darwin	bauvudi	Indg., nat., end.
Sapotaceae	*Planchonella grayana* H.St.John	bausa	Indg., nat., cmm.
Sapotaceae	*Planchonella sp.*	sarosaro	Indg., nat., cmm.
Sapotaceae	*Planchonella vitiensis* Gillespie	sarosaro	Indg., nat., end.
Saurauiaceae	*Saurauia rubicunda* Seem.	midra/mimila	Indg., nat., end.
Simaroubaceae	*Amaroria soulameoides* A.Gray	vasa ni veikau, sasawira	Indg., nat., end.
Smilacaceae	*Smilax vitiensis* (Seem.) A.DC.	warusi	Indg., nat., cmm.
Solanaceae	*Solanum torvum* Sw.	kosipeli	Intrd., poss.cult.
Sterculiaceae	*Heritiera ornithocephala* Kosterm.	rosarosa/rogi	Indg., nat., cmm.
Sterculiaceae	*Melochia vitiensis* A.Gray		Indg., nat., end.
Thymelaeaceae	*Wikstroemia foetida* (L. f.) A. Gray		Indg., nat., cmm.
Tiliaceae	*Grewia crenata* (J.R.&G.Forst) Schinz & Guillaumin	siti	Indg., nat., cmm.
Tiliaceae	*Trichospermum calyculatum* (Seem.) Burret.	mako loa	Indg., nat., end.
Tiliaceae	*Trichospermum richii* (A.Gray) Seem.	mako	Indg., nat., cmm.
Tiliaceae	*Triumfetta procumbens* G. Forst.		Intrd., adv.
Triuridaceae	*Andruris vitiensis* (A.C.Sm.) Giesen		Indg., nat., end.
Ulmaceae	*Girroniera celtidifolia* Gaud.	sisisi	Indg., nat., cmm.
Ulmaceae	*Parasponia andersonii* Planch.	drou	Indg., nat., cmm.
Ulmaceae	*Trema cannabina* Lour.	drou	Indg., nat., cmm.
Urticaceae	*Dendrocnide harveyi* (Seem.) Chew	salato	Indg., nat., cmm.
Urticaceae	*Elatostema tenellum* A.C.Smith		Indg., nat., end.

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Urticaceae	*Laportea interrupta* (L.) Chew		Indg., nat., cmm.
Urticaceae	*Leucosyke corymbulosa* Benth. & Hook.f. ex Drake		Indg., nat., cmm.
Urticaceae	*Pipturus vitiensis* A.C.Smith		Indg., nat., end.
Urticaceae	*Procris pedunculata* (J.R. Forst. & G. Forst.) Wedd.		Indg., nat., cmm.
Verbenaceae	*Faradaya ovalifolia* (A.Gray) Seem.	wavudi	Indg., nat., end.
Verbenaceae	*Lantana camara* L.	lantana	Indg., nat., cmm.
Verbenaceae	*Premna protrusa* A.C.Smith & S.Darwin	yaro	Indg., nat., end.
Verbenaceae	*Premna serratifolia* L.	yaro	Indg., nat., cmm.
Verbenaceae	*Stachytarpheta urticaefolia* (Salisb.) Sims		Intrd., adv.
Verbenaceae	*Vitex trifolia* L.	dralakaka	Indg., nat., cmm.
Vitaceae	*Cayratia seemanniana* A.C.Smith		Indg., nat., end.
Vittariaceae	*Pteris ensiformis* Burm. f.		Intrd., adv.
Angiosperm – Monocotyledons			
Agavaceae	*Cordyline fruticosa* (L.) A.Chev.	qai, vasili	Intrd., adv.
Amaryllidaceae	*Crinum asiaticum* L.	viavia	Intrd., cult.
Araceae	*Alocasia macrorrhiza* (L.) G.Don	via gaga	Intrd., cult.
Araceae	*Epiprenum pinnatum* (L.) Engl.	yalu	Intrd., cult.
Araceae	*Xanthosoma sagittifolium* (L.) Schott	dalo nitana	Intrd., cult.
Araliaceae	*Cyphosperma tanga* (H.E.Moore) H.E.Moore	tanga	Indg., nat., end.
Arecaceae	*Balaka diffusa Hodel*	balaka	Indg., nat., end
Arecaceae	*Balaka longirostris* Becc.	balaka (big fruit)	Indg., nat., end.
Arecaceae	*Cocos nucifera* L.	niu, coconut	Intrd., cult.
Arecaceae	*Metroxylon vitiense* (H.Wendl.) H.Wendl.ex Hook.f.	soga	Indg., nat., end.
Arecaceae	*Physokentia rosea* H.E.Moore	physokentia	Indg., nat., end.
Arecaceae	*Veitchia joannis* H.Wendl.	niusawa	Indg., nat., end.
Arecaceae	*Veitchia vitiensis* (H.Wendl.) H.E.Moore	niuniu	Indg., nat., end.
Commelinaceae	*Aneilema vitiense* Seem.		Indg., nat., cmm.
Cyperaceae	*Kyllinga nemoralis* (J.R.Forst. & G.Forst.) Dandy ex Hutch. & Dalziel	Intrd., adv.	
Cyperaceae	*Kyllinga polyphylla* Willd. ex Kunth	navua sedge	Intrd., adv.
Cyperaceae	*Scleria lithosperma* (L.) Sw.		Indg., nat., cmm.
Cyperaceae	*Scleria polycarpa* Boeck.		Indg., nat., cmm.
Euphorbiaceae	*Macaranga seemannii* (Müll.Arg.) Müll.Arg.	davo	Indg., nat., cmm.
Flagellariaceae	*Flagellaria indica* L.	alu	Indg., nat., cmm.
Orchidaceae	*Appendicula sp.*		Indg., nat., cmm.

Family	Scientific Name	Local name	Distribution
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Orchidaceae	*Bulbophyllum incommodum* Kores		Indg., nat., end.
Orchidaceae	*Bulbophyllum longiscapum* Rolfe		Indg., nat., cmm.
Orchidaceae	*Bulbophyllum sp.*		Indg., nat., cmm.
Orchidaceae	*Calanthe hololeuca* Rchb.f.		Indg., nat., cmm.
Orchidaceae	*Corymborkis veratrifolia* (Reinw.) Bl.		Indg., nat., cmm.
Orchidaceae	*Cynorckis fastigiata* Thouars		Intrd., adv.
Orchidaceae	*Diplocaulobium tipuliferum* (Reichenb.f.) Kraenzl.		Indg., nat., end.
Orchidaceae	*Erythrodes parvula* Kores		Indg., nat., cmm.
Orchidaceae	*Hetaeria whitmeei* Rchb.f.		Indg., nat., cmm.
Orchidaceae	*Macodes cf. petola*		Indg., nat., rare
Orchidaceae	*Nervilia cf. aragoana*		Indg; nat., rare
Orchidaceae	*Nervilia cf. punctata*		Indg; nat., rare
Orchidaceae	*Oberonia cf. equitans*		Indg., nat., cmm.
Orchidaceae	*Pristiglottis longiflora* (Rchb.f.) Kores		Indg., nat., cmm.
Orchidaceae	*Spathoglottis pacifica* Reichenb.f.	varavara	Indg., nat., cmm.
Pandanaceae	*Freycinetia storckii* Seem.	wame	Indg., nat., cmm.
Pandanaceae	*Pandanus sp.*	pandanus	Intrd., adv.
Pandanaceae	*Pandanus tectorius* Parkinson	vadra	Intrd., adv.
Poaceae	*Brachiaria mutica* (Forssk.) Stapf	paragrass	Indg., nat., cmm.
Poaceae	*Centosteca lappacea* (L.) Desv.		Indg., nat., cmm.
Poaceae	*Coix lacryma-jobi* L.	job's tears	Intrd., cult.
Poaceae	*Digitaria ciliaris* (Retz.) Koeler		Intrd., cult.
Poaceae	*Eleusine indica* (L.) Gaertn.		Intrd., cult.
Poaceae	*Imperata conferta* (Presl) Ohwi		Indg., nat., cmm.
Poaceae	*Miscanthus floridulus* (Labill.) Warb. ex K.Schum. & Lauterb.	gasau	Intrd., adv.
Poaceae	*Paspalum conjugatum* Bergius		Intrd., cult.
Poaceae	*Paspalum distichum* L.		Intrd., adv.
Poaceae	*Paspalum orbiculare* Forst.f.		Indg., nat., cmm.
Poaceae	*Paspalum paniculatum* L.		Intrd., cult.
Poaceae	*Paspalum vaginatum* Sw.		Intrd., cult.
Poaceae	*Pennisetum polystachyon* (L.) J.A.&J.H.Schultes	mission grass	Intrd., adv.
Poaceae	*Saccharum edule* Hassk.	duruka	Intrd., cult.
Poaceae	*Schizostachyum glaucifolium* (Rupr.)Munro		Indg., nat., cmm.
Poaceae	*Setaria glauca* (L.) Beauv.		Intrd., cult.

Family	Scientific Name	Local name	Distribution
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Poaceae	*Sporobolus indicus* (L.) R.Br.		Indg., nat., cmm.
Poaceae	*Sporobolus* sp.		Indg., nat., cmm.
Taccaceae	*Tacca leontopetaloides* (L.) Kuntze		Indg., poss.nat.
Zingiberaceae	*Alpinia parksii* (Gillespie) A.C.Sm.	locoloco	Indg., nat., end.
Zingiberaceae	*Geanthus cevuga* (Seem.) Loesener	cevuga damu	Indg., nat., rare.
Ferns and Fern Allies			
Acanthaceae	*Graptophyllum insularum* (A.Gray) A.C.Smith		Indg., nat., cmm.
Aspidiaceae	*Blechnum orientale* L.		Indg., nat., cmm.
Aspidiaceae	*Blechum pyramidatum* (Lam.) Urb.		Indg., nat., cmm.
Aspidiaceae	*Tectaria latifolia* (Forster) Copeland	ota loa	Indg., nat., cmm.
Aspleniaceae	*Asplenium australasicum* Hooker	birds nest	Indg., nat., cmm.
Aspleniaceae	*Asplenium nidus* L.		Indg., nat., cmm.
Aspleniaceae	*Asplenium polyodon* Forster		Indg., nat., cmm.
Cyatheaceae	*Culcita straminea* (Labillardiere) Maxon		Indg., nat., cmm.
Cyatheaceae	*Cyathea affinis* (Forster) Swartz	balabala	Indg., nat., cmm.
Cyatheaceae	*Cyathea alata* Copeland	balabala	Indg., nat., cmm.
Cyatheaceae	*Cyathea hornei* (Baker) Copel.	balabala	Indg., nat., cmm.
Cyatheaceae	*Cyathea lunulata* (G. Forst.) Copel.	balabala	Intrd., adv.
Cyatheaceae	*Cyathea medullaris* Sw.	cyathea (monasavu)	Indg., nat., cmm.
Cyatheaceae	*Cyathea propinqua* Mett.	balabala	Indg., nat., end.
Cyatheaceae	*Cyathea sp.*		Indg., nat., cmm.
Cyatheaceae	*Cyathea truncata* (Brackenridge) Copeland	balabala	Indg., nat., cmm.
Cyatheaceae	*Dicksonia brackenridgei* Mettenius	balabala	Indg., nat., cmm.
Davalliaceae	*Davallia solida* Ogata		Intrd., adv.
Davalliaceae	*Nephrolepis biserrata* (Swartz) Schott		Indg., nat., cmm.
Davalliaceae	*Nephrolepis hirsutula* (Forster) Presl		Indg., nat., cmm.
Dilleniaceae	*Dillenia biflora* (A.Gray) Martelli ex Dur.& Jacks	kuluva	Indg., nat., cmm.
Equisetaceae	*Equisetum ramosissimum* Desf. *subsp. debile* (Roxb.) Hauke		Indg., nat., end.
Gleicheniaceae	*Dicranopteris linearis* (Burmann) Underwood	qato	Indg., nat., cmm.
Gleicheniaceae	*Dicranopteris sp.*		Indg., nat., cmm.
Gleicheniaceae	*Gleichenia* sp.?		Indg., nat., cmm.
Hypolepidaceae	*Histiopteris incisa* (Thunberg) J.Smith		Indg., nat., cmm.
Lindsaeaceae	*Lindsaea ensifolia* Swartz		Indg., nat., cmm.
Marattiaceae	*Angiopteris evecta* (Forster) Hoffman	basovi	Indg., nat., cmm.

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Marattiaceae	*Marattia smithii* Mettenius ex Kuhn		Indg., nat., cmm.
Polypodiaceae	*Belvisia mucronata* (Fee) Copeland		Indg., nat., cmm.
Polypodiaceae	*Phymatosorus grossus* (Langsdorff et Fischer) Brownlie		Indg., nat., cmm.
Psilotaceae	*Psilotum nudum* (L.) Palisot de Beauvois		Indg., nat., cmm.
Schizaeaceae	*Lygodium reticulatum* Schkuhr		Indg., nat., cmm.
Selaginellaceae	*Selaginella* sp.		Indg., nat., cmm.
Thelypteridaceae	*Christella harveyi* (Mettenius) Holttum		Indg., nat., cmm.
Gymnosperms			
Araucariaceae	*Agathis macrophylla* (Lindl.) Mast.	dakua makadre	Indg., nat., cmm.
Gnetaceae	*Gnetum gnemon* L.	sukau	Indg., nat., cmm.
Pinaceae	*Pinus caribaea* Morelet	caribbean pine	Indg., nat., cmm.
Podocarpaceae	*Acmopyle sahniana* Buchh.& N.E.Gray	drautabua	Indg., nat., end.
Podocarpaceae	*Dacrycarpus imbricatus* (Blume) de Laub.	amunu	Indg., nat., cmm.
Podocarpaceae	*Dacrydium nidulum* de Laubenfels	yaka	Indg., nat., cmm.
Podocarpaceae	*Decussocarpus vitiensis* (Seem.) de Laub.	dakua salusalu	Indg., nat., cmm.
Podocarpaceae	*Podocarpus affinis* Seem.	kuasi lailai	Indg., nat., end.
Podocarpaceae	*Podocarpus neriifolius* D.Don	kuasi	Indg., nat., cmm.
SUMMARY: 100 Families, 258 Genera			

Appendix 3. Summary statistics of vegetation community structure assessment plots

Date	Plot #	Coordinates	Principal Vegetation Type	Forest/Habitat Type	# Ind. ≥ 5cm	# Tree spp.	Most common spp.	Largest trees	**# Ind. ≥ 10 cm**	Av. dbh(cm)	Range (cm)	**B. area (stems ≥** 10cm dbh)	Dom. sp.	Rel. dom. (%)
July 19 2012	T1P1	17.94314, 177.95961	Dry Forest	River flat	13	6	*Cit_gra*	*Dys_sp.*	9	22.3	5.0-72.0	8404	*Dys_sp.*	47
	T1P2	17.94322, 177.95950	Dry Forest	River flat	12	4	*Cit_gra*	*Dys_ric.*	6	17.7	3.0- 42.0	6855	*Dys_ric*	76
	T1P3	17.94289, 177.95956	Dry Forest	River flat	9	5	*Cit_gra*	*Cit_gra*	5	10.5	6.0-17.0	666	*Cit_gra*	59
	T1P4	17.94287, 177.95954	Dry Forest	River flat	13	8	*Cit_gra*	*Dys_que*	6	19.13	6.0-61.0	7099	*Dys_len*	40
	T1P5	17.94297, 177.95960	Dry Forest	River flat	7	7	None	*Dys_que*	4	18.3	7.0-34.0	2331	*Dys_len*	39
	T1P6	17.94327, 177.95962	Dry Forest	River flat	11	5	*Bac_sp.*	*Syz_mal*	7	13.07	7.0-29.0	1608	*Syz_mal*	42
	T2P1	17.94543, 177.96419	Dry Forest	River flat	20	6	*Syz_mal*	*Bis_jav*	13	28	10.0-70.0	10432	*Bis_jav*	37
	T2P2	17.94533, 177.96411	Dry Forest	River flat	18	9	*Syz_mal*	*Syz_mal*	6	20	10.9-27.0	2411	*Syz_mal*	50
	T2P3	17.94533, 177.96421	Dry Forest	River flat	17	8	*Syz_mal*	*Syz_spp.*	10	26.57	10.0-57.0	7937	*Syz_spp.*	32
	T2P4	17.94556, 177.96419	Dry Forest	River flat	15	5	*Cit_gra*	*Syz_spp.*	5	24.8	12.6-62.0	3807	*Bis_jav*	79
	T2P5	17.94560, 177.96428	Dry Forest	River flat	15	7	*Syz_mal*	*Cit_gra*	10	31.21	11.1-89.0	13645	*Cit_gra*	46
	T2P6	17.94539, 177.96440	Dry Forest	River flat	10	5	*Syz_mal*	*Syz_mal*	7	18.71	10.3-36.0	2319	*Syz_mal*	69
	T2P7	17.94550, 177.96444	Dry Forest	River flat	15	10	*Syz_mal*	*Dys_ric*	8	23.75	10.4-86.0	7369	*Dys_ric*	80
	T2P8	17.94530, 177.96448	Dry Forest	River flat	24	10	*Den_har; Lit_sp; Dys_sp*	*Dys_sp.*	16	30.93	10.4-61.2	22564	*Dys_sp*	61
	T2P9	17.94539, 177.96448	Dry Forest	River flat	12	5	*Syz_mal*	*End_sp.*	6	19.16	11.3-26.9	1847	*End_sp.*	31
	T2P10	17.94530, 177.96438	Dry Forest	River flat	13	6	*Syz_spp.*	*Deg_vit*	7	14.45	10.4-34.0	1939	*Deg_vit*	48
	T3P1	17.94335, 177.96243	Dry Forest	River flat	13	8	*Cit_gra*	*Bis_jav*	11	14	5.0-50.0	4148	*Bis_jav*	45
	T3P2	17.943384, 177.96234	Dry Forest	River flat	12	11	*Dys_sp.*	*Dys_sp.*	13	23	7.5-51.0	9054	*Dys_sp.*	42
	T3P3	17.943268, 177.96216	Dry Forest	River flat	11	10	*Syz_mal*	*Pom_pin*	13	28	5.7-67.0	15753	*Pom_pin*	22
July 23 2012	T4P1	17.94156, 177.95419	Dry Forest	Ridge top	23	13	*Dys_sp.; Gar_myr*	*Fic_obl*	16	23.1	10.5-132.0	23788	*Fic_obl*	57
	T4P2	17.94159, 177.95659	Dry Forest	Ridge flat	51	21	*Lit_sp.; Cya_sp*	*Bis_jav*	28	17.3	10.0-76.0	20999	*Bis_jav*	26

Date	Plot #	Coordinates	Principal Vegetation Type	Forest/Habitat Type	# Ind. ≥ 5cm	# Tree spp.	Most common spp.	Largest trees	**# Ind. ≥ 10 cm**	Av. dbh(cm)	Range (cm)	**B. area (stems ≥ 10cm dbh)**	Dom. sp.	Rel. dom. (%)
	T4P3	17.94151, 177.95689	Dry Forest	Ridge flat	49	21	*Lit_sp.*	*Bis_jav*	28	23.34	10.3-52.0	14652	*Bis_jav*	32
	T4P4	17.94138, 177.95692	Dry Forest	Ridge flat	35	15	*Cit_gra*	*Dys_sp.*	18	28.8	10.0-67.0	15165	*Dys_que*	31
	T4P5	17.94133, 177.95702	Dry Forest	Ridge flat	28	13	*Cit_gra; Psy _sp.*	*Bis_jav*	14	31.07	11.3-86.0	15050	*Bis-jav*	47
	T4P6	17.94123, 177.95702	Dry Forest	Ridge flat	28	14	*Lit_sp.*	*Dys_que*	15	23.93	10.0-64.0	9955	*Dys_que*	32
	T4P7	17.94107, 177.95716	Dry Forest	Ridge flat	21	10	*Den_vit*	*Can_sp.*	17	13.65	10.0-33.3	3493	*Can_sp.*	12
	T4P8	17.94068, 177.95721	Dry Forest	Ridge flat	36	17	*Lit_sp.*	*Bis_jav*	21	27.86	11.0-77.0	18287	*Bis_jav*	48
	T4P9	17.94073, 177.95702	Dry Forest	Ridge flat	40	25	*Syz_mal*	*Dys_sp.*	24	19.58	10.0-76.0	11565	*Dys_sp.*	53
	T4P10	17.94082, 177.95722	Dry Forest	Ridge flat	34	14	*Gar_myr*	*Bur_sp.*	23	22	10.0-57.0	12037	*Bur_sp.*	21
July 19 2012	T5P1	17.94452, 177.96008	Dry Forest	Slope	16	8	*Cal_vit; Cyn_ sp.*	*Cyn_sp.*	9	13.6	6.0-34.0	2980	*Cyn_sp.*	66
	T5P2	17.94464, 177.96012	Dry Forest	Slope	9	6	*Cal_vit*	*Cal_vit*	8	18.4	6.0-40.0	2938	*Cal_vit*	67
	T5P3	17.94451, 177.96014	Dry Forest	Slope	13	10	*Cal_vit*	*Mac_see*	7	14.3	7.0-25.0	2160	*Mac_see*	40
	T5P4	17.94453, 177.95968	Dry Forest	Slope	8	7	*Cya_lun*	*Cya_lun*	4	13.5	7.0-28.0	1346	*Cya_lun*	36
	T5P5	17.94451, 177.95967	Dry Forest	Slope	13	10	*Cya_lun*	*Neo_for*	9	24.1	8.0-113.0	12844	*Neo_for*	76
	T6P1	17.94151, 177.95428	Dry Forest	Slope	27	11	*Dys_sp.; Lit_sp.; Den_vit*	*Dys_que*	13	40.62	11.0-120.0	28675	*Dys_que*	63
	T6P2	17.94166, 177.95430	Dry Forest	Slope	34	13	*Lit_sp.*	*Dys_que*	18	25.6	10.0-64.3	13853	*Dys_que*	53
	T6P3	17.94180, 177.9543	Dry Forest	Slope	35	10	*Lit_sp.*	*Dys_que*	16	29.75	10.0-99.0	19330	*Dys_que*	77
	T6P4	17.94182, 177.95452	Dry Forest	Slope	27	9	*Den_vit*	*Dys_len*	11	22.18	10.5-67.0	6485	*Dys_len*	54
	T6P5	17.94196, 177.95440	Dry Forest	Slope	25	11	*Den_vit; Lit_sp.*	*Fic_obl*	17	26.35	11.3-148.0	23368	*Fic_obl*	74
	T6P6	17.94149, 177.95449	Dry Forest	Slope	37	14	*Den_vit*	*Dys_sp.*	20	20.35	10.0-58.0	9582	*Dys_sp.*	58
	T6P7	17.94148, 177.95459	Dry Forest	Slope	27	13	*Lit_sp.*	*Dys_ric*	19	25.1	10.0-67.0	12491	*Dys_ric*	36
	T6P8	17.94151, 177.95469	Dry Forest	Slope	20	14	*Lit_sp.*	*Dys_ric*	15	24.46	10.6-64.0	10208	*Dys_ric*	32
	T6P9	17.94161, 177.95473	Dry Forest	Slope	21	10	*Lit_sp.*	*Ela_kam*	11	18.63	10.4-34..0	3770	*Ela_kam*	24

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	T6P10	17.94173, 177.95450	Dry Forest	Slope	23	14	*Lit_sp.*	*Ela_kam*	14	18.36	10.0-33.0	4547	*Ela_kam*	18
July 20 2012	T7P1	17.95583, 177.96355	Upland Rainforest	Ridge top	37	26	*Cal_vit*	*Her_oli*	29	22.97	10.1-64.3	15858	*Cal_vit*	38
	T7P2	17.95568, 177.96365	Upland Rainforest	Ridge top	32	21	*Cal_vit*	*Cal_vit*	21	18.33	10.2-30.7	6138	*Cal_vit*	35
	T7P3	17.95557, 177.96371	Upland Rainforest	Ridge top	22	16	*Gar_myr*	*Cal_vit*	11	17.63	10.0-49.0	3670	*Cal_vit*	55
	T7P4	17.95546, 177.96380	Upland Rainforest	Ridge top	40	21	*Cal_vit; Lit_spp.*	*Dac_nid*	23	19.14	10.0-41.0	7694	*Dac_nid*	17
	T7P5	17.95532, 177.96381	Upland Rainforest	Ridge top	29	16	*Syz_spp.*	*Syz_spp.*	10	30	12.0-65.0	9058	*Syz_spp.*	37
	T7P6	17.95492, 177.96363	Upland Rainforest	Ridge top	26	17	*Gar_myr.*	*Syz_spp.*	10	15.67	5.0-150.0	19772	*Aga_mac*	87
	T7P7	17.95481, 177.96358	Upland Rainforest	Ridge top	41	27	*Cal_vit*	*End_mac*	18	18.9	10.3-37.0	5938	*Bur_sp.*	23
	T7P8	17.95334, 177.96445	Upland Rainforest	Ridge top	34	17	*Syz_spp.*	*Dac_nid*	19	19.47	10.0-67.0	9115	*Dac_nid*	48
	T7P9	17.95330, 177.96435	Upland Rainforest	Ridge top	31	15	*Syz_spp.*	*Dac_nid*	18	21	10.0-59.0	8550	*Dac_nid*	63
	T7P10	17.95340, 177.96434	Upland Rainforest	Ridge top	29	18	*Syz_spp.*	*Syz_spp.; Agl_spp.*	20	17.85	10.0-27.0	5575	*Syz_spp.*	39
	T8P1/753	17.97304, 177.99869	Upland Rainforest	Ridge top	20	17	*none*	*Cal_vit*	12	17.55	7.0-50.0	4107	*Cal_vit*	28
	T8P2/750	17.97302, 177.99860	Upland Rainforest	Ridge top	24	17	*Gir_cel*	*Dys_sp.*	11	15.79	6.0-40.0	1437	*Gir_cel*	4
	T8P3/724	17.97271, 177.99871	Upland Rainforest	Ridge top	22	14	*Gir_cel*	*Cal_vit*	18	20.09	7.0-58.0	11231	*Cal_vit*	25
	T8P4/726	17.97259, 177.99869	Upland Rainforest	Ridge top	27	16	*Gir_cel*	*Syz_sp.*	12	12.93	5.0-27.0	2468	*Lit_sp.*	4
	T8P5/728	17.97259, 177.99867	Upland Rainforest	Ridge top	25	15	*Syz_sp.*	*Aga_mac*	14	20.12	5.0-111.0	16698	*Aga_mac*	56
	T8P6/731	17.97256, 177.99866	Upland Rainforest	Ridge top	20	16	*Psy_ sp.*	*Cal_vit*	16	15.63	7.0-46.0	4655	*Cal_vit*	34
	T8P7/721	17.97272, 177.99877	Upland Rainforest	Ridge top	21	16	*Lit_sp.*	*Cal_vit*	12	14.33	5.0-38.0	3120	*Cal_vit*	10
	T8P8/719	17.97277, 177.99882	Upland Rainforest	Ridge top	17	13	*Lit_sp.*	*Lit_sp;. Fic_smi*	12	16.11	7.0-30.0	4038	*Lit_sp.*	36
	T8P9/718	17.97278, 177.99886	Upland Rainforest	Ridge top	18	14	*Lit_sp.*	*Lit_sp.*	13	15.33	7.0-34.0	3947	*Lit_sp.*	45
	T8P10/753	17.97304, 177.99870	Upland Rainforest	Ridge top	18	12	*Gir_cel; Lit_sp.*	*Myr_cas*	11	18.94	5.0-75.0	8757	*Myr_cas*	49
	T10P1/733	17.97304, 177.99867	Upland Rainforest	Ridge top	53	29	*Gar_pse*	*Aga_mac*	23	13.54	5.0-140.0	23442	*Aga_mac*	63

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	T10P2/731	17.94980, 177.99630	Upland Rainforest	Ridge top	51	21	*Syz_sp.*	*Aga_mac*	24	12.37	5.0-62.0	10229	*Aga_mac*	34
	T10P3/712	17.95120, 177.99072	Upland Rainforest	Ridge slope	55	24	*Syz_sp.*	*Aga_mac*	26	13.4	6.0-152.0	22879	*Aga_mac*	75
	T10P4/663	17.95328, 177.00103	Upland Rainforest	Ridge top	54	23	*Gar-pse*	*Dec_vit*	20	14.61	5.0-107.0	16135	*Dec_vit*	18
	T10P5/728	17.95050, 177.99830	Upland Rainforest	Flat	30	16	*Cya_sp.*	*End_mac*	16	15.03	5.0-58.0	95	*End_mac*	31
	T10P6/737	17.95051, 177.99851	Upland Rainforest	Flat	24	14	*Gir_cel; Gar_pse*	*Myr_sp.*	11	15.46	5.0-44.0	93	*End_mac*	34
July 21 2012	T11P1	17.95540, 177.96350	Upland Rainforest	Slope	32	20	*Cry_spp.*	*Cal_vit*	14	13.49	5.0-65.0	7205	*Cal_vit*	22
	T11P2	17.95530, 177.96342	Upland Rainforest	Slope	21	14	*Cya_lun; Cal_vit*	*End_mac*	18	20.65	5.0-65.0	13351	*End_mac*	33
	T11P3	17.95523, 177.96352	Upland Rainforest	Slope	23	19	*None*	*End_spp.*	16	19.2	5.0-61.5	10760	*End_mac*	27
	T11P4	17.95271, 177.96400	Upland Rainforest	Slope	44	25	*Cal_vit*	*Aga_mac*	22	22.82	10.0-69.0	11958	*Aga_mac*	31
	T11P5	17.95267, 177.96400	Upland Rainforest	Slope	44	23	*Cya_aff*	*End_mac*	21	19.71	10.5-48.0	8103	*End_mac*	23
	T11P6	17.95234, 177.96401	Upland Rainforest	Slope	34	23	*Sau_rub*	*Sem_vit*	14	25.5	10.7-47.0	8615	*Sem_vit*	20
	T11P7	17.95244, 177.96401	Upland Rainforest	Slope	30	18	*Dol_lat*	*Deg_vit*	10	18.48	10.0-33.0	3051	*Deg_vit*	27
	T11P8	17.95254, 177.96401	Upland Rainforest	Slope	23	18	*None*	*Buc_vit*	10	20.1	10.0-63.0	4901	*Buc_vit*	64
	T11P9	17.95234, 177.96351	Upland Rainforest	Slope	10	8	*Gir_cel*	*End_mac*	5	14.5	11.0-41.1	2717	*End_mac*	47
March 23 2013	T9P1/708	17.97644, 178.0018	Upland Rainforest	Slope	29	19	*Gar_myr*	*Gar_myr*	11	17.38	5.0-89.0	16348	*Gar_myr*	48
	T9P2/707	17.97345, 177.99920	Upland Rainforest	Slope	23	16	*Gir_cel*	*Syz_sp.*	14	18	7.0-63.0	8953	*Syz_sp.*	33
	T9P3/698	17.97337, 177.99918	Upland Rainforest	Slope	22	13	*none*	*Cal_vit*	15	20.09	7.0-68.0	11541	*Par_ins*	31
	T9P4/699	17.97339, 177.99918	Upland Rainforest	Slope	20	14	*Lit_ sp.*	*Lit_sp.*	14	19.5	6.0-65.0	8776	*Lit_sp.*	58
	T10P5/726	17.95030, 177.99750	Upland Rainforest	Slope	25	12	*Gar_pse; Gir_cel*	*Cya_sp.*	17	15.72	5.0-54.0	7129	*Cya_sp.*	31
	T10P6/735	17.95000, 177.99770	Upland Rainforest	Slope	40	21	*Gir_cel; Myr_sp.*	*Gar_pse*	21	10.8	5.0-32.0	3320	*Gar_pse*	19
March 23 2013	T12P1/1104	17.95310, 178.00850	Cloud Rainforest	Slope	47	12	*Dic_bra*	*Cal_vit*	25	10.51	5.0-22.0	4040	*Cal_vit*	85
	T12P2/1113	17.95300, 178.00840	Cloud Rainforest	Slope	34	11	*Cya_sp.*	*Cal_vit*	24	12.26	5.0-41.0	4720	*Cal_vit*	31

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	T12P3/1090	17.95290, 178.00820	Cloud Rainforest	Slope	35	14	*Cya_sp.*	*Cal_vit*	16	11.91	5.0-60.0	5622	*Cal_vit*	48
	T12P4/1068	17.95260, 178.00770	Cloud Rainforest	Slope	31	16	*Syz_sp.*	*Ast_ sp.*	10	11.95	5.0-39.0	94	*Ast_ sp.*	18
	T12P5/1034	17.95220, 178.00720	Cloud Rainforest	Slope	32	12	*Cya_sp.*	*Cya_med*	16	12.94	5.0-34.0	91	*Syz_sp.*	18
	T12P6/1071	17.95270, 178.00790	Cloud Rainforest	Flat	42	12	*Cya_ sp.*	*Syz_sp.*	23	12.04	5.0-30.0	87	*Syz_sp.*	35
	T12P7/1035	17.95210, 178.00700	Cloud Rainforest	Flat	54	15	*Mac_see*	*Deg_vit*	28	13.7	5.0-43.0	15663	*Deg_vit*	16
	T12P8/1052	17.95250, 178.00750	Cloud Rainforest	Ridge top	41	22	*Syz_sp.*	*Cya_* cf. *ins*	21	12.84	5.0-30.0	87	*Cya_* cf. *ins*	26
	T12P9/1025	17.95180, 178.00610	Cloud Rainforest	Slope-ridge	30	13	*Syz_sp.*	*Cya_sp.*	18	11.95	5.0-31.0	4800	*Cya_sp.*	23
	T12P10/990	17.95150, 178.00580	Cloud Rainforest	Ridge top	42	19	*Cit_ vit*	*Cal_vit*	23	13.63	5.0-36.0	5526	*Cal_vit*	22
	T12P11/1022	17.94950, 177.98990	Cloud Rainforest	Ridge top	70	22	*Syz_sp.*	*Syz_sp.*	35		5.0-181.0	97	*Syz_sp.*	82
March 23 2013	T13P1/484	17.98216, 178.00836	Lowland Rainforest	Ridge top	33	19	*Gir_ cel*	*Bur_fij*	22	14.67	5.0-49.0	7670	*Bur_ fij*	23
	T13P2/482	17.98215, 178.00835	Lowland Rainforest	Ridge top	24	11	*Gir_ cel; Vei_vit*	*Gon_pun*	13	13.2	6.0-36.0	3909	*Man_flo*	23
	T13P3/480	17.98210, 178.00830	Lowland Rainforest	Ridge top	9	8	*none*	*Syz_ sp.*	6	15.22	5.0-42.0	2432	*Syz_sp.*	56
	T13P4/485	17.98218, 178.00837	Lowland Rainforest	Ridge top	17	9	*Gar_ myr*	*Cal_vit*	7	14.47	5.0-57.0	4825	*Cal_vit*	49
	T13P5/479	17.98209, 78.00830	Lowland Rainforest	Ridge top	18	8	*Gar_myr*	*Myr_cas*	11	22	5.0-74.0	11694	*Cal_vit*	42
	T13P6/478	17.98208, 178.00829	Lowland Rainforest	Ridge top	17	10	*Gar_ myr*	*Bur_fij*	11	16.71	6.0-51.0	5218	*Bur_fij*	37
	T13P7/480	17.98206, 178.00825	Lowland Rainforest	Ridge top	24	12	*Cal_vit; Gir_cel*	*Syz_sp.*	14	16.1	5.0-32.0	4926	*Syz_sp.*	16
	T13P8/481	17.98200, 178.00820	Lowland Rainforest	Ridge top	24	11	*Fic_smi*	*End_mac*	14	22.77	5.0-98.0	16565	*End_mac*	45
	T13P9/482	17.98204, 178.00818	Lowland Rainforest	Ridge top	24	7	*Gar_myr*	*Syz_sp.*	3	8	5.0-15.0	425	*Syz_sp.*	25
	T13P10/482	17.98210, 178.00815	Lowland Rainforest	Ridge top	24	14	*Gar_myr*	*Cal_vit*	17	18	5.0-55.0	10226	*Cal_vit*	29
	T14P1/614	17.97558, 178.00117	Lowland Rainforest	Ridge top	39	19	*Gar_myr*	*End_mac*	17	14.21	5.0-95.0	12100	*End_mac*	55
	T14P2/610	17.97550, 178.00116	Lowland Rainforest	Ridge top	36	14	*Gar_myr*	*Can_har*	18	14.33	5.0-37.0	6551	*Can_har*	20
	T14P3/612	17.97555, 178.00115	Lowland Rainforest	Ridge top	28	17	*Syz_sp.*	*Syz_sp.*	12	14.14	6.0-41.0	5691	*Syz_sp.*	37

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	T14P4/613	17.97558, 178.00114	Lowland Rainforest	Ridge top	22	9	*Gar_myr*	*Fic_smi*	13	13.2	5.0-25.0	3380	*Gar_myr*	69
	T14P5/619	17.97557, 178.00119	Lowland Rainforest	Ridge top	33	15	*Gar_myr*	*Syz_sp.*	16	12.72	5.0-40.0	5223	*Syz_sp.*	22
	T14P6/614	17.97556, 178.00118	Lowland Rainforest	Ridge top	28	12	*Gar_myr*	*Cal_vit*	13	13.32	6.0-48.0	5563	*Cal_vit*	42
	T14P7/612	17.97552, 178.00113	Lowland Rainforest	Ridge top	15	7	*Gar_myr*	*Tur_vit*	8	13.93	6.0-43.0	2910	*Tur_vit*	45
	T14P8/599	17.97549, 178.00109	Lowland Rainforest	Ridge top	25	12	*Gar_myr*	*Cal_vit*	12	15.12	6.0-82.0	11423	*Cal_vit*	44
	T14P9/595	17.97550, 178.00112	Lowland Rainforest	Ridge top	29	11	*Gar_myr*	*Syz_sp.*	20	16.34	5.0-62.0	8808	*Syz_sp.*	38
	T14P10/598	17.97540, 178.00109	Lowland Rainforest	Ridge top	25	16	*Gar_myr*	*Myr_mac*	14	12.16	5.0-32.0	3460	*Myr_mac*	21
March 23 2013	T15P1/490	17.98268, 178.00916	Lowland Rainforest	Slope	13	9	*none*	*Fic_smi*	8	14.08	5.0-24.0	114	*Gar_myr*	1
	T15P2/489	17.98267, 178.00910	Lowland Rainforest	Slope	11	9	*Gar_myr*	*Myr_cas*	5	15.09	5.0-50.0	3219	*Myr_cas*	1
	T15P3/488	17.98270, 178.00911	Lowland Rainforest	Slope	17	11	*Gar_myr*	*Gar_myr*	7	10.17	5.0-24.0	415	*Gar_myr*	19
	T15P4/486	17.98265, 178.00915	Lowland Rainforest	Slope	12	8	*Gar_myr*	*Gar_myr*	7	17.5	5.0-52.0	3708	*Gar_myr*	61
	T15P5/492	17.98261, 178.00910	Lowland Rainforest	Slope	18	7	*Gar_myr*	*Syz_sp.*	10	14.72	5.0-35.0	2339	*Gar_myr*	30
	T15P6/480	17.98269, 178.00917	Lowland Rainforest	Slope	19	16	*none*	*Pal_sp.*	9	12.1	5.0-33.0	1836	*Pal_sp.*	1
	T15P7/479	17.98259, 178.00911	Lowland Rainforest	Slope	20	11	*Gar_myr*	*Myr_cas*	13	17.55	5.0-46.0	5636	*Myr_cas*	47
	T15P8/478	17.98258, 178.00910	Lowland Rainforest	Slope	13	8	*Gar_myr*	*Sto_vit*	7	15.08	5.0-78.0	8351	*Sto_vit*	2
	T15P9/476	17.98257, 178.00909	Lowland Rainforest	Slope	23	11	*Gar_myr*	*Pal_ sp. ; Myr_cha*	10	12.56	5.0-36.0	1006	*Myr_cha*	2
March 23 2013	T16P1/624	17.97644, 178.00183	Lowland Rainforest	Slope	26	14	*Gar_myr*	*End_mac*	19	21.81	6.0-100.0	17213	*End_mac*	45
	T16P2/623	17.97479, 178.00065	Lowland Rainforest	Slope	15	10	*Gar_myr*	*Myr_cas*	10	14.8	6.0-28.0	2962	*Myr_cas*	23
	T16P3/622	17.97487, 178.00073	Lowland Rainforest	Slope	20	9	*Gir_cel*	*Gar_myr*	11	11.5	6.0-31.0	2478	*Gar_myr*	35
	T16P4/621	17.97491, 178.00079	Lowland Rainforest	Slope	19	12	*Gar_myr*	*Xyl_sp.*	10	12.79	6.0-25.0	90	*Gar_myr*	38
	T16P5/620	17.97450, 178.00083	Lowland Rainforest	Slope	22	11	*Gar_myr*	*Bur_fij*	15	15.32	5.0-36.0	5050	*Bur_fij*	19
	T16P6/619	17.97503, 178.00086	Lowland Rainforest	Slope	26	15	*Gar_myr*	*Syz_sp.*	17	14.96	6.0-33.0	5526	*Syz_sp.*	26

Date	Plot #	Coordinates	Principal Vegetation Type	Forest/Habitat Type	# Ind. ≥ 5cm	# Tree spp.	Most common spp.	Largest trees	**# Ind. ≥ 10 cm**	Av. dbh(cm)	Range (cm)	**B. area (stems ≥ 10cm dbh)**	Dom. sp.	Rel. dom. (%)
	T16P7/620	17.97508, 178.00088	Lowland Rainforest	Slope	28	13	*Gar_myr*	*Cal_vit*	13	12.32	5.0-40.0	3985	*Cal_vit*	29
	T16P8/ 618	17.974836, 178.00069	Lowland Rainforest	Slope	21	10	*Gar_myr*	*Cal_vit*	13	17.19	5.0-39.0	6494	*Cal_vit*	18
March 23 2013	T2P1/492	17.98269, 178.00917	Lowland Rainforest	River flat	15	12	*Gar_myr*	*Pal_por*	10	18.67	5.0-48.0	5028	*Pal_por*	14
	T1P2/657	17.95400, 177.99150	Lowland Rainforest	River flat	33	15	*Gar_pse*	*Dec_vit*	15	16.42	5.0-131.0	24156	*Dec_vit*	86
	T1P3/656	17.95281, 177.99173	Lowland Rainforest	River flat	28	16	*End_gil*	*Deg_vit*	20	16.36	5.0-55.0	7417	*Deg_vit*	30

Keys to abbreviations of acronyms of species used are:

Aga_mac=*Agathis macrophylla*
Agl_sp.=*Aglaia* species
Amo_sou=*Amoraria soulameoides*
Ast_sp.=*Astronidium* species
Bac_sp.=*Baccaurea* species
Bis_jav=*Bischofia javanica*
Buc_vit=*Buchanania vitiensis*
Bur_fij=*Burckella fijiensis*
Bur_sp.=*Burckella* species
Cal_vit=*Calophyllum vitiense*
Can_har=*Canarium harveyi*
Can_sp.=*Canarium* species
Cit_gra=*Citrus grandis*
Cit_vit=*Citronella vitiensis*
Cry_sp.=*Cryptocarya sp.*
Cya_aff=*Cyathea affinis*
Cya_lun=*Cyathea lunulata*
Cya_sp.=*Cyathea* species
Cya_c.f. ins=*Cyathocalyx* cf. *insularis*
Cyn_fal=*Cynometra falcata*
Cyn_sp.=*Cynometra* species
Dac_nid=*Dacrydium nidulum*
Dec_vit=*Decussocarpus vitiensis*
Deg_vit=*Degeneria vitiensis*
Den_har=*Dendrocnide harveyi*
Den_vit=*Dendrocnide vitiensis*
Dic_bra=*Dicksonia brackenridgei*
Dol_lat=*Dolicholobium latifolium*
Dys_len=*Dysoxylum lenticellare*
Dys_que=*Dysoxylum quercifolium*
Dys_sp.=*Dysoxylum* species
Dys_ric=*Dysoxylum richii*
Ela_kam=*Elaeocarpus kambi*
End_gil=*Endiandra gillespiei*
End_sp.=*Endiandra species*
End_mac=*Endospermum macrophyllum*
Fic_obl=*Ficus oblique*
Fic_smi=*Ficus smithii*
Gar_myr= *Garcinia myrtifolia*
Gar_pse=*Garcinia pseudoguttifera*
Gar_sp=*Garcinia* species
Gir_cel=*Gironniera celtidifolia*
Gon_pun=*Gonystylus punctatus*
Hap_flo=*Haplolobus floribundus*
Her_oli=*Hernandia olivacea*
Lit_sp.=*Litsea* species
Mac_see=*Macaranga seemannii*
Mac_sp.=*Macaranga species*
Man_flo=*Maniltoa floribunda*
Man_gra=*Maniltoa grandiflora*
Myr_cha=*Myristica chartacea*
Myr_cas=*Myristica castaneifolia*
Neo_for=*Neonauclea forsteri*
Pal_por=*Palaquium porphyreum*
Pal_sp.=*Palaquium* species
Par_ins=*Parinari insularum*
Pom_pin=*Pometia pinnata*
Psy_sp.=*Psychotria* species
Psy_tur=*Psychotria turbinata*
Sau_rub=*Saurauia rubicunda*
Sem_vit=*Semecarpus vitiensis*
Sto_vit=*Storckiella vitiensis*
Syz_mal=*Syzygium malaccense*
Syz_spp.=*Syzygium* species
Tur_vit=*Turrillia vitiensis*
Vei_vit=*Veitchia vitiensis*
Xyl_sp.=*Xylopia* species

Other acronyms used are:
Veg. = Vegetation; #Ind. = number of individuals; com. = common; Av. = Average; dbh = diameter at breast height; B. area = Basal area; Dom. sp. = Dominant species; Rel. dom. = relative dominance

Appendix 4. Description of forest and non-forest habitat types

Cover	Veg. type	Forest type	Impacts	Habitat Description and its acronym	Assessment
Forested	Lowland	Flat (river flat)	Low	Primary forest, 75-100% canopy cover, 50-90% ground cover, >90% native flora; general absence of weeds and invasive species; no known history of logging. Farming and/or human habitation may have taken place since time immemorial. LfCF low	Observed and assessed
Forested	Lowland	Flat	Medium	Transition (secondary and primary) forest; weeds, invasive and secondary succession plants are present; may have history of damage from natural disasters and/or human habitation. LfCF medium	Present but not observed and assessed.
Forested	Lowland	Ridge Top	Low	Primary forest; 75-100% crown cover with 25-50% ground cover; >90% native flora; general absence of weeds and invasive species; no known history of logging, mine exploration, farming; trees with dbh >35cm are common. LfCR low	Observed and assessed
Forested	Lowland	Ridge	Medium	Transition (secondary and primary) forest; 50-75% canopy and ground cover; high density of succession plants; history of selective logging and natural disaster; overall absence of large trees (dbh >50cm) LfCR medium	Present but not assessed
Forested	Lowland	Slope	Low	Primary forest, 75-100% canopy cover, <25-50% ground cover, >90% native flora; no known history of logging, mine exploration, farming; trees with DBH >35cm are common. LfCS low	Observed and assessed
Forested	Lowland	Slope	Medium	Transition (secondary and primary) forest; 50-75% canopy cover; 75-100% ground cover; some invasive and weeds present and some culturally important species. The forest is regularly visited by the local inhabitants. LfCS medium	Present but not assessed
Forested	Upland	Flat	Low	Assumed to have primary forest; high percentage of native flora.	Not observed on this survey.
Forested	Upland	Ridge	Low	Primary forest, 75-100% canopy cover, 50-75% ground cover with greater diversity of herbs, shrubs and climbers; stems of trees covered with mosses and liverworts; no known history of logging, >98% native flora. Lots of large trees present.	Observed and assessed

Cover	Veg. type	Forest type	Impacts	Habitat Description and its acronym	Assessment
Forested	Upland	Slope	Low	Primary forest; 75-100% crown cover; 25-50% ground cover; stems of trees covered with mosses and liverworts; no known history of logging, >98% native flora.	Observed and assessed
Forested	Cloud Forest	Slope	Low	Assumed to have primary forest; high percentage of native flora.	Present but not visited
Forested	Cloud Forest	Flat	Low	Assumed to have primary forest; high percentage of native flora.	Present but not visited
Forested	Cloud Forest	Ridge	Low	Assumed to have primary forest; high percentage of native flora.	Present but not visited
Forested	Dry Forest	Riparian	Medium	Smaller creeks and streams without associated flood plains; 75-100% crown cover.	Present, observed but not assessed
Forested	Dry Forest	Riparian	Low	Mostly restricted to the upper streams/creek and head waters; canopy is closed with lots of bryophytes and filmy ferns on stream banks. General lack of invasive and weedy species.	Observed but not assessed
Non-forested	Talasiga/ grassland	Woody shrubland	Medium	Here a mixture of the grass *Pennisetum polystachyon*, the reed *Miscanthus floridulus* and woody shrubs of most secondary succession plants with an occasional clump of the native bamboo *Schizostachyum glaucifolium* characterises this habitat.	Observed but not assessed
Non-forested	Talasiga/ grassland	River bank/ riparian	High	These are systems that are dominated by the grass *P. polystachyon*, the ferns *Pteridium* spp. and *Dicranopteris* spp. Trees and shrubs are literally absent except for some that may be found in gullys.	Observed but not assessed.

Appendix 5. Herpetofauna suvey sites locations and sampling methods

Site	Location (map reference points)	Vegetation description	Date	Sampling method	Weather	Time Span	Hours
Nasa catchment							
1	Ridge above base camp TOVH-15, 19	Ridge forest	21/7/2012	Opportunistic visual	100% cloud Rain	0900-1400	5
	TOVH-15, 16, 17, 18, 19	Ridge forest	22/7/2012	Standard sticky trap	100% cloud Fine	1150-1330	25.5
	TOVH-15, 19	Ridge forest	23/7/2012	Standard visual	100% cloud Fine	1133-1415	2.5
2	Wainirovurovu Stream	Stream and riparian vegetation	20/7/2012	Standard nocturnal	100% cloud Fine	1831-1931	1
3	Mataemalu TOVH- 3, 14	Lowland forest	23/7/2012	Standard visual	100% cloud Fine	0900-1330	4.5
	Mataemalu TOVH- 3, 4, 5, 6, 7, 8, 10, 11, 12, 14	Lowland forest	23/7/2012	Standard sticky trap	100% cloud Fine	0900-0900	24
4	Nasa River TOVH- 21, 22	Inland river bank	23/7/2012	Standard nocturnal	10% cloud Fine	1813-2036	2
Waikarakarawa catchment							
1	Wainivilekutu	Stream and riparian vegetation	21/3/2013	Standard nocturnal	100% cloud Fine	1900-2000	1
2	Waikutukutuvatu	Stream and riparian vegetation	23/3/2013	Standard nocturnal	100% cloud Fine	1800-1930	1.5
3	Waikarakarawa Base Camp	Stream and riparian vegetation	23/3/2013	Standard nocturnal	100% cloud Fine	1930-2030	1
4	Waikarakarawa Base Camp	Stream bank	24/3/2012	Standard sticky trap	30% cloud Fine	1230-1430 (next day)	26
Mavuvu catchment							

Site	Location (map reference points)	Vegetation description	Date	Sampling method	Weather	Time Span	Hours
5	Main ridge to Mt. Vonolevu	Upland cloud forest		Opportunistic visual	100% cloud Rain	1100-1500	4
6	Main ridge into Mavuvu catchment	Lowland rainforest		Opportunistic visual	60% cloud	0730-1230	4

Appendix 6. Conservation status of herpetofauna species known from Viti Levu

Target endemic and extirpated species (*) and species captured during this survey (†).

Scientific name	Common name	Fijian name (Navosa dialect)	Conservation Status
Iguanas			
Brachylophus bulabula	*Banded iguana	Vokai, saumure	Viti Levu endemic Critically Endangered
Snakes			
Candoia bibronii	Pacific boa	Gata (qwata)	Native
Ogmodon vitianus	*Fiji burrowing snake	Gata/ Bolo	Viti Levu endemic
Geckoes			
Gehyra vorax	†Giant forest gecko	Moko kabi	Native
Gehyra oceanica	Oceanic gecko	Moko kabi	Native
Lepidodactylus lugubris	Mourning or Pacific gecko	Moko kabi	Introduced
Lepidodactylus manni	*Mann's Gecko	Moko kabi	Endemic
Nactus pelagicus	†Slender toed gecko	Moko	Native
Hemidactylus frenatus	House gecko		Introduced
Hemidactylus garnotti	Fox gecko		Introduced
Hemiphyllodactylus typus	Indopacific tree gecko		Native
Skinks			
Emoia nigra	*Pacific black skink	Moko loa	Native, extirpated from Viti Levu
Emoia trossular	*Barred tree skink	Moko sari	Native, extirpated from Viti Levu
Lipinia noctua	Moth skink		Native
Cryptoblepharus eximus	*Pygmy snake-eyed skink		Endemic
Emoia campbelli	*Montane tree skink		Endemic
Emoia concolor	*†Green tree skink	Moko sari	Endemic
Emoia sp. *novum?*	*		Endemic to Viti Levu
Emoia impar	Blue-tailed copper-striped skink	Moko sari	Native
Emoia cyanura	Brown-tailed copper-striped skink	Moko sari (Boliti)	Native
Emoia parkeri	*†Bronze-headed skink	Moko sari	Endemic
Amphibians			
Bufo marinus	†Cane toad	Boto karokaro	Introduced, invasive
Platymantis vitiensis	*†Fiji tree frog	Ula	Endemic, Near Threatened
Platymantis vitianus	*Fiji ground frog	Ula, Dreli, Botoniviti	Endemic, Critically Endangered

Appendix 7. Avifauna species checklist, distribution and abundance

Common name	Status	Distribution	Abundance (#/ km²)
Barking Pigeon		Endemic	157
Black-face Shrikebill	VU	Native	5
Blued crested Broadbill		Endemic (subspecies endemic to Viti Levu)	51
Collared Lory	Cites Appendix II	Endemic	21
Fantail Cuckoo		Endemic (subspecies)	13
Fiji bush Warbler		Endemic	208
Fiji Goshawk	Cites Appendix II	Endemic (subspecies endemic to Viti Levu)	7
Fiji Parrotfinch		Endemic	31
Fiji Woodswallow		Endemic	9
Giant forest Honeyeater		Endemic	125
Golden Dove		Endemic	51
Golden Whistler		Endemic (subspecies)	36
Friendly ground Dove	VU	Native	7
Island Thrush		Endemic (subspecies)	52
Lesser Shrikebill		Endemic (subspecies)	23
Long-legged Warbler	EN	Endemic (subspecies endemic to Viti Levu)	16
Many-coloured fruit Dove		Native	5
Orange breasted Myzomela		Endemic	87
Pacific black Duck		Native	3
Pacific Harrier	Cites Appendix II	Native	4
Pink-billed Parrotfinch	VU	Endemic to Viti Levu	4
Polynesian Starling		Endemic (subspecies)	5
Polynesian Triller		Endemic (subspecies endemic to Viti Levu)	76
Red vented Bulbul	(exotic, invasive)	Introduced	16
Scarlet Robin		Endemic (subspecies)	33
Silvereye		Native	33
Slaty Monarch		Endemic	28
Streaked Fantail		Endemic (subspecies)	52
Yellow-breasted musk parrot		Endemic to Viti Levu	56
Vanikoro Broadbill		Endemic (subspecies)	39
Wattled Honeyeater		Native	77
White-collared Kingfisher		Endemic (subspecies)	5
White-rumped Swiftlet		Native	12

Common name	Status	Distribution	Abundance (#/ km²)
White-throated Pigeon		Endemic (subspecies)	1
Fiji White-eye		Endemic	251
Samoan flying fox	Cites Appendix I	Endemic (subspecies)	15
Pacific flying fox	Cites Appendix I	Native	2
Species likely to be present, but not recorded			
Eastern Reef heron		Native	
Peregrine falcon	AR	Native	
Red throated Lorikeet	CR	Endemic	
Barn Owl		Native	
IUCN Red List: CR=Critically endangered; VU=Vulnerable; EN=Endangered. Fiji threat status: AR, at risk			

Appendix 8. Location of point count stations, habitat and birds recorded

Station	Longitude	Latitude	No. of birds	No. of species	Vegetation/habitat type	Habitat
1	177.93285	17.94032	12	6	secondary lowland forest	riparian
2	177.93155	17.94189	25	12	plantation, garden lowland	slope
3	177.93013	17.94394	3	2	secondary lowland forest	riparian
4	177.9292	17.94554	16	8	plantation, garden lowland	slope
5	177.93074	17.94513	16	7	grassland	slope
6	177.93211	17.94672	16	8	grassland	ridge slope
7	177.93391	17.94539	9	5	secondary lowland forest	ridge top
8	177.93318	17.94334	9	4	secondary lowland forest	ridge top
9	177.93517	17.9404	13	6	plantation, garden lowland	flat
10	177.93736	17.93911	5	4	secondary lowland forest	riparian
11	177.95975	17.94377	12	8	primary lowland forest	flat
12	177.95853	17.94216	16	14	primary lowland forest	steep slope
13	177.9563	17.9416	12	10	primary lowland forest	ridge slope
14	177.94504	17.94159	12	6	primary lowland forest	steep slope
15	177.96205	17.94467	15	9	primary lowland forest	flat
16	177.96169	17.94676	14	10	primary lowland forest	ridge top
17	177.96271	17.94855	11	9	primary lowland forest	steep slope
18	177.98424	17.9673	12	7	primary lowland forest	riparian
19	177.98227	17.96482	14	7	secondary lowland forest	flat
20	177.9807	17.96259	15	9	secondary lowland forest	flat
21	177.97766	17.95999	16	11	secondary lowland forest	flat
22	177.97585	17.95988	9	5	primary lowland forest	steep slope
23	177.97388	17.95921	21	12	primary lowland forest	ridge
24	177.97185	17.9572	9	8	primary lowland forest	ridge
25	177.96951	17.95697	17	10	primary lowland forest	ridge top
26	177.96312	17.94414	14	8	primary lowland forest	steep slope
27	177.96538	17.94351	17	8	primary lowland forest	ridge
28	177.96793	17.94335	25	14	primary lowland forest	ridge
29	177.96785	17.94516	10	8	primary lowland forest	ridge slope
30	177.96999	17.94598	10	8	primary lowland forest	riparian
31	177.97156	17.94579	13	7	primary lowland forest	riparian
32	177.95189	17.94689	10	8	secondary lowland forest	riparian
33	177.95375	17.94677	3	2	primary lowland forest	slope
34	177.95584	17.94637	11	5	primary lowland forest	steep slope

Station	Longitude	Latitude	No. of birds	No. of species	Vegetation/habitat type	Habitat
35	177.9646	17.94497	21	10	primary lowland forest	flat
36	177.96185	17.94283	24	11	primary lowland forest	steep slope
37	177.96382	17.95281	23	13	primary lowland forest	ridge
38	177.97212	17.96587	7	5	primary lowland forest	riparian
39	177.97183	17.96945	11	9	secondary lowland forest	riparian
40	177.97214	17.97586	4	3	primary lowland forest	slope
41	177.97133	17.97986	13	8	primary lowland forest	flat
42	177.97057	17.99098	20	8	primary lowland forest	slope
43	177.97188	17.99266	12	8	primary lowland forest	ridge slope
44	177.9725	17.99568	15	10	primary lowland forest	ridge
45	177.97156	17.97309	6	4	primary lowland forest	slope
46	177.97331	17.99778	21	12	primary lowland forest	ridge slope
47	177.97435	17.00055	24	11	primary lowland forest	ridge
48	177.9769	17.00301	22	14	primary lowland forest	ridge
49	177.95966	17.99751	7	5	primary lowland forest	riparian
50	177.95729	17.99587	8	5	primary lowland forest	slope
51	177.95514	17.99372	8	6	primary lowland forest	slope
52	177.95357	17.99063	4	2	primary lowland forest	ridge
53	177.9523	17.98797	2	2	primary upland forest	ridge
54	177.94458	17.97956	12	8	primary cloud forest	ridge slope
55	177.9429	17.97705	8	8	primary upland forest	slope
56	177.94034	17.97512	7	6	primary lowland forest	slope
57	177.93669	17.97383	7	6	primary lowland forest	ridge
58	177.93285	17.97309	17	10	primary lowland forest	slope
59	177.92996	17.97395	18	12	secondary lowland forest	ridge slope
60	177.99716	17.97207	7	7	primary cloud forest	ridge
61	178.00037	17.96806	5	5	primary cloud forest	ridge
62	178.0006	17.96531	5	7	primary cloud forest	ridge top
63	177.99872	17.9638	8	5	primary cloud forest	ridge slope
64	177.99286	17.99286	6	5	primary upland forest	ridge
65	177.99152	17.95473	12	8	primary upland forest	riparian
66	177.99185	17.95199	5	6	primary upland forest	riparian
67	177.9931	17.95256	15	12	primary upland forest	flat
68	177.99527	17.9504	11	5	primary upland forest	slope
69	177.99924	17.9506	4	14	primary upland forest	ridge flat
70	178.00458	17.95373	7	11	primary cloud forest	ridge
71	178.00958	17.95391	7	4	secondary cloud forest	ridge top

Station	Longitude	Latitude	No. of birds	No. of species	Vegetation/habitat type	Habitat
72	178.00525	17.94992	12	6	primary cloud forest	ridge
73	178.0036	17.94737	10	6	primary cloud forest	slope
74	177.99036	17.94921	9	12	primary cloud forest	ridge top
75	177.99072	17.95205	8	10	primary upland forest	ridge
76	177.98587	17.9674	6	11	primary upland forest	slope
77	177.98634	17.96457	10	9	primary upland forest	ridge
78	177.98796	17.96216	7	7	primary upland forest	ridge
79	177.98918	17.95978	8	12	primary upland forest	riparian
80	177.98709	17.96027	11	7	primary upland forest	slope
81	177.98814	17.96805	5	8	primary upland forest	ridge
82	177.99052	17.96877	9	12	primary upland forest	ridge
83	177.99176	17.9706	12	9	primary upland forest	ridge slope
84	177.99113	17.97244	5	13	primary upland forest	slope
85	177.98918	17.97278	7	6	primary upland forest	slope
86	177.98708	17.97298	4	7	primary lowland forest	riparian
87	177.98601	17.97147	7	5	primary lowland forest	slope
88	177.98538	17.96977	5	6	primary lowland forest	slope
89	177.99361	17.9715	8	8	primary upland forest	ridge
90	177.99567	17.97143	7	13	primary cloud forest	ridge
91	177.99887	17.97315	5	7	primary upland forest	ridge
92	178.00041	17.97448	7	8	primary cloud forest	ridge
93	178.00175	17.97624	8	9	primary upland forest	ridge
94	178.00314	17.97803	4	5	primary lowland forest	ridge top
95	178.00414	17.98059	7	7	primary lowland forest	slope
96	178.00781	17.98191	6	7	primary lowland forest	slope
97*	177.91397	17.96840	>1000 individuals		Secondary lowland forest	Slope

* Location of *Pteropus tonganus* roost

Appendix 9. Focal avifauna species recorded within Emalu

Common name	Scientific name	Status	Abundance (#/km²)
Land birds			
Black-face Shrikebill	*Clytorhynchus nigrogularis*	VU	5
Collared Lory	*Phigys solitarius simus*	CITES Appendix II	21
Fiji Goshawk	*Accipiter rufitorques*	CITES Appendix II	7
Friendly ground Dove	*Gallicolumba stairi*	VU	7
Long-legged Warbler	*Trichocichla rufa rufa*	EN	16
Pacific Harrier	*Circus approximans*	CITES Appendix II	4
Pink-billed Parrotfinch	*Erythrura kleinschmidti*	VU	4
Red-vented Bulbul	*Pycnotus cafer*	Invasive*	16
Bats			
Samoan flying fox	*Pteropus samoensis*	NT, CITES Appendix I	15
Tongan flying fox	*Pteropus tonganus*	CITES Appendix I	2
IUCN Red List: NT=Near Threatened; VU=Vulnerable; EN=Endangered. *Exotic invasive, restricted to grassland and open secondary forest habitats			

Appendix 10. Species checklist of insects and arachnids in the Tovatova catchment

Key: * = known endemics ** = endemic and focal species.

Order	Family	Scientific name	Light Traps	Leaf Litter	Pitfall Traps	Active search	Opportunistic
Coleoptera	Anthribidae		-	18	4	-	-
	Cerambycidae		1	-	-	-	-
	Chrysomelidae		1	7	7	-	-
	Corylophidae		-	20	13	-	-
	Curculionidae		3	83	26	-	-
	Elateridae		3	-	-	-	-
	Endomychidae		-	2	2	-	-
	Eucnemidae		1	-	-	-	-
	Languriidae		-	6	11	-	-
	Mordellidae		1	-	-	-	-
	Nitidulidae		-	4	4	-	-
	Passalidae		-	-	-	-	1
	Platypodidae		-	2	-	-	-
	Propalticidae		-	5	-	-	-
	Pselaphidae		-	23	1	-	-
	Salpingidae		-	4	3	-	-
	Scarabaeidae		13	-	-	-	-
	Scolytidae		5	46	50	-	-
	Staphylinidae		-	37	28	-	-
	Tenebrionidae		21	14	-	-	-
	Zopheridae		-	-	5	-	-
Diptera	Drosophilidae		-	-	1	-	-
	Others		4	-	-	-	-
Hymenoptera	Formicidae		2	139	8	-	-
	Ichneumonidae		7	-	-	-	-
Hemiptera	Cicadidae		11	-	-	-	-
	Others		-	-	2	-	-

Key: * = known endemics ** = endemic and focal species.

Order	Family	Scientific name	Light Traps	Leaf Litter	Pitfall Traps	Active search	Opportunistic
Dermaptera			1	-	-	-	-
Isoptera	Termitidae		13	-	-	-	-
Tricoptera			4	-	-	-	-
Lepidoptera	Lymantridae	*Calliteara fidjiensis* *	16	-	-	-	-
	Noctuidae	*Dysgonia koroensis*	1	-	-	-	-
		Pallaeocoleus sypnoides	2	-	-	-	-
		Stictoptera vitiensis	2	-	-	-	-
		Speiredonia mutabilis	1	-	-	-	-
		Ericeia inangulata	1	-	-	-	-
		Tricola plagiata	2	-	-	-	-
		Bocana manifestalis	1	-	-	-	-
	Geometridae	*Cleora perstricta*	1	-	-	-	-
		Cleora fowlesi	1	-	-	-	-
		Cleora sp	7	-	-	-	-
		Thallasodes liquenscens	8	-	-	-	-
	Limacodidae	*Beggina sp**	6	-	-	-	-
	Pyralidae	*Stemorrhages oceanitis*	2	-	-	-	-
		Palpita sp	5	-	-	-	-
		Conogethes punctiferalis	1	-	-	-	-
		Botyodes asialis	6	-	-	-	-
		Lipararchis hyacinthopa	1	-	-	-	-
Lepidoptera	Nymphalidae	*Hypolimnas inopinata* **	-	-	-	5	3
		Hypolimnas bolina	-	-	-	1	-
		Tirumala hamata	-	-	-	3	-
		Melanitis leda	-	-	-	2	-
		Euploea boisduvalli	-	-	-	4	-
	Hesperiidae	*Oriens augustula*	-	-	-	1	-
	Papilionidae	*Papilio schmeltzi* *	-	-	-	1	1
	Satyridae	*Xois sesara* *	-	-		8	-

Key: * = known endemics ** = endemic and focal species.

Order	Family	Scientific name	Light Traps	Leaf Litter	Pitfall Traps	Active search	Opportunistic
Orthorptera			-	-	1	-	-
	Gryllacrididae		-	-	-	-	2
	Gryllidae		18	-	-	-	-
Odonata		*Nesobasis* spp. **	-	-	-	-	19
Phasmida	Phasmatidae	*Nysirus spinulosus* **	-	-	-	-	2
		*Cotylosoma dipneusticum***	-	-	-	-	1
Arachnidae			-	10	5	-	1
Opiliones			-	16	1	-	-
Acari			-	46	-	-	-
Scorpions	Liochelidae		-	1	-	-	1

Appendix 11. Species checklist of insects and arachnids in the Waikarakarawa catchment

Key: * = known endemics ** = endemic and focal species.

Order	Family	Scientific name	Light Traps	Leaf Litter	1 km transect	Active search	Opportunistic
Coleoptera	Anobidae			22			
	Anthribidae			8			
	Brentidae		1				
	Carabidae			2			
	Cantharidae						2
	Curculionidae			64			
	Chrysomelidae			8			
	Elateridae			1			
	Eucnemidae		1				
	Lathrididae			72			
	Nitidulidae			39			
	Passalidae		1				
	Platypodidae		3				
	Pselaphidae			49			
	Scolytidae			296			
	Staphylinidae			100			
	Tenebrionidae		1	2			
Blattodea				1			
Diptera			1				
Hemiptera				19			
	Cicadidae		7				2
Hymenoptera	Formicidae			259			
Lepidoptera	Lymantridae	*Calliteara fidjiensis**	7				
	Geometridae	*Cleora diversa*	8				
		Cleora ochricolis	1				
		Agathia pisina	2				

Key: * = known endemics ** = endemic and focal species.

Order	Family	Scientific name	Light Traps	Leaf Litter	1 km transect	Active search	Opportunistic
		Pyrrhorachis pyrrhogona	1				
		Petelia aesyla	3				
		Thallasodes figurata	4				
	Noctuidae	*Mecodina variata*	1				
		Sarbissa bostrychonota	1				
	Pyralidae	*Palpita vitiensis*	1				
		Cyadalima laticostalis	1				
		Botyodes asialis	2				
		Bradina chalcophea	2				
		Liparachis hyacinthopa	2				
		Stemorrhages oceantis	2				
	Torticidae		2				
	Nymphalidae	*Euploea boisduvalii*			8		
		*Hypolimnas inopinata***			7		
		Hypolimnas bolina			3		
		Tirumala hamata			1		
Odonata	Agrionidae	*Nesobasis erythrops***			4		
		*Nesobasis angolicollis***			35		
		*Nesobasis heteroneura***			5		
Orthoptera				49			
	Gryllacrididae		2				1
	Gryllidae		1				
	Tettigonidae		2				3
	Raphidophoridae						1
Phasmatodea	Phasmatidae	*Cotylosoma dipneusticum***					1
		*Nisyrus spinulosus***					2
Acari				5			
Araneae				55			1

Key: * = known endemics ** = endemic and focal species.

Order	Family	Scientific name	Light Traps	Leaf Litter	1 km transect	Active search	Opportunistic
Scorpiones				4			
		Liocheles australasiae					3
Opiliones				36			

Appendix 12. Species checklist of insects and arachnids in the Mavuvu catchment

Key: * = known endemics ** = endemic and focal species.

Order	Family	Scientific name	Light Traps	Leaf Litter	1km transect	Active search	Opportunistic
Coleoptera	Anthribidae			5			
	Curculionidae			46			
	Chrysomelidae			3			
	Lathrididae			4			
	Nitidulidae			10			
	Pselaphidae			17			
	Scolytidae			38			
	Staphylinidae			15			
Hemiptera				2			
Hymenoptera	Formicidae			27			
Lepidoptera	Nymphalidae	*Hypolimnas inopinata***			8		
		Tirumala hamata			2		
		Euploea boisduvalii			4		
		Melanitis leda			1		
Odonata	Agrionidae	*Nesobasis erythrops***			34		
		*Nesobasis angolicollis***			58		
		*Nesobasis heteroneura***			27		
Orthoptera				1			
Acari				18			
Araneae				10			
Opiliones				2			

Appendix 13. Species checklist of freshwater fish in the upper Sigatoka River tributaries

Site	Date	Coordinates	Method of collection	Species	Abundance
Nakoro, Navitilevu and Draubuta villages	18/07/2012	not recorded	Anecdotal (village interviews)	*Anguilla marmorata* *Anguilla megastoma* *Kuhlia rupestris* *Kuhlia marginata** *Oreochromis niloticus** *Eleotris fusca** *Lamnostoma kampeni** *Awaous guamensis**	
NU1: Nasa upstream 1	19/07/2012	17.94593,177.96658	Visual observation	*Sicyopterus lagocephalus* *Sicyopus zosterophorum*	N/A
Nasa stream Upstream from basecamp	20/07/2012	not recorded	Opportunistic collection (spear)	*Anguilla marmorata* *Anguilla megastoma*	7 2
NU2: Nasa upstream 2	22/07/2012	17.94495,177.4431	Beach seine	*Sicyopterus lagocephalus* *Sicyopus zosterophorum* *Anguilla marmorata*	6 2 1
WL: Wainirovurovu lower	23/07/2012	17.94431,177.96056	Beach seine	*Sicyopterus lagocephalus*	2
WU: Wainirovurovu upper (above waterfall)	23/07/2012	17.94195,177.95972	Beach seine	*Sicyopterus lagocephalus* *Anguilla marmorata*	9 1
Wainirovurovu stream	24/07/2012	not recorded	Opportunistic collection (poison)	*Anguilla marmorata* *Anguilla megastoma*	39 16
Tributary to Nasa stream, downstream from Navitilevu	26/07/2012	17.95611,177.90222	Visual observation	*Sicyopterus lagocephalus*	N/A

Site	Date	Coordinates	Method of collection	Species	Abundance
WK1: Waikarakarawa stream upstream from base camp	20/03/2013	17.98003,178.01088	Visual observation	*Sicyopus zosterophorum* *Sicyopterus lagocephalus* *Anguilla marmorata* *Awaous guamensis*	N/A
MV1: Upper Mavuvu upstream from base camp	22/03/2013	17.95007,177.99333	Visual observation	*Sicyopterus lagocephalus* *Anguilla marmorata*	N/A
MV2: Lower Mavuvu below waterfall	23/03/2013	17.96912,178.98687	Visual observation	*Kuhlia rupestris*	11

*presence of the species is yet to be verified by means of thorough fishing methods

Appendix 14. Water quality parametres at freshwater fish sampling stations

Sampling Stations	Date	Disolved oxygen (mg/l)	pH	Conductivity (uS)	Temperature (°C)	Salinity (ppt)	TDS	Turbidity (NTU)	Altitude (m)
NS2 Nasa stream upstream	22/7/2012	8.95	8.05	0.047	19.7	0.02	0.03	5.8	511
WL Wainirovurovu lower	23/7/2012	8.86	7.37	0.084	19.6	0.04	0.053	0	507
WU Wainirovurovu upper	23/7/2012	8.77	8.05	0.081	20.2	0.04	0.052	0	556
Waikarakarawa stream (above base camp)	20/3/2013	8.27	6.88	0.077	21.9	0.03	0.049	0	404
Mavuvu upper	22/3/2013	8.36	6.84	0.066	21.1	0.03	0.042	0	550
Mavuvu mid	23/3/2013	8.60	7.01	0.091	21.4	0.04	0.057	0	459

Appendix 15. Location and descriptions of macroinvertebrate sampling stations

Catchment, Sampling dates	River/stream	Station Code	Location coordinates	Description	Survey type
Tovatova catchment, July 2012	Nasa Creek	NU1QT	17. 94477,177.96318	Upstream	Quantitative
		NU1QL	17.94685,177.965850	Upstream	Qualitative
	Wainirovurovu Stream (tributary)	WRD2QT	17.94431,177.96056	Downstream	Quantitative
		WRU3QT	17.941041,177.960060	Upstream-above waterfall	Quantitative
		WRU3QL	17.942233,177.959156	Upstream-above waterfall	Qualitative
	Nasa-Wainirovurovu Confluence	NWCQL	17.94476,177.96075	Confluence	Qualitative
Waikarakarawa catchment, March 2013	Waikarakarawa stream	WKQT	17.981617,178.009133	650m from 1st campsite	Quantitative
		WKQL	17.979282,178.005956	600m from 1st campsite	Qualitative
Mavuvu catchment, March 2013	Qalibovitu stream (Upper Mavuvu)	QB1QL	17.948117,177.995467	Upstream	Qualitative
		QB2QL	17.951911,177.991813	200m from 2nd campsite	Qualitative
		QB3QL	17.955224,177.990614	Downstream from campsite	Qualitative
	Wainasoba stream (Mid Mavuvu)	WSLQT	17.968750,177.984850	Tributary of Mid Mavuvu River	Quantitative
		WSLQL	17.968750,177.984850		Qualitative

The four/five letter site codes are composed from the initials of the stream/creek, the station and the type of sampling, for example QB1QL indicates a station sampled in Qalibovitu stream (QB) at station 1 using Qualitative (QL) sampling technique.

Appendix 16. Physiochemical parameters of macroinvertebrate sampling stations

Station code	Temperature (°C)	pH	Conductivity (mS/cm)	TDS (g/l)	Turbidity (NTU)	Dissolved O_2 (g/m^3)	Salinity (ppt)
NU1QT	19.7	8.05	0.047	0.030	5.8	8.95	0.02
WRD2QT	19.6	7.37	0.084	0.053	0	8.86	0.04
WRU3QT	20.2	8.05	0.081	0.052	0	8.77	0.04
WKQT	21.9	6.88	0.077	0.049	0	8.27	0.03
WSLQT	21.8	6.94	0.085	0.055	0	8.41	0.04
QB1QL	21.2	6.56	0.065	0.041	0	8.31	0.03

Appendix 17. Habitat and riparian characteristics of macroinvertebrate sampling stations

Station	Channel characteristics			Habitat type				Organic matter			Riparian characteristics, % shade	Bank characteristics
	Width (m)	Depth (m)	Velocity (m/s)	Pool (%)	Run (%)	Riffle (%)	Chute (%)	Logs (%)	Leaves (%)	Branches (%)		
NU1QT	3-5.6	0.22-2.4	0.30	5	70	20	5	-	10	<1	native trees and shrubs, 60%	well vegetated, gravel, sandy & highly stable
WRD2QT	2-5	0.14-0.8	0.40	20	20	10	40	-	10	-	native trees and shrubs, 95%	well vegetated, stony, sandy & highly stable
WRU3QT	2.5-4	0.1-1.5	0.50	20	40	20	20	<1	40	<1	native trees and shrubs, 20%	well vegetated, stony & highly stable
WKQT	4-6	0.10-1	0.32	20	30	30	20	<1	20	-	native trees and shrubs, 60%	well vegetated, rootmass, gravel, sandy & highly stable
WSLQT	1.2-8	0.10-0.85	0.35	10	50	20	20	-	30	-	native trees and shrubs, 90%	well vegetated, stony & highly stable
QB1QL	1.5-3	0.23-0.82	0.8	5	20	70	5	<1	30	<1	native trees and shrubs, 90%	Native trees and shrubs, well vegetated, stony, rootmass & highly stable

Appendix 18. Abundance of freshwater macroinvertebrates collected with Surber sampling

Key to abundance categories: very abundant (>100), abundant (20-99), common (5-19), few (2-4), very few (1)

Group	Order/class/family	Taxa	Distribution	Common name	Station				
					NU1QT	WRD2QT	WRU3QT	WKQT	MVLQT
Insecta	Ephemeroptera	*Cloeon* sp.	Endemic/Native	Mayfly	27	23	7	6	7
		Pseudocloeon sp.	Endemic/Native	Mayfly	1050	390	433	1413	500
		Cloeodes sp.	Endemic/Native	Mayfly	17	-	17	-	-
	Trichoptera	*Abacaria fijiana*	Endemic	Caddisfly	700	1163	1177	87	1367
		Abacaria ruficeps	Endemic	Caddisfly	67	93	210	-	103
		Anisocentropus fijianus	Endemic	Caddisfly	10	3	3	-	7
		Goera fijiana	Endemic	Caddisfly	30	33	70	-	100
		Hydrobiosis spp.	Endemic/Native	Caddisfly	73	57	13	23	-
		Odontoceridae spp.	Endemic/Native	Caddisfly	167	30	22	80	383
		Chimarra sp.	Endemic/Native	Caddisfly	348	153	43	77	220
		Rhyacophilidae spp.	Endemic/Native	Caddisfly	88	20	40	20	97
		Hydroptilidae sp.	Endemic/Native	Caddisfly	30	17	217	53	40
	Lepidoptera	*Nymphula* sp.	Endemic/Native	Moth	23	-	347	-	100
		Unknown species	Endemic/Native		-	-	3	-	-
	Diptera	*Chironomus* sp.	Endemic/Native	Midge	333	300	130	67	7
		Chironominae sp. A	Endemic/Native	Midge	17	10	-	-	-
		Chironominae sp. B	Endemic/Native	Midge	10	7	3	-	-
		Tanypodinae sp.	Endemic/Native	Midge	17	3	40	-	-
		Culicidae sp.	Introduced,tropics	Mosquitoes	-	20	57	-	-
		Dixidae sp.	Endemic/Native	Dixid midges	20	13	-	-	-
		Psychodidae sp.	Endemic/Native	Moth Fly	-	3	7	-	-
		Simulium jolli	Endemic	Black fly	443	390	7	167	57
		Simulium sp. B	Endemic/Native	Black fly	10	-	-	-	-
		Tipula sp.	Endemic/Native	Crane fly	33	27	3	13	10
		Tipulidae sp. B	Endemic/Native	Crane fly	-	-	3	3	-

Key to abundance categories: very abundant (>100), abundant (20-99), common (5-19), few (2-4), very few (1)

Group	Order/class/family	Taxa	Distribution	Common name	Station				
					NU1QT	WRD2QT	WRU3QT	WKQT	MVLQT
		Empididae sp.	Native (Indo-Pacific)	Lacewing fly	20	10	27	-	3
		Muscidae sp.	Endemic/Native		-	-	-	-	3
	Odonata	*Nesobasis* sp. A	Endemic/Native	Damselfly	3	-	-	-	3
	Hemiptera	Vellidae sp.	Endemic/Native	Water bug	-	-	3	-	-
	Coleoptera	Hydraenidae sp.	Endemic/Native	feather-winged beetles	20	7	7	7	-
		Ptilodactylidae sp.	Endemic/Native		-	-	3	-	-
		Dytiscidae sp.	Endemic/Native	diving beetles	7	3	-	-	-
		Scirtidae sp.	Endemic/Native	marsh beetles	-	3	-	-	-
		Hydrophilidae sp.	Endemic/Native	water scavenger beetles	-	3	-	-	-
		Dineutus sp.	Native (Pacific)	Whirligig beetles	-	-	-	7	-
	Orthoptera	Nemobiinae sp.	Native (Indo-Pacific)	Water cricket	17	10	10	13	-
Arachnida	Araneae	Species 1	Unknown	Water spider	3	-	-	-	1
Annelida	Oligochaeta	Oligochaeta spp.	Native (Indo-Pacific)	Worm	3	-	-	-	7
	Nereidae	*Nereid* sp.	Endemic/Native		-	7	-	-	-
Nematoda		Species 1	Endemic/Native		-	3	7	-	-
		Species 2	Endemic/Native		-	-	7	-	-
Mollusca	Gastropoda	Fluviopupa spp.	Endemic/Native	Snail	97	-	23	13	177
		Melanoides tuberculata	Introduced, tropics	Snail	3	-	-	-	-
Total abundance					3686	2801	2939	2049	3192
Number of taxa					30	28	30	16	20

Appendix 19. Abundance of freshwater macroinvertebrates collected opportunistically

Taxa	End./Nat./Intr.	Common name	Stations							
			NU1QL	WRUQL3	NWCQL	WKQL	MVLQL	QBUQL1	QBUQL2	QBUQL3
Cloeon sp. A	Endemic/Native	Mayfly	-	1	-	-	-	-	-	-
Cloeon sp. B	Endemic/Native	Mayfly	-	1	-	1	2	3	9	-
Pseudocloeon sp. A	Endemic/Native	Mayfly	-	1	-	12	20	36	-	-
Pseudocloeon sp. B	Endemic/Native	Mayfly	-	1	-	20	30	22	2	-
Pseudocloeon sp. C	Endemic/Native	Mayfly	-	1	-	100	60	-	-	-
Pseudocloeon sp. D	Endemic/Native	Mayfly	-	1	-	38	46	-	-	-
Pseudocloeon spp.	Endemic/Native	Mayfly	-		-	-	-	242	-	-
Apsilochorema sp. 1 (*"greenish"*)	Endemic/Native	Caddisfly	-	1	-	4	3	2	-	-
Apsilochorema sp. 2 (*"pinkish"*)	Endemic/Native	Caddisfly	-		-	-	2	-	-	-
Hydrobiosis sp. 1 (*"green"*)	Endemic/Native	Caddisfly	-	1	-	4	-	-	-	-
Hydrobiosis sp. 2 (*"pinkish"*)	Endemic/Native	Caddisfly	-	1	-	-	-	-	-	-
Anisocentropus fijianus	Endemic/Native	Caddisfly	2	-	-	5	1	5	2	-
Odontoceridae spp.	Endemic/Native	Caddisfly	5	-	-	28	14	41	24	-
Abacaria fijiana	Endemic	Caddisfly	-	-	-	25	128	24	-	-
Abacaria ruficeps	Endemic	Caddisfly	-	-	-	-	-	2	-	-
Chimarra sp.	Endemic/Native	Caddisfly	-	-	-	19	3	3	-	-
Oxyethira sp.	Endemic/Native	Caddisfly	-	-	-	6	1	1	-	-
Goera fijiana	Endemic	Caddisfly	-	-	-	-	10	4	-	-
Trianodes fijiana	Endemic	Caddisfly	-	-	-	-	-		1	-
Nymphula sp.	Endemic/Native	Moth	-	-	-	-		2	-	-
Nesobasis sp. 1 (*"dark green"*)	Endemic/Native	Damselfly	-	1	-	-	3	-	-	-
Nesobasis sp. 2 (*"orangish"*)	Endemic/Native	Damselfly	-	1	-	-	-	-	-	-
Nesobasis sp. 3 (*"light brown"*)	Endemic/Native.	Damselfly	-	-	2	1	3	-	20	-
Nesobasis sp. 4 (*"dark brown"*)	Endemic/Native	Damselfly	-	-	2	-	4	-	10	-

Taxa	End./Nat./Intr.	Common name	Stations							
			NU1QL	WRUQL3	NWCQL	WKQL	MVLQL	QBUQL1	QBUQL2	QBUQL3
Hemicordulia sp.	Endemic/Native	Dragonfly	-	-	-	-	4	-	4	-
Procordulia sp.	Endemic/Native	Dragonfly	-	-	-	-	-	-	1	-
Tipula sp.	Endemic/Native	Cranefly	-	1	-	2	2	2	-	-
Tipulidae sp. B	Endemic/Native	Cranefly	-	-	-	1	1	-	-	-
Simulium jolli	Endemic	Blackfly	-	-	-	15	48	101	-	-
Empididae sp.	Endemic/Native	Dagger fly	-	-	-	1	-	-	-	-
Chironomus sp.	Endemic/Native	Midge	-	-	-	34	3	13	-	-
Corixidae sp.	Endemic/Native	Water bug	-	2	-	-	-	-	-	-
Lymnogonus sp.	Endemic/Native	Water-strider	-	-	-	-	1	-	-	-
Hydraenidae sp.	Endemic/Native	Featherwinged beetle	1	-	-	-	2	1	-	-
Dineutus sp.	Native (Pacific)	Whirligig beetle	1	-	-	3	4	5	3	-
Unknown species	Endemic/Native	Beetle	1	-	-	2	-	-	-	-
Unknown species	Endemic/Native	Diving beetle	-	-	-	1	1	4	-	-
Macrobrachium latimanus	Native (Indo-Pacific)	Prawn	-	-	1	-	-	-	-	-
Macrobrachium lar	Native (Indo-Pacific)	Prawn	-	-	-	3	2	-	1	-
Caridina sp. A	unknown	Shrimp	-	-	-	-	-	-	41	-
Caridina sp. B	unknown	Shrimp	-	-	-	-	-	-	2	-
Caridina sp. C	unknown	Shrimp	-	-	-	-	-	-	3	-
Caridina sp. D	unknown	Shrimp	-	-	-	-	-	-	1	-
Caridina sp. E	unknown	Shrimp	-	-	-	-	-	-	1	-
Caridina sp. F	unknown	Shrimp	-	-	-	-	-	-	1	-
Antecaridina sp.	Native (Indo-Pacific)	Shrimp	-	-	1	-	-	-	-	-
Atyoida pilipes	Native (Indo-Pacific)	Shrimp	-	-	-	1	-	-	-	-
Unknown species	unknown	Amphipod	-	-	-	-	-	1	-	-
Fluviopupa sp.	Endemic/Native	Snail	31	-	-	32	4	145	80	25

Taxa	End./Nat./Intr.	Common name	Stations							
			NU1QL	WRUQL3	NWCQL	WKQL	MVLQL	QBUQL1	QBUQL2	QBUQL3
Melanoides tuberculata	Introduced	Snail	-	-	-	2	1	-	-	-
Physastra nasuta	Native (Pacific)	Snail	-	-	-	1	-	4	-	-
Oligochaeta sp.	Native (Indo-Pacific)	Freshwater worm	-	-	-	-	1	2	-	-
Tricladida sp.	Endemic/Native	Flatworm	-	-	-	-	-	5	-	-
Total abundance			41	14	6	358	402	659	206	25
Number of taxa			6	13	4	24	27	21	18	1

Appendix 20. Checklist of invasive and potentially invasive animals

Scientific Name	Common Name, *Fijian Name*	Abundance
*Mus musculus**	House mouse, *kucuve, kalavo*	Uncommon
*Rattus exulans**	Pacific rat, *kucuve, kalavo*	Uncommon
Rattus rattus	Black rat, ship rat, *kucuve, kalavo*	Rare
*Rattus norvegicus**	Norway rat, *kucuve, kalavo*	Uncommon
Felis catus	Feral cat, *vusi, pusi*	Rare
Sus scrofa	Feral pig, *vuaka, vore*	Common
Bufo marinus	Cane toad, *boto*	Common
*Herpestes fuscus***	Indian brown mongoose, *manivusi*	Rare
*Herpestes auropunctatus***	Small Indian mongoose, *manivusi*	Locally common
Pycnonotus cafer	Bulbul, *ulurua*	Uncommon
Equus caballus	Horse, *ohe, ose*	Common

* Not directly observed but anecdotal evidence strongly indicates presence in village
** Presence of mongooses is confirmed but not which of the two possible species

Appendix 21. Locations of rodent transects in Tovatova catchment

Transect	Number of traps	Trap nights	Location	Transect coordinates
1	34 traps (17 pairs)	1	From Tovatova base camp towards the ridge	Start: -17.943719°, 177.961474° End: -17.943656°, 177.959597°
2	30 traps (15 pairs)	1	Uphill track from Tovatova base camp to Mavuvu Creek	Start: -17.943632°, 177.961495° End: -17.944801°, 177.962060°
3	24 traps (12 pairs)	1	In and around the Tovatova base camp	Start: -17.943683°, 177.961511° End: -17.943366°, 177.962837°

Appendix 22. Record of pigs (*Sus scrofa*) caught

Date	Gender and age
11/07/2012	Juvenile male
12/07/2012	Juvenile male
14/07/2012	Large pregnant female
15/07/2012	undetermined *
20/07/2012	Juvenile male
20/07/2012	undetermined *

* Eaten by dogs before determination could be made of gender and age

Appendix 23. Checklist of invasive and potentially invasive plants

Family	Scientific Name	Common name, *(Fijian)*	Habitat	Abundance
1. Agavaceae	*Dracaena fragrans*	*Vasili ni vavalagi*	Found in secondary forest	Rare
2. Asteraceae	*Crassocephalum crepidioides*	thick head	Observed in abandoned plantations.	Uncommon
3. Asteraceae	*Mikania micrantha*	mile-a-minute, *wabosucu*	Abandoned farms.	Uncommon
4. Asteraceae	*Tridax procumbens*	coat buttons, *tabu keka*	Can be seen growing on village green in Navitilevu and Nakoro Village and also on abandoned plantations.	Uncommon
5. Bignoniaceae	*Spathodea campanulata*	African tulip, *pasi*	Two trees in the Nasa catchment, one in Waikarakarawa	Rare
6. Malvaceae	*Sida rhombifolia*	Broomweed	Common around horse tracks, grazing areas, former plantation areas.	Uncommon
7. Myrtaceae	*Psidium guajava*	guava, *quawa*	Commonly found in paddocks.	Common
8. Fabaceae	*Derris malaccensis*	Derris, *duva, tuva*	Very common near streams smothering the vegetation.	Common
9. Fabaceae	*Samanea saman*	rain tree, monkeypod, *Vaivai ni valagi*	Large stands can be seen growing along the river from Nakoro to Navitilevu village	Common
10. Fabaceae	*Leucaena leucocephala*	*vaivai ni vavalgi*	Observed along grazing areas and paddocks.	Common
11. Lamiaceae	*Hyptis pectinata*	*tamoli ni vavalagi*	Found in abandoned plantations and along creek-bed.	Uncommon
12. Lythraceae	*Cuphea carthagenensis*	tar weed	Observed along main track.	Uncommon
13. Melastomataceae	*Clidemia hirta*	Koster's curse, *karausiga, vuti*	Common through all forest types visited	Very common
14. Melastomataceae	*Dissotis rotundifolia*	pink lady	Stream banks in disturbed areas	Common

Family	Scientific Name	Common name, *(Fijian)*	Habitat	Abundance
15. Poaceae	*Arundo donax*	Giant reed, g*asau ni valagi*	Along creeks and streams	Uncommon
16. Poaceae	*Bambusa vulgaris*	*bitu ni vavalagi*		Rare
17. Poaceae	*Imperata cylindrica*		Open areas and in grassland	Uncommon
18. Poaceae	*Pennisetum polystachyon*	mission grass, *co manivusi*	Dominant species in grasslands.	Common
19. Piperaceae	*Piper aduncum*	*Yaqoyaqona*	Large monotypic stand found along the boundary of Emalu Forest and within disturbed areas within the Emalu Forest.	Common
20. Solanaceae	*Brugmansia sp.*	Angel's trumpet	Found along creeks and streams.	Common
21. Verbenaceae	*Lantana camara*	lantana, *lanitana*	Observed near grazing areas.	Uncommon
22. Solanaceae	*Solanum torvum*	*Kosipeli*	Favourite food for pigeons, found in abandoned plantations and fallow areas.	Uncommon
23. Zingiberaceae	*Alpinia purpurata*	*Boia*	Along creeks	Uncommon
24. Zingiberaceae	*Curcuma longa*	tumeric, *cago*	Grassland and abandoned plantations.	Common
25. Zingiberaceae	*Hedychium coronarium*	White ginger, *jija*	Along creeks and streams bank.	Uncommon
26. Zingiberaceae	*Zingiber zerumbet*	*Lalaya*	Locally common on some ridge-top	Uncommon

Appendix 24. Summary descriptions and locations of cultural heritage sites

Note: Lowland and upland vegetation zones refer to those below and above 650m, respectively.

Site Code	Site type	Site evidence	Vegetation zone	Site coordinates	Date recorded
M28-0001	Old village site	House mounds	Lowland	17.955722, 177.913025	24/07/12
M28-0002	Traditional land boundary	Rock feature	Lowland	17.95156, 177.927147	25/07/12
M28-0003	Sacred Pool	Pool	Lowland	17.951434, 177.927296	25/07/12
M28-0004	House mound	Highly raised mound	Lowland	17.946785, 177.925627	18/07/12
M28-0005	House mound	House mound	Lowland	17.947028, 177.932636	18/07/12
M28-0006	Ditch	Causeway, ditch feature	Lowland	17.945145, 177.933914	18/07/12
M28-0007	Agricultural terrace	Terrace platforms, pottery sherds	Lowland	17.94184, 177.94267	18/07/12
M28-0008	Old village site	House mounds, pottery sherds	Lowland	17.94132, 177.94766	19/07/12
M28-0009	Old village site	House mounds, pottery sherds	Lowland	17.94554, 177.953848	21/07/12
M28-0010	Old village site	House mounds, terrace platforms, pottery sherds	Lowland	17.953684, 177.947787	21/07/12
M28-0011	Hill fortification	House mounds, terrace platforms	Lowland	17.953714, 177.948715	21/07/12
M28-0012	Old village site	House mounds, pottery sherds, metallic pot	Lowland	17.957585, 177.94673	21/07/12
M28-0013	Agricultural terrace	Terrace platforms	Lowland	17.943933, 177.960069	19/07/12
M28-0014	Old village site	House mounds, pottery sherds	Lowland	17.943989, 177.961356	18/07/12
M28-0015	Agricultural terrace	Terrace platforms	Lowland	17.945014, 177.959152	21/07/12
M28-0016	Sacred Pool	Natural pool (Tobu ni Nanai)	Lowland	17.945415, 177.959916	21/07/12
M28-0017	Hill fortification	Causeway, defensive ditch, house mound	Upland	17.956124, 177.96347	20/07/12
M28-0018	Hill fortification	House mound, defensive ditch	Upland	17.957459, 177.966507	20/07/12
M28-0019	Old village site	House mounds, pottery sherds	Lowland	17.945685, 177.964307	22/07/12
M28-0020	Old village site	House mound, pottery sherds, terrace platforms	Lowland	17.943541, 177.96696	22/07/12
M28-0021	Pottery site	Pottery sherds	Upland	17.941519, 177.968532	22/07/12
M28-0022	Old village site	Pottery sherds	Upland	17.942736, 177.96926	22/07/12
M28-0023	Hill fortification	House mounds, pottery sherds	Upland	17.956789, 177.971649	20/07/12
M28-0024	Old village site	House mounds, terrace platforms	Lowland	17.942156, 177.972743	23/07/12
M28-0025	Old village site	Terrace platform, pottery sherds, stone alignment feature	Lowland	17.941205, 177.973868	23/07/12
M28-0026	Old village site	House mounds, pottery sherds	Lowland	17.942908, 177.959728	19/07/12
M28-0027	Hill fortification	House mounds, pottery sherds	Upland	17.936667, 177.970696	22/07/12
M28-0028	House mound	House mound	Lowland	17.94112, 177.957129	19/07/12

Note: Lowland and upland vegetation zones refer to those below and above 650m, respectively.					
Site Code	Site type	Site evidence	Vegetation zone	Site coordinates	Date recorded
M28-0029	Ditch	Raised flat platform	Lowland	17.9880039,178.008375	20/03/13
M28-0030	Platform	Flat terrace	Lowland	17.989214, 178.005662	20/03/13
M28-0031	Platform	Flat terrace	Lowland	17.989222, 178.004928	20/03/13
M28-0032	Ditch	Trench	Lowland	17.990073, 178.003454	20/03/13
M28-0033	House mound	House foundation, fire place, indicator plants	Lowland	17.991264, 178.001543	20/03/13
M28-0034	House mound	House foundation	Upland	17.991658, 178.000810	20/03/13
M28-0035	House mound	House foundation	Upland	17.990698, 177.998185	20/03/13
M28-0036	House mound	Flat terrace,stone alignment,house foundations	Upland	17.988996, 177.995172	20/03/13
M28-0037	Platform	Flat terrace	Upland	17.987994, 177.994121	20/03/13
M28-0038	Platform	Flat terrace, house foundation	Upland	17.987405, 177.993662	20/03/13
M28-0039	House mound	House foundation	Lowland	17.980532, 178.003924	20/03/13
M28-0040	House mound	House foundation	Lowland	17.982715, 178.009278	20/03/13
M28-0041	Agricultural terrace	Series of terraces	Lowland	17.984366, 178.011242	20/03/13
M28-0042	House mound	House foundation	Lowland	17.982227, 178.006033	20/03/13
M28-0043	Platform	Raised flat	Lowland	17.982030, 178.006467	20/03/13
M28-0044	House mound	House foundation, indicator plants and trees	Lowland	17.981805, 178.007046	20/03/13
M28-0045	Agricultural terrace	Series of terraces	Lowland	17.982740, 178.011033	20/03/13
M28-0046	Hill fortification	Circular ditches, causeways	Upland	17.988327, 177.994194	21/03/13
M28-0047	Agricultural terrace	Series of terraces	Lowland	17.983373, 177.006021	21/03/13
M28-0048	Platform	Raised flat	Lowland	17.982922, 178.005426	21/03/13
M28-0049	House mound	House foundation, indictor plant	Lowland	17.982736, 178.005193	21/03/13
M28-0050	Stone alignment	Stone wall	Lowland	17.981549, 178.003506	21/03/13
M28-0051	House mound	House foundation	Upland	17.982559, 177.991147	21/03/13
M28-0052	Hill fortification	Platform, trench, causeways, indicator plants	Lowland	17.984130, 177.986690	21/03/13
M28-0053	House mound	House foundation, stone alignment	Lowland	17.984486, 177.985674	21/03/13
M28-0054	House mound	House foundation	Lowland	17.984322, 177.986048	21/03/13
M28-0055	Old village site	House mounds, platforms, indicator plants,	Lowland	17.984255, 177.984087	21/03/13
M28-0056	Habitational terrace	Flat platform	Lowland	17.985933, 177.979203	21/03/13
M28-0057	House mound	House mound	Lowland	17.986574, 177.971813	21/03/13
M28-0058	House mound	House foundation	Lowland	17.986849, 177.971249	21/03/13

Note: Lowland and upland vegetation zones refer to those below and above 650m, respectively.					
Site Code	Site type	Site evidence	Vegetation zone	Site coordinates	Date recorded
M28-0059	Old village site	House foundations, raised stone wall, stone alignment for initiation	Lowland	17.997551, 177.962255	21/03/13
M28-0060	House mound	House foundation	Lowland	17.987036, 177.970733	21/03/13
M28-0061	House mound	House foundation	Lowland	17.987265, 177.970283	21/03/13
M28-0062	Agricultural terrace	Series of terraces	Lowland	17.988284, 177.968851	21/03/13
M28-0063	House mound	House foundations,indicator plants	Lowland	17.989261, 177.969247	21/03/13
M28-0064	Agricultural terrace	Series of terraces	Lowland	17.995930, 177.965134	21/03/13
M28-0065	Old village site	House foundations, pottery sherds, stone alignment	Lowland	17.985088, 177.975448	22/03/13
M28-0066	Hill fortification	House foundations, fortification trench, fortification stone wall	Upland	17.993331, 177.980870	22/03/13
M28-0067	Habitational platform	Flat terraces,house mounds,indicator plants	Lowland	17.989834, 177.979605	22/03/13
M28-0068	Hill fortification	Platforms,house mounds,trenches	Lowland	18.001788, 177.964786	23/03/13
M28-0069	Hill fortification	Stone wall alignment,house foundations, indicator plants, rock shelter	Lowland	17.990722, 177.968911	23/03/13
M28-0070	Hill fortification	House mounds,fortification trench,stone alignment	Lowland	17.985345, 177.970595	24/03/13
M28-0071	Old village site	House foundations,indicator plants,pottery sherds	Lowland	17.975304, 177.977471	24/03/13
M28-0072	Hill fortification	Fortification trenches,house foundations,indicator plants, pottery sherds	Lowland	17.9698685,177.982617	24/03/13
M28-0073	House mound	House foundation,standing stones	Lowland	17.965324, 177.985803	24/03/13
M28-0074	House mound	House foundations	Lowland	17.963856, 177.986926	24/03/13
M28-0075	House mound	House foundations	Lowland	17.961816, 177.988338	24/03/13
M28-0076	House mound	House foundations	Lowland	17.960967, 177.987922	24/03/13
M28-0077	Platform	Flat terraces,pottery sherds	Lowland	17.973944, 178.004944	24/03/13

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