Rapid Biodiversity Assessment of Key Biodiversity Areas: Falealupo Peninsula Coastal Rainforest, Central Savai'i Rainforest, and Uafato-Tiavea Coastal Rainforest, Samoa

March 2017

SMSMCL PROJECT

CONSERVATION INTERNATIONAL
Pacific Islands

ISBN:

Suggested citation:

Ministry of Natural Resources and Environment, Conservation International Pacific Islands Programme. 2017. *Rapid Biodiversity Assessment of Key Biodiversity Areas: Falealupo Peninsula Coastal Rainforest, Central Savaii Rainforest, and Uafato-Tiavea Coastal Rainforest, Samoa*. Apia, Samoa. 285pp.

Cover photos:

Top left: Taga montane rainforest (Mark O'Brien)
Top right: Micronesian skink (Jonathan Richmond)
Bottom Left: *Thalassodes* species emerald moth (Eric Edwards)
Bottom Right: Samoan Broadbill (James Atherton)

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Organizational Profiles

Birdlife Pacific Partnership

BirdLife International is a global network of 117 national NGOs (Partners) - including seven in the Pacific - whose mission is "to conserve wild birds, their habitats and global biodiversity, working with people towards sustainability in the use of natural resources".

The BirdLife Partnership is supported by a Secretariat with headquarters in Cambridge, UK. A regional supporting Secretariat for the Pacific Partnership is based in Fiji, and includes a 'BirdLife Fiji Programme' pending the admission to the Partnership of an eligible Partner NGO there. BirdLife's Pacific Partners are in Australia, Cook Islands, French Polynesia, New Caledonia, New Zealand, Palau and Samoa with a country programme managed by the Pacific Secretariat in Fiji.

For more information visit:
http://www.birdlife.org

Conservation International Pacific Islands Program

The focus of Conservation International's Pacific Islands Program is to provide for the development of sustainable societies by the people of the Pacific Islands, through the preservation of natural capital and adaptation to climate change. CI's Pacific Islands Program covers 20 - 30,000 islands in the 22 countries and territories which make up the Polynesia-Micronesia and New Caledonia Biodiversity Hotspots, and Papua New Guinea. The total oceanic coverage of the program is around 40 million sq km (more than four times the size of the continental United States). The Pacific Islands Program is the only regional program within CI's Asia-Pacific Field Division. It consists of three sub-country/territory programs with linked national strategies for Fiji, Papua New Guinea and New Caledonia, and a regional Pacific Oceanscape field program.

For more information visit
http://www.conservation.org/Pages/default.aspx

Ministry of Natural Resources and Environment (MNRE)

MNRE

The Ministry of Natural Resources and Environment focuses on developing regulatory frameworks for sustainable management of the Samoan environment and its natural resources along with the implementation of projects at the local and national levels that promote improved quality of life for all. The Ministry has six main goals within its organisational framework including policy development, resource management, programme planning, scientific and technological information, along with effective implementation of projects at all levels. The involvement of the Ministry in this BIORAP indicates its strong support and commitment to preserve and protect the biodiversity of Samoa in order to maintain Samoan culture and natural heritage.

For more information visit:
http://www.mnre.gov.ws/

New Zealand Department of Conservation (DOC)

Department of Conservation
Te Papa Atawhai

The New Zealand Department of Conservation works nationally conserving natural and historic heritage and recreational opportunities on public conservation lands including national parks, world heritage areas, much mountain land and many islands along with some marine protected areas. The department has an official role advocating protection of wildlife including for example birds, freshwater and marine life. Active Maori relationships with natural heritage are respected under the principles of the Treaty of Waitangi. The Department partners many agencies and organisations in its work and provides some capacity to cooperate internationally in work such as pest eradication from islands and technical support for conservation management such as this BIORAP.

For more information visit:
http://www.doc.govt.nz/

United States Geological Survey (USGS)

The United States Geological Survey (USGS) is a science organization that provides impartial information on the health of our ecosystems and environment, the natural hazards that threaten us, the natural resources we rely on, the impacts of climate and land-use change, and the core science systems that help us provide timely, relevant, and useable information.

As the United States' largest water, earth, and biological science and civilian mapping agency, the USGS collects, monitors, analyses, and provides scientific understanding about natural resource conditions, issues, and problems. The diversity of our scientific expertise enables us to carry out large-scale, multi-disciplinary investigations and provide impartial scientific information to resource managers, planners, and other customers at home and overseas.

For more information visit:
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Acknowledgements

This Biodiversity survey was coordinated and implemented by Conservation International staff and partners, through contract by the Samoan Ministry of Natural Resources and Environment (MNRE), with funding support from the Global Environment Facility (GEF) via the United Nations Development Programme (Apia Office). This project funding was to support the "Strengthening multi-sectoral management of critical landscape" (SMSMCL) project being implemented by MNRE. It involved a multi-disciplinary team of scientists and local staff with significant support of local field guides and trail cutters from the surveyed villages.

The Biodiversity Rapid Assessment Program (BIORAP) targeted: the Central Savai'i Rainforest KBA, and the Falealupo Peninsula Coastal Rainforest KBA on Savaii; and the Uafato-Tiavea Coastal Rainforest KBA on Upolu. The survey took three weeks to collect biodiversity data from the field by a team of four lead scientists from various organisations and academic institutions (Department of Conservation New Zealand, BirdLife International in Fiji, United States Geological Surveys, University of Hawaii).

The BIORAP would not have been possible without the support from the villages we surveyed, without funding from UNDP-GEF and technical support and assistance from MNRE. We express our gratitude and thanks to UNDP for funding support, and to MNRE Chief Executive Officer Suluimalo Amataga Penaia, and all of the staff from each division of MNRE that participated, especially to the SMSMCL project team led by Seumalo Afele Faiilagi, Tofilau Tepa Suaesi and Gardenia Morrison. You were all a pleasure to work with. We would also like to give thanks to Maiava Veni Gaugatao for his contributions within the plant team and help with village liaison as well as to our overseas interns for their support: Michelle Gan, Benjamin Liau, Zhong Ruifeng, and Ms Asihrwarya Bhattacharjei. We also thank Kristiane Davidson, and Ernesto Rollando for their communications support. And a special thank you to James Atherton for the technical advice, references and providing the maps.

We want to sincerely thank all the scientists: Dr Art Whistler, Dr Mark O'Brien, Eric Edwards and Dr Jonathan Richmond who led each survey team and wrote the chapters for each taxonomic group being surveyed. We would like to further give special thanks for the contribution from Dr Greg Sherley for his technical editing and report input, as well as to Leilani Iosefa Duffy for all the initial project arrangements and pre-planning.

In addition, we are grateful to the following CI Staff, Isaac Rounds and Vilikesa Masibalavu for support in the field (CI Fiji Office), to Mrs. Sue Taei, the CI Executive Director for Pacific Islands Program for her support and advice, and Emmeline Johansen for communications support, and especially to the CI Samoa staff Pualele Pene and Danita Strickland. This project was made possible by your hard work behind the scenes and Danita you committed over and above to support logistical arrangements and scientific survey operations.

Faafetai tele lava to all!

Acronyms

ACEO	Assistant Chief Executive Officer
ASL	Above Sea Level
BES	Baseline Ecological Survey
BIORAP	Rapid Biodiversity Assessment Programme
CI	Conservation International
EBS	Environmental Baseline Study
FAO	Food and Agriculture Organization
GEF	Global Environment Facility
GPS	Global Position System
IBA	Important Bird Areas
ICCRIFS	Integration of Climate Change Risks and Resilience into Forestry Management in Samoa
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
KBA	Key Biodiversity Area
MNRE	Ministry of Natural Resources and Environment
NUS	National University of Samoa
SMSMCL	Strengthening multi-sectoral management of critical landscapes
SOE	State of the Environment
STA	Samoa Tourism Authority
UNDP	United Nations Development Programme
USGS	United States Geological Survey
YCA	Yellow Crazy Ants

Foreword

This report presents the results from the Biological Rapid Assessment Programme (BIORAP) of three Key Biodiversity Areas (KBAs) for the SMSMCL project….

Executive Summary

1. INTRODUCTION

A Biological Rapid Assessment Program (BIORAP) was conducted from July 16 to August 3, 2016 in three Key Biodiversity Areas (KBAs) in Samoa: the Central Savai'i Rainforest KBA, and the Falealupo Peninsula Coastal Rainforest KBA on Savaii; and the Uafato-Tiavea Coastal Rainforest KBA on Upolu. A literature review of biodiversity information was also conducted on a fourth site - the Apia Catchments KBA (see Fig.1 for the location of survey sites).

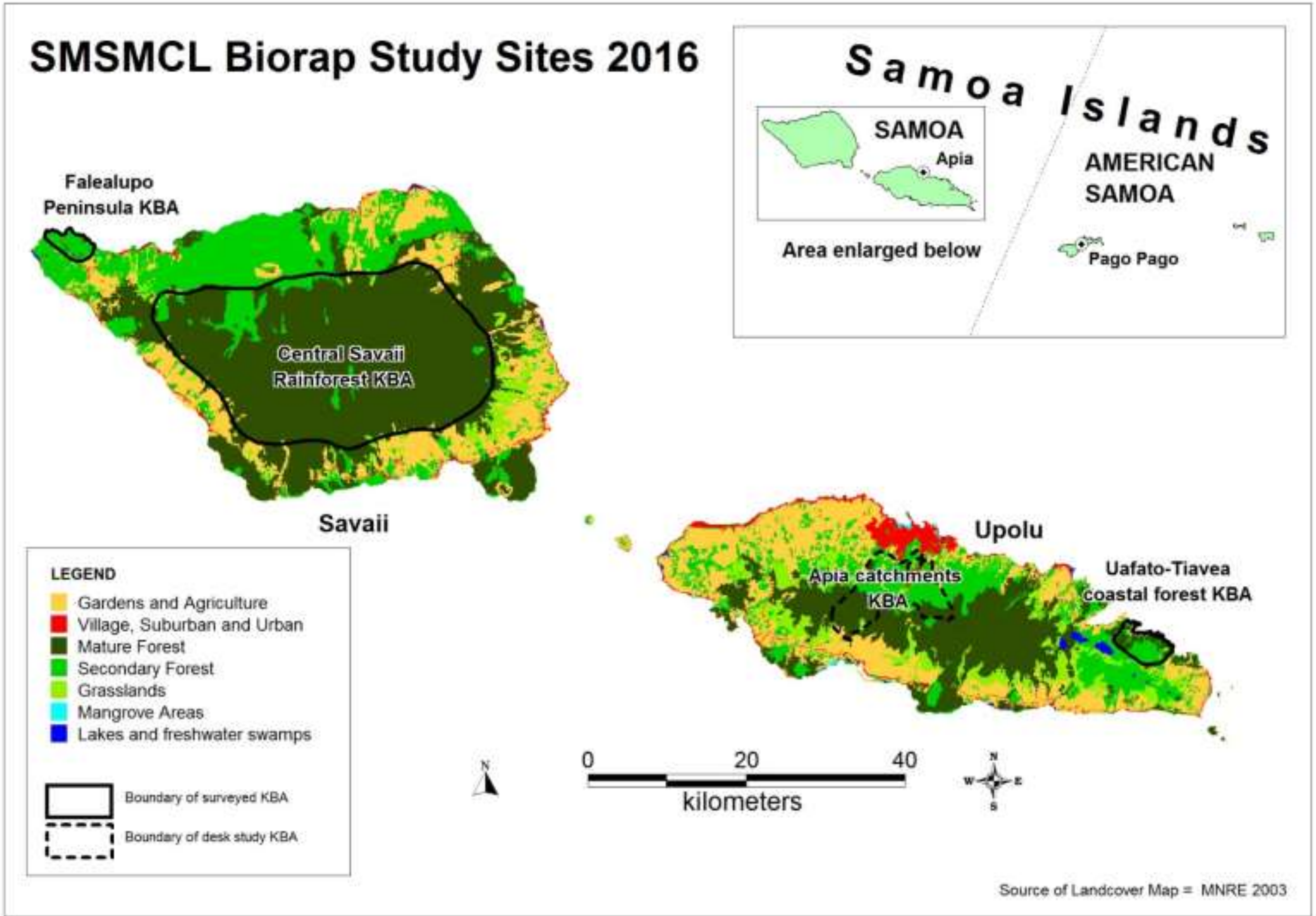
The BIORAP was coordinated by staff from the Conservation International Pacific Islands Programme and the Samoan Ministry of Natural Resources and Environment (MNRE) with funding support from the Global Environment Facility (GEF) via the United Nations Development Programme (Apia Office). The client for the BIORAP is the "Strengthening multi-sectoral management of critical landscape" (SMSMCL) project being implemented by MNRE with GEF funding support. A multi-disciplinary team of scientists and local staff implemented the BIORAP with support of local field guides and trail cutters from survey villages.

BIORAPs are an innovative biological inventory method developed by Conservation International (CI) to use scientific information to catalyze conservation action. Criteria are usually selected to enable identifying priority areas for conservation using wide range of taxonomic groups. These taxonomic data inform the following criteria for selecting KBAs: species richness, endemism, rare and/or threatened species and habitat conditions (Morrison and Nawadra 2009). An assessment of rare and/or threatened species that are known or suspected to occur within a given area provides an indicator of the importance of the area for the conservation of global biodiversity.

The SMSMCL BIORAP was conducted in order to gather, systematically record and analyse biodiversity data for the three target KBAs. These data will serve as "baseline" data for future comparative studies that will improve understanding about the vulnerability of coastal and upland forest areas to the impacts of climate change in these three KBAs. It is hoped that future comparisons using the BIORAP data will allow inferences on the state of the environment (SOE) including the impact of climate change on the SOE, particularly biodiversity.

The BIORAP work included gathering and identifying species from the KBAs following accepted protocols which have been used in Samoa on previous BIORAPs. Some of these species may be suitable as indicator species whose abundance and distribution may change in response to environmental conditions influenced by climate change. Candidate indicator species are described. The data on species distribution and abundance will also be valuable for informing decisions on priority management interventions to conserve the biodiversity in the upland forests of Upolu and Savai'i.

Figure 1. Location of SMSMCL BIORAP Study Sites



2. SCOPE OF BIORAP PROJECT

This BIORAP was conducted to provide critical biodiversity information for the SMSMCL project. The SMSMCL project aims to integrate sustainable landscape management into relevant Government Sector planning frameworks. In so doing the Government of Samoa will make progress towards meeting the following long-term goal (UNDP/GoS 2013):

"Samoa's productive landscapes are protected and sustainably managed to mitigate land degradation and to increase soil carbon sequestration so as to contribute to poverty alleviation and mitigation and adaptation to climate change impacts, as well as to contribute to global environmental benefits by overcoming barriers to integrated sustainable land management."

The primary objective of the SMSMCL programme is to strengthen local capacities, incentives and actions for integrated landscape management in order to reduce land degradation and greenhouse gas emissions and to promote nature conservation whilst enhancing sustainable local livelihoods (UNDP/GoS 2013). Given the wider policy of the SMSMCL programme of inclusive participation of as many sectors as possible, every effort was made to include MNRE staff and locals as far as practically possible in the planning and implementation of the BIORAP.

The BIORAP surveys concentrated on baseline surveys of the following taxonomic groups: plants, birds, mammals, land reptiles and moths and butterflies (lepidoptera) including invasive species within each taxonomic group. The methodology included permanent plots which are compatible with previous surveys conducted in Samoa such as those conducted under the Integration of Climate Change Risks and Resilience into Forestry Management in Samoa project (ICCRIFS)-(MNRE 2015a) and the BIORAP of the Upland Forest of Samoa conducted in 2012 through SPREP (Atherton and Jefferies 2012).

3. BIORAP PROJECT OBJECTIVES

There were four main objectives for the SMSMCL BIORAP (UNDP 2015):

1. Conduct surveys to create an Environmental Baseline Study (EBS) on selected forest areas in the following three key biodiversity areas that were inadequately assessed in a comprehensive manner in previous surveys:
    - Central Upland and Cloud Forests of Savai'i,
    - Uafato-Tiavea Coastal Rainforest, and
    - Falealupo Peninsula Coastal Rainforest
2. Conduct a desktop comprehensive review and analysis of all recently conducted surveys, including any current management plans such as for Lake Lanoto'o) for the area to substitute for an EBS a fourth KBA site in - the Apia Watersheds basin.
3. Establish baseline biodiversity information needed for the revision and establishment of effective multi-sectoral conservation and management plans at each of these sites, and their surrounding areas, and
4. Establish planning, monitoring and reporting baseline information and indicators (species & habitats) for the SMSMCL project.

To achieve the overall objectives of the BIORAP surveys, the following activities were conducted:

1. Survey of the fauna, flora and avifauna in the project sites
2. MNRE staff, local villagers and other interested groups and individuals in Samoa trained on surveying skills and techniques
3. Community participation
4. Developed protection and conservation management policies and sustainability options developed for climate resilience.

4. SUMMARY OF BIORAP RESULTS BY TAXONOMIC GROUP

The survey results re-confirm the conservation importance of the three target KBAs in capturing rare and threatened biodiversity and ecosystems and their priority for future conservation investment in Samoa.

4.1 Key Biodiversity findings

- A total of 144 plant species was recorded, 113 (78%) of them native species (106 indigenous and seven endemic) and about 30 (22%) of them alien species (introductions by early Polynesians and subsequent arrivals).
- Three new plant records for Samoa were reported including the: epiphytic orchid *Dendrobium macrophyllum* (red orchid), an unknown shrub related to *ava'ava'aitutu* (*Macropiper puberulum*) and a shrub related to *so'opini* (*Melicope latifolia*)
- Twelve of the 14 known native reptiles in Samoa were collected, including one new island record for the common dwarf gecko *Hemiphyllodactylus typus* on Savai'i.
- Ninety three reptile specimens were collected using glue traps and 124 incidental field observations were made.
- The upper elevation limit for reptiles was 1260 m in upland Savai'i.
- The upper limit for the invasive alien species Yellow Crazy Ant (*Anoplolepis gracilipes*) was 662 m above-sea-level on Savai'i
- The Lepidoptera survey documented 329 taxa and over 180 confirmed species.
- Ten species of moth collected in the 1920's were reported from this survey for the first time since they were originally described.
- Approximately 150 species of micro-moth were recorded most of which are unidentified
- Thirty three species of bird, and both species of Flying Fox in Samoa, were recorded on at least one site during the bird survey.
- The endangered Manumea (*Didunculus strigirostris*), a Samoan Endemic, was recorded twice, and the Friendly Ground Dove *Alopecoenas* (formerly *Gallicolumba*) *stairi* was seen for the first time in some upland areas of Samoa.
- The survey failed to find Samoan Moorhen (no confirmed observations for more than 100 years).
- Invasive plants and insects typically impacting islands elsewhere in the Pacific are mostly not found in the upland forests of Savaii, and measures to limit their spread are possible.
- Wild cats, rats and pigs have penetrated some remote higher altitude areas with visible

impacts on birdlife and native vegetation however, natural values still persist and active management can conserve these values.

- The biodiversity findings confirm the value of the three KBAs for the conservation of threatened biodiversity in Samoa, and also reconfirm that the Central Savaii Rainforest is the most important of KBA for Samoan birds.
- This was the first time the South side of the Upland Savaii KBA area has ever been surveyed

4.2 Flora and Vegetation

- Three areas of Samoa were visited during the botanical survey, which was carried out from 16 July to 3 August 2016: the Central Savaiʻi Rainforest KBA (comprising the montane regions of Taga and Aʻopo), the Falealupo Peninsula Coastal Rainforest KBA, and the Uafato-Ti'avea Coastal Rainforest KBA.
- A total of 18 plots measuring 10 x 100 m were surveyed. All trees with a dbh (diameter at base height) of 5 cm or more were measured and identified in each plot. Notes on the vegetation were taken, and a checklist of all vascular plant species (ferns and higher plants), including all terrestrial herbs, epiphytes, vines, shrubs, and trees, at each site was prepared. The GSP coordinates of the ends of each 100m survey line were recorded so that the exact same plot could be sampled in the future. The tree measurements were then processed and compiled into a table of the relative dominance of all tree species in the plot.
- Five plots were sampled in the Falealupo KBA in the lowlands from 16 to 141 m elevation in areas that would normally be lowland rainforest. A total of 144 plant species was recorded, 113 (78%) of them native species (106 indigenous and seven endemic) and about 30 (22%) of them alien species (introductions by early Polynesians and subsequent arrivals).
- Ten plots (four in Taga and six in Aʻopo) were sampled in Central Savaiʻi KBA in the upland region from 600 to 1800 m elevation in areas that would normally be lowland rainforest to cloud forest. A total of 374 plant species was recorded, 339 (91%) of them native species (224 indigenous and 115 endemic) and about 35 (9%) of them alien species.
- Three plots were sampled in the upland region from 220 to 400 m elevation in areas that would normally be lowland rainforest. From these records and those from previous surveys, a total of 377 plant species was recorded, 287 (74%) of them native species (245 indigenous and 42 endemic) and about 94 (26%) of them alien species.
- Several weedy species were found to be invasive in the study areas. In the Falealupo KBA *Adenanthera pavonina* (*lopā*, red bead tree) was very invasive in three of the five plots. A few *Elaeocarpus angustifolius* (*sapatua*, blue-marble tree) and *Castilla elastica* (*pulu mamoe*) trees were found in the area, but probably will not thrive because of the relative dry conditions at the west end of the island. The cloud forest in the Central Savaiʻi KBA is relative free of weeds, but *Clidemia hirta* (Koster's curse) is common along trails and in clearings in montane forest. *Merremia peltata* (*fue lautetele*) is common in clearings at the lowest elevations. The two most invasive species in the Uafato KBA are *Paraserianthes falcataria* (*tamaligi*) and *Adenanthera pavonina*, but they were virtually absent from the three plots. The Polynesian introduction *Inocarpus fagifer* (Tahitian chestnut, *ifi*) was common in the area, but does not readily spread and hence is not invasive. Three other trees, *Canarium harveyi* (*mafoa*), *Syzygium samarangense* (*nonu vao*), and *Garcinia myrtifolia* (no Samoan name) are also alien species that are occasional to common in the area, but they are not considered to be harmful to native forests.

4.3 Reptiles

- A rapid biodiversity assessment for reptiles was conducted at four main survey sites in Samoa between 16 July and 2 August 2016. Sites were located within three key biodiversity areas including two on Savai'i (Falealupo Peninsula Coastal Rain Forest and the Central Savai'i Rainforest) and one on Upolu (Uafato/Tiavea Coastal Rain Forests).
- Our objectives were to: determine presence/absence of reptile species in each of the three KBAs; identify elevation limits for each species detected; determine presence/absence of invasive species with known or presumed effects on reptiles, with emphasis on the yellow crazy ant (*Anoplolepis gracilipes*); and finally to compare findings to previous work to provide a current assessment on the conservation status, diversity and distribution of Samoas' reptiles.
- Sampling techniques included 13.2 km of trapping transects and visual encounter surveys (day and night), ranging in elevation from sea level to approximately 1500 m. We captured a total of 93 specimens using glue board transects, made 124 incidental field observations, and collected 99 voucher specimens and 110 tissue samples during this effort. Twelve of the 14 known native reptiles in Samoa were represented in this sample, including one new island record for the common dwarf gecko (*Hemiphyllodactylus typus*) on Savai'i.
- The upper elevation limit for reptiles is 1260 m in upland Savai'i. *Anoplolepis gracilipes* was present at all sites, but we found a sharp, elevation maximum for the species at 662 m above-sea-level on Savai'i. This work provides critical comparative data for future assessments on the status of Samoa's herpetofauna, where the effects of climate change, anthropogenic habitat loss and disturbance, and continuing spread of non-native species pose threats to this largely endemic fauna.

4.4 Lepidoptera

- Butterfly and moth information for the three KBAs was analysed in the context of other Samoan and Pacific wide information about Lepidoptera, vegetation pattern and the state and trend of ecosystems. The survey documents 329 taxa and over 180 species in detail.
- A five million year history of the current Samoan islands together with an older regional persistence of islands has supported the evolution of a unique biological identity. Many unique butterflies and moths (including unique genera) have populations within these three KBAs.
- The scale and integrity of the Central Savai'i Rainforest KBA should not be as assumed because other large oceanic island uplands are more impacted by pest invasions, human induced fragmentation processes and in some cases volcanism. Both its irreplaceability and vulnerability to a range of threats have been identified (eg. see Atherton and Jefferies 2012). The entire central rainforest can be viewed as a single entity and would benefit considerably were this to occur.
- The Uafato-Tiavea coastal rainforest KBA is of Pacific wide significance. An ancient lowland biota is retained because of steepland resilience and because of the past and present stewardship which has allowed native fauna to survive. Throughout many countries, the gradual trend is for lower altitude sites of indigenous natural character to be overcome and irreplaceably lost.
- The Falealupo Peninsula coastal rainforest KBA is also coastal lowland but has landforms, climate and ecosystems in contrast with Uafato-Tiavea and therefore complements the range of ecosystems or biodiversity still present. It has a depleted natural character with

reduction of land-crab, bat and birdlife and invasion of lopa (red bead tree *Adenanthera parvonina*) in some parts. However, it retains important indigenous plant and invertebrate elements, is >700 ha in size and is a compact shape including coastal linkage. Its ecosystems could be described as vulnerable or endangered but not collapsed (see Rodriguez *et. al*. 2015). These ecosystems are also poorly protected for natural values among inhabited islands of the Pacific and therefore of much more than of national significance. Enhancing these values would also be an inspiring example of best practice for many others around the Pacific to follow.

4.5 Birds

- The avifauna team undertook rapid surveys at 4 sites in Samoa, 3 on Savaii and 1 on Upolu. A total of 157 standardised point counts were obtained, along with supplementary information on bird presence at each of the sites. This data-set, combined with the ICCRIFS survey in 2014 provides a comprehensive, standardised set of data for forest birds in Samoa.
- Thirty three species of bird, and both species of Flying Fox, were recorded on at least one site during the survey.
- The five most commonly recorded species were Polynesian Wattled-honeyeater, Samoan Fruit-dove, Samoan Starling, Pacific Imperial-pigeon and Cardinal Myzomela – for all these species numbers in excess of 100 individuals were recorded during the survey.
- The survey failed to find Samoan Moorhen (no confirmed observations for more than 100 years) but confirmed the presence of Tooth-billed Pigeon and 35 other species of native and introduced species in at least one of the sites surveyed.
- The dataset provides the basis for assessing the global importance of each of the sites for bird species. The data confirms that the Central Savaii Rainforest is the most important of the KBA sites for Samoan bird populations, and indicates areas within that site that are of particular importance. The data also indicate the importance of the Apia Catchments KBA and Uafato-Tiavea coastal rainforest KBA.
- The dataset agrees with previous information on altitudinal range of species – except that we recorded observations of Flat-billed Kingfisher at Mt Silisili at more than 1500m asl. The implications of this, the impact of increasing temperatures, and measures to minimise the effects of these changes are discussed.
- First attempts at deriving population estimates for forest birds in Samoa are presented, although it is emphasised that a number of assumptions have been made in order to derive these estimates. Recommendations for further surveys and conservation actions are included.

5. INITIAL IMPACTS OF CLIMATE CHANGE ON SURVEY SITES AND SPECIES

A recent study by Wiens (2016) showed that 47% of 976 plant and animal species around the world have already experienced local extinctions related to climate change, with tropical species experiencing significantly higher rates of extinction than temperate species. Islands in particular are particularly vulnerable to the effects of climate change because of their small size, low elevation, remote locations, and the tendency for human populations to inhabit the coastlines (Leong *et al*. 2014). With rising sea level and increased air temperatures predicted by climate change models, humans may be forced to move upslope into the more interior and less disturbed parts of Upolu and Savai'i, further reducing the amounts of habitat that wildlife is able to occupy (Benning *et al*. 2002). Coincident with this transition could be the increased spread of non-native, invasive species, as the invasives tend to be more concentrated in disturbed areas (Leong *et al*. 2014).

There are a number of scenarios or projections for future climate presented by the Intergovernmental Panel on Climate Change (IPCC) based on a series of assumptions of human behaviour ranging from a "business as usual" and fast population growth model, through to the other extreme of a slow-down in population growth and the enforcement of stringent emissions quotas by greenhouse gas emitting countries (IPCC 2014). These scenarios are now called "Representative Concentration Pathways" and have been generated at a global level but have reduced accuracy at small scales such as for a tiny country like Samoa (NIWA 2014).

According to the best available current information, the Samoan climate in 2090 (Samoa Meteorological Division and Australian Bureau of Meteorology 2011) is expected to be:

- 2 °C warmer (medium projection) with an increase in the number of days of extreme heat
- >5% wetter (with most rainfall increases expected in the wet season and with little change in dry season rainfall) and with increases in the number of days of extreme rainfall
- Little change in drought (at once to twice every 20 years for moderate to severe drought)
- Probable decline in the number of tropical cyclones, but a possible increase in their intensity

Predicting the current and future impacts of climate change on species or sites in Samoa is severely constrained by a lack of knowledge of the ecological factors that currently limit species and habitat distributions in Samoa, as well as our limited understanding of the interactions between climate change and forest ecology and how climate will change at different elevations and locations (MNRE 2015b). Therefore, any observations or predictions are simply "educated guesses", based on currently available information and a number of assumptions. Teasing out the causative factors and relationships between climate variables and biodiversity and better understanding forest community scale climate interactions are important areas for further research over the coming decades so that we can more accurately predict the impacts of climate change on Samoa's biodiversity and forests then take the most appropriate measures to manage the impacts (MNRE 2015b). A list of predicted changes in the distribution of 36 common Samoan trees is shown in Annex 1 but should be considered preliminary pending more knowledge (MNRE 2015b).

The major assumption in the predictions used in this report is that plants and many other species are mainly limited by temperature and rainfall and will tend to become more restricted upslope as temperatures rise (just as plant species in temperate climates are predicted to move towards the poles). Over a period of decades, forest community boundaries may be expected to move upslope as plant species within the community slowly retreat from areas they are no longer adapted to while spreading into other areas with the required environmental conditions. Species such as insects, birds and reptiles that are adapted to certain forest habitats for food or shelter will be forced to move along with the moving vegetation.

It can also be predicted that forest along the foreshore (eg coastal and mangrove forest) will be impacted by rising sea levels, storm surge, cyclonic winds and coastal erosion/sedimentation and that riparian vegetation may be impacted by a possible increased risk of flash flooding (Thomson, Thaman and Fink 2014). We might also predict that plant communities and plant species well adapted to a range of conditions, especially to high and variable temperature and rainfall, will do better in a future climate that is warmer and wetter and prone to more extremes compared to plants adapted to a narrow range of climate. Furthermore, slow-growing species, such as late successional trees, or those with restricted seed dispersal are expected to be replaced by faster-growing, highly adaptable or more mobile species (Kirshbaum and Fischlin 1995).

In the following section, some observations of possible climate change impacts on the vegetation of each KBA and on certain taxonomic groups are described.

5.1 Impacts of climate change on the vegetation of the KBAs

Falealupo Peninsula Coastal Rainforest KBA

Climate change is expected to result in a change in the vegetation of the Falealupo KBA but the nature of these changes is difficult to predict, since few if any of the trees in the KBA have been studied to see what possible changes in their distribution will occur with a warming climate. The whole site is below about 150 m elevation, so is more homogeneous than the other KBA's studied during the present survey. Probably the major effect of climate change will be an increase in temperatures, which can adversely affect plant species and their distribution as well as a possible increase in cyclone intensity, coastal erosion and coastal flooding from sea level rise (MNRE 2015b). An increase in rainfall might make the area more hospitable to more lowland forest trees, but there is no way of knowing what will happen to the mix of species that now occurs there, or if new invasive species will arrive and become troublesome.

Central Savaii Rainforest KBA

The Central Savaiʻi Rainforest KBA extends from around 600m up to 1860 m elevation, and comprises mostly montane and cloud forest vegetation. Climate change may have a profound impact on the vegetation of the KBA as a result of the increase in temperature, as well as a predicted increase in cyclone intensity in Samoa. Some of the plants found in the KBA occur only at the cool, high elevations of the cloud forest. When the climate warms up, trees that have temperate affinities and cool weather requirements will be the ones most likely to suffer. When the summit area warms up to a temperature out of their survival range, they will disappear because they have no way to escape to higher elevations. It is estimated that about ¼ of the cloud forest will be lost from Samoa by 2090 (MNRE 2015b). The area vacated by the cloud forest may become dominated by montane forest trees adapted to higher temperatures.

Uafato-Tiavea Coastal Rainforest KBA

The Uafato-Tiavea KBA extends from sea level up to about 700 m elevation, and the natural vegetation for this area is mostly lowland forest, especially lowland ridge forest. As with the other KBAs, probably the major effect of climate change will be an increase in temperatures, which can adversely affect plant species and their distribution as well as a possible increase in cyclone intensity, coastal erosion and coastal flooding from sea level rise (MNRE 2015b). Some of the plants found in the KBA are only found at the cool highest elevations at the top of Mt. Malata, but this peak comprises a very small proportion of the area. As with the Central Savaii Rainforest KBA, when the climate warms up, trees that have temperate affinities will be adversely effected by the warmer conditions. Because of the limited elevation of the KBA, they cannot simply move up in elevation, and will thus probably eventually disappear from the area. The lowland forest may not disappear but may be impacted by intense cyclones, flooding and coastal erosion.

5.2 Impacts of climate change on species

Climate change impacts on reptiles

It is important to note that very little is known about the behavioral ecology of Samoa's reptiles, and that the potential effects of climate change have not been studied. To the extent that we can speculate about the effects of climate change in Samoa, some existing models suggest that rate of niche shifts are likely to be outpaced by the magnitude of projected climate change over the next half century (Jezkova and Wiens 2016). In other words, the magnitude of climate change could potentially outpace the rate at which plants and animals are able to adapt to new niches and/or shift their distributions, resulting in local extinctions.

While our surveys suggest that certain species are more tolerant of disturbance than others (e.g. *E. cyanura* vs. *E. impar*, respectively) and may therefore be less effected by climate change, others that are less tolerant of disturbance, have restricted distributions, and/or have specific habitat requirements may therefore be more susceptible to extinction. This is particularly true for species that only occur near the coastline, where sea level rise could eliminate preferred habitat. These species include *G. mutilata*, *C. poecilopleurus*, and possibly *E. adspersa* (although Fisher and Uili (2012) recorded *E. adspersa* ~8.0 km inland at 240 m ASL). *Gehyra mutilata* and *C. poecilopleurus* are both rare species that only occur in a few restricted areas on the coast, with *G. mutilata* seemingly having the highest degree of habitat specialization.

In contrast, more generalist species with broad elevation ranges may have room to expand upslope. The highest elevation record for reptiles in our survey was 1260 m, close to the 1320 m record from the 2012 BIORAP (surveys in the 2014 BIORAP did not reach these elevations). Both records were for *E. samoensis* at sites that were relatively close to each other on Savai'i (2318 m apart, straight-line distance from Google Earth). The fact that the glue board transects near and above 1200 m failed to detect lizards, combined with only one capture above 990 m in the BIORAP 2012, suggests that ~1300 m represents a thermal tolerance limit for lizards in Samoa. Cooler night time temperatures and increased rainfall could mean that longer sunny periods during the day are needed to instigate lizard activity near this elevation, and that the absence of cloud cover may be even more critical for survey efforts compared to the lowlands (i.e. below 900 m). It is interesting that the highest record is for a large skink species, rather than one of the nocturnal geckos, which tend to be more tolerant of cooler conditions. However, lower nighttime temperature and increased rainfall at these elevations may simply be too extreme even for nocturnal geckos.

We note that weather conditions during surveys that approached or went beyond 1300 m ASL consisted of intermittent cloud cover, or were overcast, and/or it was raining. Similar conditions were reported in the 2012 BIORAP for transects near the same elevation (Fisher and Uili 2012), and Hathaway (2014) reports being rained out completely from one of their survey sites. Due to the dependency of reptile activity on weather and the short BIORAP time frame, additional surveys at sites where weather impeded previous efforts would be useful, particularly at ~900 m and higher. Inclement weather was a factor in our surveys at Transects 3 and 4 at Taga, Transect 6 in upland Savai'i, and Transects 9 and 10 at Uafato, which happen to be some of our highest transects.

In the Savai'i upland rainforest, one finding that adds support to the ~1300 m threshold hypothesis for reptiles was the near absence of Orthopterans (e.g. crickets) on glue boards below 1000 m, where lizards were present, and the near 100% presence of crickets on all glue boards above 1200 m, where lizards were absent. In fact, our 1200 m campsite in upland Savai'i was notably more infested with crickets than all other campsites combined. As top predators of insects, these crickets almost certainly constitute a large portion of the lizard diet (although gut content data are needed to confirm this idea). The striking increase in the presence/abundance of crickets across the same elevation range where lizard presence/abundance markedly drops off suggests that the absence of a major cricket predator near the ~1300 m threshold may explain (among other things) the shift in cricket densities.

Climate change impacts on birds

Species restricted to high altitudes may find that increases in annual temperature for Samoa, as predicted by climate change models (eg Whan *et al* 2014), will further restrict their distribution. Two species, island thrush and Samoan white-eye were only recorded at higher altitudes on Savai'i, while a third (mao), was recorded more frequently in the Savai'i uplands than elsewhere. It is unclear how this might work, and whether the mechanism here is due directly to the change in temperature itself, or the influence of other factors, such as changes in the phenology of the species food source, changes in predation rates as the suitability of sites for introduced species varies. Studies on Mao in lowland areas indicate that there are high predation rates on nests by introduced black rats, and that this predation varies with distance from disturbed habitat (Stirnemann *et al* 2015). The relatively high density of Mao in the uplands of Savaii may be due to reduced predation (as black rats are at lower densities at high altitude and/or in natural habitats), or due to increased presence of their preferred food sources, either of which could be impacted by increased temperature.

Another likely consequence of climate change is a reduction in frequency but increasing intensity of cyclones in the region. We do not have much detail on the impact of cyclones on bird populations. We know that species such as pigeons and honeyeaters move away from cyclone-flattened forests. We do not know how far the birds move, what their subsequent survival rates are, or how long it takes sites to become suitable for the species again. Answers to these questions can only come from observations of individually-recognisable birds that are subjected to cyclones.

One feature of cyclones is that their maximum impact is felt only at a local level. They are unlikely to destroy all forest in the whole of a species' range. Clearly, however, species most at threat from cyclones are those that already have a very restricted range, such as Samoan white-eye (on the uplands of Savai'i) or those whose range has already been restricted by other factors (such as habitat loss and/or the impact of invasive species). The tooth-billed pigeon and mao may come into these categories. We can minimise the risk of cyclones to these species by ensuring healthy populations across their range so that a single cyclone is unlikely to eradicate them. Creating or maintaining suitable habitats for at risk species at widely-dispersed areas within their range, rather than concentrating in one particular area, should be a strong focus of mitigating the impact of extreme weather events, such as cyclones, on small/remnant bird populations.

6. INDICATOR SPECIES FOR MONITORING ECOSYSTEM CHANGES

Proposed indicator species for monitoring climate change and other changes in forest ecosystems are listed below for different taxonomic groups.

6.1 Plant indicator species

Arguably the best indicator species to monitor changes in flora, including from climate change, are plant species with restricted environmental "niches" ie species with a narrow elevational and climatic tolerance. These species can be expected to be less likely to adapt to increased temperature or more variable rainfall in future. Plants restricted to cloud forest such as vivao (*Reynoldsia lanutoensis* and *Reynoldsia pleiosperma*) would be expected to be particularly vulnerable to climate change because they will have limited suitable habitat to spread or migrate into. It can also be assumed that species restricted to the coastal rainforest are likely to be heavily impacted by sea level rise, coastal inundation and wind damage (MNRE 2015b).

6.2 Reptile indicator species

Two reptile species are proposed as good indicators of changes to land reptile communities:

- Samoan skink *Emoia samoensis*: This species has the highest elevation record for all reptile species in Samoa. Climate change models predict upslope shifts in species' distributions as average air temperatures become warmer and sea level rises. The existing data provide a good approximation of the current upper elevation limit for E. samoensis, and sticky board transect surveys could assist in monitoring any upward shifts in the species' distribution in the coming years. An upward shift in the distribution would not necessarily indicate negative impacts on E. samoensis; rather, this species could be viewed as useful 'tool' for monitoring the predicted impacts of climate change.
- Steindachner's Emo skink, or Micronesian skink *Emoia adspersa*: This species occurs from the coastline up to 800 m, but is considered to be more common in habitats along the immediate coastline. As the coastline retracts with rising sea levels, the species may either (1) decline in overall density and or (2) experience upper elevation range shifts as described.

6.3 Bird indicator species

Species restricted to high altitudes may be the best indicators of climate change. Two species, in particular- Island thrush (*Turdus poliocephalus*) and Samoan white-eye (*Zosterops samoensis*) were only recorded at higher altitudes on Savai'i and may be the most impacted by increased temperature in the cloud forest and changes in food sources.

7. CONSERVATION RECOMMENDATIONS AND JUSTIFICATION

The recommendations describe key management and policy options based on the findings of the field surveys and analysis that the project and local communities should consider to protect the three KBAs and their ecosystem values.

7.1 Overall Recommendations

A number of key conservation recommendations were made by the BIORAP team. These are listed below. More details on these recommendations including their justification is written under recommendations for each taxonomic group.

1. Pursue international recognition and protection of the Central Savaii Rainforest KBA. A key task is to investigate UNESCO Biosphere protection designation for this site.
2. Implement immediate conservation actions for the protection and restoration of the rainforests in all KBAs. This will involve the development of conservation areas and implementation of logging restrictions, hunting restrictions, restoration of degraded areas and other resource management actions in collaboration with village councils.
3. Manage threats to the biodiversity of all three KBAs from invasive species. This will involve identifying a list of target invasive species for management as well as for exclusion from each KBA.
4. Establish long-term ecological monitoring programs using the permanent plots established under this project. This will allow for the success of conservation interventions to be measured as well as the impacts of threats such as climate change and invasive species.
5. Raise awareness on, and enforce, environmental legislation. Samoa has numerous environmental laws that need to be better promoted amongst the public and more effectively enforced.
6. Promote eco- tourism in KBAs through local cultural and natural heritage. There is significant potential to better capitalise on ecotourism in KBAs as a way of providing a sustainable income stream for village communities that is linked to conservation efforts.
7. Increase community awareness on the ecological and cultural values of the KBAs and promote more active participation of village groups in all conservation management programs.

7.2 Recommendations by taxonomic group

Plants

1. Resurveys: The Falealupo Peninsula KBA has a relatively poor flora because of its lowland locations. It has been relatively well surveyed and few additional native species, other than indigenous coastal species and weeds, would be likely to turn up during further work. The Uafato KBA has been surveyed several times now, and the flora is pretty well known. The only area that would be useful to resurvey would be the highest elevations, i.e., Mt. Malata, which apparently has never been visited by a botanist. The Central Savaiʻi KBA is in definite need of additional surveys. Most of the surveys done so far have been along the Aʻopo to Mt. Silisili corridor, leaving the vast remainder of the area unsurveyed.

2. Orchid Survey: With nearly 100 native species, the largest Family of flowering plants in the Samoan flora is the Orchidaceae. Many of these species, especially the terrestrial ones, are threatened by destruction of the forest canopy and by invasive weeds, especially *Clidemia hirta* (Koster's curse), that covers the floor of disturbed montane forest. Several Samoan orchids have not been collected in over a century and are in danger of going extinct, if they haven't already. A survey of the montane regions of the archipelago is needed, particularly for epiphytic orchids, and would involve climbing forest trees to find the species.
3. Research is needed on how to eliminate some of the worst invasive species in Samoa, particularly *Adenanthera pavonina*, *Castilla elastica*, *Funtumia elastica* (*pulu vao*), *Spathodea campanulata* (tulip tree), *Elaeocarpus angustifolius,* and *Clidemia hirta.*
4. Legislation: Samoa needs effective legislation that can protect the forests. Most of what exists is not enforced by the government or clearly understood by village communities. Formulating effective legislation is very difficult, and getting village communities to completely understand that it is their benefit even harder, but it is critical to the survival of Samoa's forests.

Reptiles

1. Sites where at least one trapping session was prevented by rain should be revisited to gain baseline information about reptile species occurrence and abundance at those sites. We also advocate for additional survey work above ~1300 m in the Central Savai'i uplands to confirm the absence of reptiles above this threshold, given that the potential for new species discoveries are highest in this area.
2. Manage and limit access to the upland rainforest in Central Savai'i – this is the best way to minimize disturbance to the habitat and prevent the further spread of non-native species.
3. Educate village communities about the damage of human foot and vehicle traffic on the upland habitat, as well as accidental transport of non-native and potentially invasive species that could lead to the extinction of certain native species found nowhere else in the world outside of Samoa. Education should coincide with management so that locals have an understanding of the impacts of this activity and are directly involved with the safeguarding of this habitat. This would limit the perception of being 'policed' by government regulatory agencies.
4. Provide training for local communities to develop strategies to aid in the protection of Samoa's biodiversity (non-exclusive of #3). Key to this endeavor is helping people understand why this is important and not simply an exercise. This starts with education about the historical biogeography of Samoa, and how that history has led to the evolution of a unique fauna and flora. Emphasis on endemism and extinction adds context to the importance of conserving biodiversity.
5. Conduct studies that investigate the impacts of *A. gracilipes* on the distribution and abundance of Samoa's land reptiles. To date, evidence supporting *A. gracilipes* as a leading cause of reptile declines in Samoa is speculative (although it is almost certainly true). Assuming rather than having definitive evidence in support of this hypothesis could be directing attention away from other important factors causing population declines. If certain reptile species are differentially effected by the ant's presence, it may be possible to focus ant eradication efforts (or prevent introductions) in areas known to support the more sensitive species. Investigations on *A. gracilipes* eradication on Nu'utele are ongoing (Hoffman *et al.* 2014) and baseline reptile data already exist for that island (Fisher *et al.*

2012); thus, opportunities to examine reptile responses to *A. gracilipes* eradication are already in place in Samoa and merit serious attention. As climate change is predicted to increase the spread of *A. gracilipes* and other invasive species, it is important to understand the degree to which these species influence the current distributions and survival of native reptiles.

6. Conduct studies on the viability of cat eradication in the Central Savai'i upland rain forest. Cats have a clear presence in this high elevation habitat, and they were observed to prey on at least one native bird species. Removal of cats from this area would increase resilience and potentially decrease the risk of extinction in native species in this unique habitat. Certain techniques have already been used to success on islands and should be considered here (Nogales *et al*. 2004; Campbell *et al*. 2011)
7. Continue to monitor previously surveyed areas with the same protocols to assess stability in species composition and abundance at the different survey sites. The best way to test for effects of climate change, spread of invasive species, land conversion, and other factors potentially leading to species' declines is to detect 'early warning signals' that indicate disruptions in the status quo.

Lepidoptera

1. Build on existing knowledge of butterflies and moths by further survey in the sites and in the region but most significantly at Malololelei –Upolu where most of the known moth fauna of Samoa was first collected. This is to identify changes at that site and the significance of alternative areas such as the uplands of Savai'i and the steeplands of Uafato where many of the species were rediscovered. This also builds a better picture of threatened butterflies and moths.
2. Identify populations and habitats of the ghost moth *Phassodes vitiensis* in both Samoa and Fiji since this moth has not been recorded from Samoa since 1924, American Samoa since early 1960s and is rarely recorded in Fiji. This moth is large and likely attracted to night time lights and so would not be mistaken. A taxonomic investigation of Samoan *Phassodes* may also identify a new species.
3. Survey Falealupo Peninsula and Uafato-Tiavea KBA outside of the dry season for the potential presence of four cryptic endemic butterflies including Samoan dart *Oriens augustula alexina*, Samoan eggfly *Hypolimnas errabunda*, Samoan ranger *Phalanta exulans (*caterpillar host *Melicytus samoensis* not recorded yet in these two areas) and Samoan cornealian *Deudorix doris*.
4. The forest shrub *Micromelum minutum* (talafalu) was recorded in Falealupo Peninsula during the survey and is not yet reported for Uafato-Tiavea. Talafalu was the caterpillar host plant for Samoan swallowtail butterfly prior to its extinction from Upolu and Savai'i. A future programme to re-introduce this lost butterfly would need healthy populations of talafalu which now appears common at the A'opo Flow near Letui but rare and occasional elsewhere in Upolu and Savai'i.
5. Investigate the complex of rat species present and their montane and cloud forest ecology.
6. Begin a conversation with village ownership of these regions about their desire for the future of indigenous ecosystems and for ecosystem services from them.

Birds

There are three primary responses that conservation managers can use to help to reduce the impact of pressures on bird populations:

1. Protect sufficient key areas

Identifying the key areas for biodiversity is the first step to developing a basis for an effective national conservation plan. This study supports the recommendations of Conservation International (2010) in identifying the Central Savaii Rainforest, the Uafato-Tiavea Coastal Rainforest and, to a lesser extent, the Falealupo Peninsula Coastal Rainforest KBA as key areas for birds. The review of recent bird sightings in the Apia Catchments KBA indicate that this, also is a key area for birds. The remaining sites in the KBA report (CI 2010), in particular the Eastern Upolu Craters and O le Pupu Pue National Park, are likely to provide the remaining priority sites for a network of areas that are protected to benefit avian (and other) biodiversity. Considered planning is required to ensure that there are sufficient key conservation sites distributed in the landscape that can provide refugia following cyclones. Valleys (and craters) might be particularly important as refugia since it has been noted that, following past cyclones, many birds moved into forest sheltered from the cyclone that contained native vegetation with fruit, flowers and leaves; less sheltered areas had little leaves, flowers and fruit remaining on the tress (Elmqvist *et al*. 1994, Park *et al*. 1992, Schuster *et al*. 1999).

2. Improve forest quality in key sites

Improving habitat within the above key areas by removing invasive weeds and replanting native species is likely to further benefit many bird species. This is, clearly, a long term plan that can help to improve sites over decades. There is an initial need to develop a canopy that will benefit most species, but then also to incorporate the species identified as of most importance to the avifauna – with nectar-bearing flowering trees being of particular importance for the honeyeaters, for instance. One of the immediate areas of concern would be the re-establishment of forested areas following cyclone damage. Improved understanding of how to minimise the spread and establishment of invasive species, and the extent to which this then impacts on the development of a native forest would be an area of study that would benefit our understanding of the response to extreme weather events.

3. Increase survival and reproductive success of key endangered species

Many key declining species are threatened by the increasing presence of non-native mammalian predators, particularly species (eg black rat) that have been introduced, or become common, since the arrival of Western peoples. In some species removing one predator, such as black rats, may benefit not just egg survival, but also adult survival. This appears to be true for mao where targeted rat control during the breeding season is predicted to increase both reproductive success and adult survival (Stirnemann *et. al*. 2016). Targeting the early breeding season in Samoa for Mao means May, June and July may have the greatest impact on adult and chick survival. Cat control may also improve survival of juveniles in the early weeks, post-fledgling. Predator control should occur in sites which are identified as being important for the at-risk species.

The conservation of the Tooth-billed pigeon is now of greatest urgency. The species has been upgraded to critically endangered (IUCN 2016). The Mao is also considered to be a globally Endangered species (BirdLife 2017). The Species Recovery Plans for both these species (MNRE 2006 a,b) are now up for review and will need to focus on identifying site-based priority conservation actions based on the best available current evidence.

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Chapter 1: Report on the survey of flora and vegetation of the Falealupo Peninsula Coastal Rainforest, Central Savai‘i Rainforest and Uafato-Ti‘avea Coastal Rainforest

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Photo credits: All photos by Art Whistler unless otherwise stated.

The Mata-ole-Afi camp site showing environmental damage from vehicles.

Summary

- Three areas of Samoa were visited during the survey, which was carried out from 16 July to 3 August 2016: the Central Savaiʻi Rainforest KBA (comprising the montane regions of Taga and Aʻopo), the Falealupo Peninsula Coastal Rainforest KBA, and the Uafato-Ti'avea Coastal Rainforest KBA.
- A total of 18 plots measuring 10 x 100 m were surveyed. All trees with a dbh (diameter at base height) of 5 cm or more were measured and identified in each plot. Notes on the vegetation were taken, and a checklist of all vascular plant species (ferns and higher plants), including all terrestrial herbs, epiphytes, vines, shrubs, and trees, at each site was prepared. The GSP coordinates of the ends of each 100m survey line were recorded so that the exact same plot could be sampled in the future. The tree measurements were then processed and compiled into a table of the relative dominance of all tree species in the plot.
- Five plots were sampled in the Falealupo KBA in the lowlands from 16 to 141 m elevation in areas that would normally be lowland rainforest. A total of 144 plant species was recorded, 113 (78%) of them native species (106 indigenous and seven endemic) and about 30 (22%) of them alien species (introductions by early Polynesians and subsequent arrivals).
- Ten plots (four in Taga and six in Aʻopo) were sampled in Central Savaiʻi KBA in the upland region from 600 to 1800 m elevation in areas that would normally be lowland rainforest to cloud forest. A total of 374 plant species was recorded, 339 (91%) of them native species (224 indigenous and 115 endemic) and about 35 (9%) of them alien species.
- Three plots were sampled in the upland region from 220 to 400 m elevation in areas that would normally be lowland rainforest. From that and previous surveys, a total of 377 plant species was recorded, 287 (74%) of them native species (245 indigenous and 42 endemic) and about 94 (26%) of them alien species.
- Several weedy species were found to be invasive in the study areas. In the Falealupo KBA *Adenanthera pavonina* (***lopā***, red bead tree) was very invasive in three of the five plots. A few *Elaeocarpus angustifolius* (***sapatua***, blue-marble tree) and *Castilla elastica* (***pulu mamoe***) trees were found in the area, but probably will not thrive because of the relative dry conditions at the west end of the island. The main weed in the Central Savaiʻi is relative free of weeds, but *Clidemia hirta* (Koster's curse) is common along trails and in clearings in montane forest. *Merremia peltata* (***fue lautetele***) is common in clearing at the lowest elevations. The two most invasive species in the Uafato KBA are *Paraserianthes falcataria* (***tamaligi***) and *Adenanthera pavonina*, but they were virtually absent from the three plots. The Polynesian introduction *Inocarpus fagifer* (Tahitian chestnut, ***ifi***) was common in the area, but does not readily spread and hence is not invasive. Three other trees, *Canarium harveyi* (***mafoa***), *Syzygium samarangense* (***nonu vao***), and *Garcinia myrtifolia* (no Samoan name) are also alien species that are occasional to common in the area, but they are not considered to be harmful to native forests.

1. Introduction

The project involved three study areas—the KBAs (Key Biodiversity Areas) of the Falealupo Peninsula Coastal Rainforest KBA, the Central Savaiʻi Rainforest KBA (comprising the montane regions of Taga and Aʻopo), and the Uafato-Tiʻavea Coastal Rainforest KBA. Additionally, a literature review of botanical information from the Lake Lanoto'o National Park was also conducted.

The Falealupo KBA, which comprises the Falealupo Conservation Area and a peripheral zone around it, is situated on old lava flows on the western end of Savaiʻi, and was visited on 18–20 July 2016. The vegetation is a combination of managed land (villages and plantations), disturbed native vegetation (mostly secondary forest), dry lowland lava flow forest, and littoral vegetation. Elevations range from sea level to over 120 m. Five 100 x 10 m forest plots were sampled in the study area along newly cut forest trails. The second study area, the Central Savaiʻi KBA, is comprised of two parts. The first part, the lowland to cloud forest above Taga on the south coast of Savaiʻi, was visited 21–24 July. Four forest plots were sampled along a newly cut trail from 600 to 1075 m. The second part, upland Aʻopo, was visited from 25–29 July 2016. Six plots were sampled there in montane to cloud forest, mostly along the established trail from a parking area at 800 m up to the volcanic flows at 1670 m and beyond to the top of the highest mountain in Samoa, Mt. Silisili at 1860 m. The third study area comprised the mountainous area between Uafato and Tiʻavea on the northeast portion of ʻUpolu, and was sampled on 1–3 August 2016. Three plots—between the ridges east of the village and one on the south side of the mountains—were sampled there. These plots ranged from 200 to 400 m elevation, and were comprised entirely of lowland forest. The study areas are described in more detail in the three respective sections below.

2. Methodology

The methodology plan called for the setting up of "an appropriate number of permanent plots (up to six for each of the three sites) in the forest, with some plots below 600 m (lowland forest) and some above 600m (montane or upland forests)." The actual number was contingent upon the time available in the field, the weather, and the accessibility of study areas. In the end, a total of 18 plots were sampled, from 3 to 6 for each of the sites (see Fig.1.1 for plot locations). The GPS locations at the two ends of each plot were recorded so that they can be relocated for future study, making them "permanent plots."

When establishing the plots, an area of representative vegetation (i.e., one without disturbance and with a homogeneous cover) was selected and two 50-m tapes were laid out end to end. The area to be sampled comprised the zone extending out 5 m from each side of the line, making the plot 100 x 10 m in extent. The center line of the plot was marked by the tapes on the ground and the boundaries 5 m from it were marked with flagging tape. The survey crew then went down the line measuring all trees with a diameter at breast height (DBH) of 5 cm and above within 5 m of one side of the line (Fig. 1.2), and returned on the other side doing the same thing. The trees were measured using a DBH tape placed around the trunk at breast height. If the trunk comprised multiple stems, the measurement was made lower down the trunk or, depending upon the structure of the tree, on all sufficiently large branches at breast height. If the tree had a large buttress, it was measured above the buttress, but only with great difficulty.

Figure 1.1 Plant and Vegetation Survey Sites

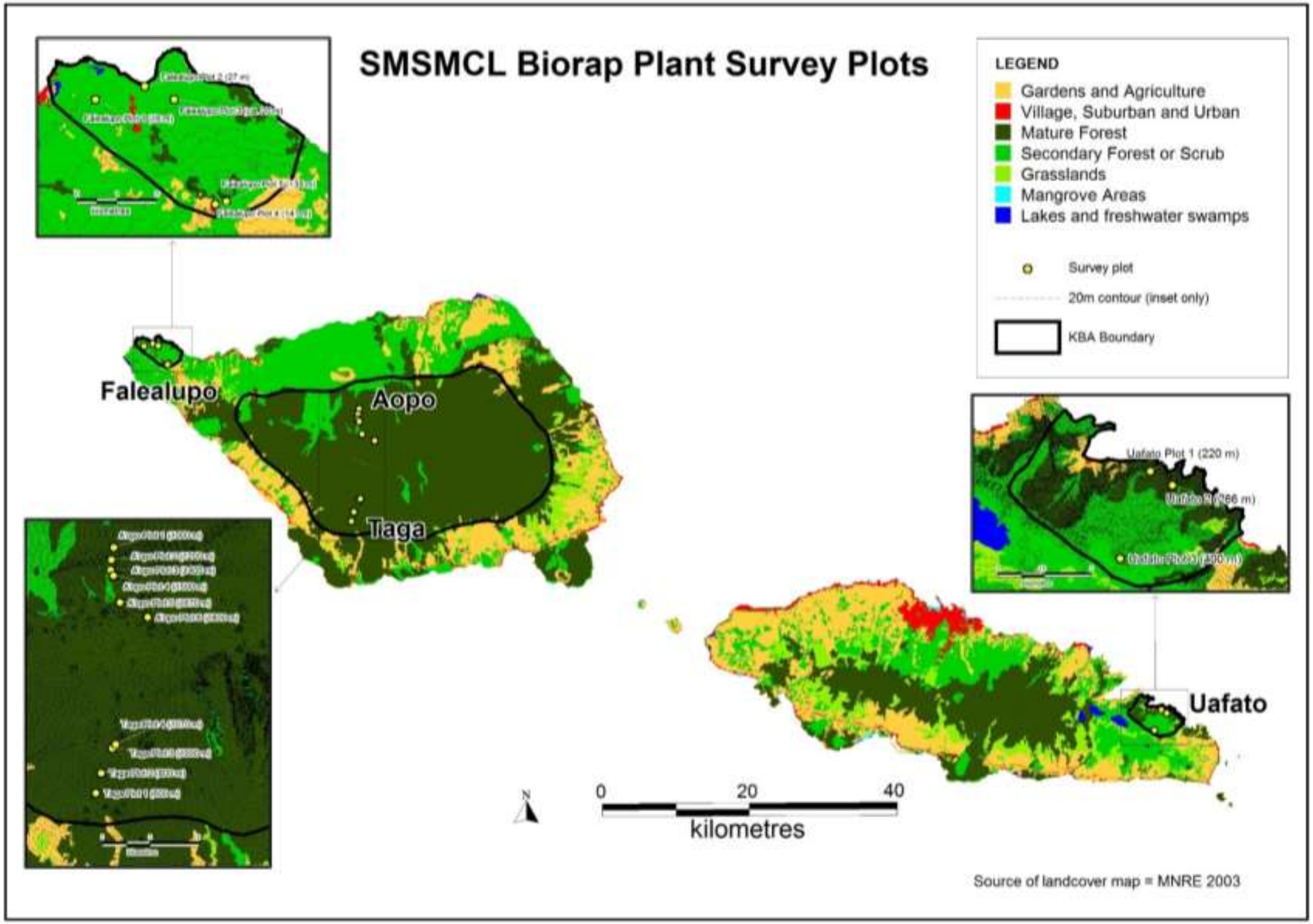

Figure 1.2. Paolo measuring the DBH of a tree in the Taga rainforest.

After the plot was sampled, data was collated and relative dominance for each species was calculated by dividing the total stem cross-sectional area of the species by the total stem cross-sectional area of all species. The stem area of an individual tree is determined by measuring the DBH, which is a diameter rather than a circumference. The diameter is squared and multiplied by 0.789. The latter is the ratio of the area of a circle (a tree trunk cross-section) to the area of a square. Alternatively, in mathematical terms, this is πr^2. The total basal areas of all of trees were summed up and the species placed in a table in descending order of relative dominance (see Appendices 1.2, 1.4 and 1.6). The column to the right of the two species names columns (scientific and Samoan name) shows the number of individuals of that species in the plot. The column to the right of that shows the number of sampled individuals having a basal diameter of 15 cm or more, which is a simple indication of the relative size of the individuals (i.e., how many of the individuals are relatively large trees). The next column shows the total basal area of each species. The last (far right) column shows the relative dominance of each species. The total number of trees, the total number of trees over 15 cm DBH, and the total tree basal area of the plot are shown at the bottom of each table. The relative dominance of a species is determined by dividing its total basal area by the total basal area of all trees in the plot, giving a percentage figure.

A checklist of all species (trees, herbs, shrubs, and ferns) encountered was compiled during the surveys of each site. Trees encountered in the sampling of the plots were added if they had not been found earlier. Some tree species not found during the plot sampling were found around the plot or as seedlings or saplings in the plot but too small to be measured (i.e., below 5 cm DBH). These were all added to the checklist. In the cases of the Uafato KBA and the Aʻopo part of the Central Savaiʻi KBA, species recorded only in earlier surveys were added to the checklist to make the accounts of known flora from these areas comprehensive.

As little time was available for each plot, there was no concerted effort to check the epiphytes on the trees by using binoculars. More time would have allowed this and would have increased the number of species found in the plot or surrounding area. A list of all species found in the study areas is found in Appendices 1.1, 1.3, and 1.5. Notes were also taken on the frequency species were encountered and the composition of the vegetation to help in the subsequent writing of vegetation descriptions.

Voucher specimens (that vouch for the presence of species in an area) were collected. The consultant recognised most of the species collected, but some, especially small ferns, needed further research of the literature and the consultant's notes to determine their identity. Those still not recognised were later studied by the Consultant after he returned to Honolulu. After collection, voucher specimens were put into newspapers, which were then inserted between sections of cardboard (ventilators) and arranged into stacks. The stack was then put into a wooden plant press and two straps wrapped around it to compress the whole. These presses were put into a jerry-rigged plant drier situated in a room at the Vaisala Hotel. All the plants from the first two study areas (three sites) were processed in this way. Because of the volume of specimens and the little time available between field days, the specimens were slow to dry, so when the whole team returned to 'Upolu, the presses were taken to the forestry office where they were further dried in a large laboratory drier. When all the specimens were dry, they were sorted into sets because duplicates of most the specimens were made. One set was transferred to MNRE, one was sent to the Auckland War Memorial Museum (New Zealand) herbarium, and two (sometimes one) to the National Tropical Botanical Garden in Hawai'i. The goal was to collect four duplicates of each specimen, but some species, especially orchids, are represented by a single set since only one or a few were found.

3. Falealupo Peninsula Coastal Rainforest Key Biodiversity Area

3.1. Introduction

The Falealupo Key Biodiversity Area (KBA) is located on the northwestern end of the Falealupo peninsula (see Fig. 1.1). It encompasses the previously established Falealupo Conservation Area, which comprises 1537 ha (although several sources cite 12000 ha as the area of preserved land, an area much larger than the whole peninsula), as well as an expanded peripheral area perhaps as large. It lies between the two parts of Falealupo village, Falealupo-Uta and Falealupo-Tai. The area is very disturbed from recent cyclones (in the early 1990s) and by human activity, but patches of lowland native forest still cover much of the area. This is a unique forest because of its location in the driest part of the archipelago. It sits on the leeward side of the island in the rain shadow of the massive volcanic dome of Savai'i, shielded from the rain-bearing southeast trade winds. This results in a relative dry area with only about 200 cm of annual rainfall, just over half of that recorded for the windward side of the island. One consequence of this is that the tree species dominating the lowland forest around most of the island, *Pometia pinnata* (***tava***), is absent or only a minor component of the lowland forest, at least on the western portion (see the plot data in Appendix 1.2).

3.2. Methodology

The survey team worked in the Falealupo KBA from 18–20 July 2016. Five 100 x 10 m permanent plots were set up over the three days. The first plot (S 13.50114, W 172.77551 to S 13.50167, W 172.77617) was sampled along a trail cut through lowland lava flow forest dominated by a combination of lowland forest species, especially *Syzygium inophylloides* (***asi toa***). The second day two more plots were sampled (S 13.49818, W 172.76419 to S 13.49894, W 172.76466 and S 13.50114, W 172.75742 to S 13.50106, W 172.75647) along the trail to Fagalele Bay and an extension of the trail cut through forest on an adjacent area. These plots were both dominated by the invasive tree *Adenanthera pavonina* (***lopa***, red bead tree). On the third day, a plot (S 13.52482, W 172.74799 to S 13.52565, W 172.74803) in relatively undisturbed lowland lava flow forest dominated by *Pometia pinnata* was sampled. The last plot (S 13.52416, W 172.74551 to S 13.52367, W 172.74632) was sampled in a previously burned area dominated by native secondary forest species, especially *Macaranga harveyana* (***lau pata***) mixed with other typical secondary forest species. The methods used in this work are discussed in the introductory portion of this report (above). Tree data for the five plots the Falealupo KBA can be found in Appendix 1.2.

3.3. Vegetation

Although included in the site is the Falealupo Conservation Area that has been on the books for several decades, there apparently have been no organized botanical surveys in the area. The closest thing to a survey is part of a tree data table from Whistler (2002) that includes references to a plot sampled in the area (see below). Based upon the present survey, several types of vegetation are recognized: Undisturbed Vegetation (Littoral Strand, Lowland Forest) and Disturbed Vegetation (Managed Land Vegetation, Successional Vegetation, and Secondary Forest).

3.3.1. Undisturbed Vegetation

Undisturbed vegetation is relatively stable in structure and flora and changes little over time. Although it is periodically disturbed by natural events, such as fire, cyclones, and drought, and by human events, such as land clearing, over time it returns to what it looked like before the disturbance ("primary vegetation"). This is in contrast to disturbed vegetation, which is described below. Scientists who study vegetation usually divide it into "plant communities" that are similar in structure. One plant community may look structurally like another, but may have an entirely different dominant or set of dominant species, and thus belong to a different "association." For example, one Littoral Strand forest may be dominated by *Barringtonia asiatica* (***futu***, fish poison tree) while another may be dominated by *Calophyllum inophyllum* (***fetau***), and thus the two belong to different associations of the Littoral Forest plant community. Only two types of undisturbed vegetation were observed in the KBA, Littoral Strand and Lowland Lavaflow Forest.

3.3.1.1. Littoral Strand

This community comprises all types of natural vegetation occurring on the seashore and dominated by plant species whose presence and distribution are affected either directly or indirectly by the sea. This vegetation is sometimes called "coastal," but "littoral" (Latin: *litoris* = shore) is a more precise term, since a different kind of non-littoral community called "coastal forest" has sometimes been distinguished in Samoa. Littoral vegetation differs from most inland vegetation in both its extent (area) and distribution. It occupies a very narrow area on the immediate coast, and typically exhibits zonation into several bands that run roughly parallel to the coastline. The zones typically recognized in the literature are herbaceous strand (often further distinguished into those occurring on sandy shores and rocky shores), littoral shrubland, *Pandanus* scrub, and littoral forest. Littoral Strand occurs in the Falealupo KBA in a narrow band all along the shore of the peninsula. Most of the KBA coastline is formed by lava cliffs, but at Fagalele Bay the beach is covered with beachrock (lithified beach sand). The Littoral Strand on that beach comprises a zone of shrubs (littoral shrubland) dominated by *Scaevola taccada* (***to'ito'i***) on the shore, and inland from that a narrow zone of littoral forest dominated by typical littoral trees such as *Barringtonia asiatica*, *Calophyllum inophyllum*, and *Cordia subcordata* (***tauanave***). No plots were established in this plant community during the present survey (or any previous survey to our knowledge) so will not be further discussed. A comprehensive description of the Littoral Strand vegetation can be found in *The Samoan Rainforest* (Whistler 2002).

3.3.1.2. Lowland Lavaflow Forest

Lowland rainforest occurs in the lowlands of Samoa, from near sea level to any height between 600 and 1000 m elevation, depending upon a number of factors. Lowland forest in Samoa is composed of a great number of tree species, although not nearly as many as in most areas of tropical rainforest in Melanesia and Asia to the west or in tropical America to the east. Because so many tree species are present, each of which acts independently from the others and responds differently to variation in environmental factors (e.g. soil type, elevation, exposure), it is nearly impossible to subdivide lowland forest in a meaningful way since natural boundaries are almost non-existent. Even if a forest type can be recognized, it may have a wide elevation range, causing changes in species composition with increasing or decreasing elevation. Nevertheless, it is useful to describe different types, based on different species mixes, even if no distinct boundaries can be recognized. Only one type of lowland rainforest is found in this KBA at the dry western end of Savai'i—Lowland Lavaflow Forest, which is described below.

During the survey, two plots were sampled in this type of forest, and the results are presented in Tables 1 and 4 in Appendix 1.2. The first site was dominated by the native *Syzygium inophylloides* with 29% relative dominance. The forest was somewhat disturbed, however, as seen by the next two most important trees, *Adenanthera pavonina* and *Aleurites moluccanus* (***lama***, candlenut tree). The other top ten trees in the plot are a mixture of lowland forest trees, such as *Dysoxylum samoense* (***maota***), *Diospyros samoensis* (***'au'auli***), and *Syzygium clusiifolium* (***asi vai***), and the disturbed forest trees *Hibiscus tiliaceus* (***fau***, beach hibiscus), and *Rhus taitensis* (***tavai***). Four species that characterize disturbed forest are also present. The most common of these is *Adenanthera pavonina* that occurs in all size classes, an indication that it will persist there. The other area of Lowland Lavaflow Forest was in Plot 4, which was dominated by *Pometia pinnata* with 45% relative dominance, and *Dysoxylum samoense* with 15%. The rest of the trees are a mixture of primary and secondary forest species, which indicate past disturbance. This is similar to a forest briefly listed from Falealupo (Whistler 2002) that was dominated by *Pometia pinnata Intsia bijuga* (***ifilele***), and *Syzygium inophylloides*.

3.3.2. Disturbed Vegetation

This category (sometimes referred to as "secondary vegetation") includes several different types of vegetation that—because of climatic or human disturbance—have a structure and flora that are in a state of transition. Two concepts—"plant succession" and "climax community," are keys to understanding the role of disturbance in tropical vegetation. Plant succession refers to the gradual change in vegetation, both in flora (species composition) and structure, that occurs in an area after some kind of natural or man-made disturbance has occurred. For example, a fresh lava flow is devoid of all plant life, but over time and through a predictable, continuous series of stages, eventually becomes covered with rainforest. If a forest is burned down, decimated by a cyclone, or cleared for a plantation and eventually abandoned, succession follows, eventually returning the forest to its original condition. Depending upon the type of disturbance, these examples of plant succession may take hundreds or even thousands of years.

A climax plant community is one in which the component species perpetuate themselves by reproduction, resulting in its flora and structure, barring further major disturbance, that change little over time. For example, a *Pometia* Lowland Forest is a stable climax community. That is not to say that these communities never change. Given enough time, even without disturbance, change will eventually occur. *Pometia* lowland forest, over a period of thousands of years, may be replaced by one dominated by other tree species when the soil becomes better developed.

The final stage of plant succession in forest is called "climax forest." This term is often confused with "primary forest," which is the natural and undisturbed forest in an area. However, nearly all of the mature forests in Samoa are better described as climax rather than primary forest, since in ancient times much of the interior of the islands was inhabited and cleared for cultivation before being abandoned early in the European Era (after 1830). Three disturbed plant communities occur in the Falealupo KBA—managed land vegetation, successional vegetation, and secondary forest. However, it must be kept in mind that these are interrelated successional stages that blend into each other in space and time.

3.3.2.1. Managed Land Vegetation

Managed Land Vegetation comprises the vegetation on land actively managed by man for his uses, including paved and unpaved roads, roadsides, village greens (*malae*), plantations, and pastures. It also includes land where timber has just been felled, since this is a form of management (even though the active management may end after the tree felling). When trees are felled, the land may be converted into permanent plantations or utilized for a short while for growing crops. But Samoan soils, like others in the tropics, are characteristically poor in minerals, and much of the available mineral content is tied up in the trees. When the trees are felled and burned or left to rot, the minerals suddenly released into the soil are quickly washed away or are used up by the crop plants. After a few crop cycles, the harvest becomes greatly diminished and the land is abandoned or planted with permanent tree crops, which (compared to taro) are less demanding on the soil. Active management prevents disturbed land from returning to its natural plant cover and promotes the dominance of cultivated plants (which are wanted) and weeds (which are not). The amount of management, in the form of weeding (mechanical means, hand-weeding, or herbicides), determines whether the cultivated or weedy plants will dominate. Once active management ends, herbaceous weeds soon dominate. Probably most of this type of vegetation in the KBA comprises plantations. Most of the weeds in the checklist of the flora of the KBA (Appendix 1.1) are found in this vegetation. No permanent plots were sampled here, so it will not be discussed further. It is more completely described in *The Samoan Rainforest* (Whistler 2002).

3.3.2.2. Successional Vegetation

This is the scrubby vegetation found on recently disturbed land or recently abandoned managed land. The first stage following abandonment or severe disturbance is dominated by herbaceous adventive plants (i.e. weeds). This stage is, in turn, followed by one in which new shrub or tree invaders eventually dominate for awhile. In Managed Land Vegetation, the woody species are eliminated or at least inhibited by cutting or weeding. However, when management ends, they can become established and grow above the herbaceous plants producing shade that is unfavorable for the growth of most of the smaller plants beneath them. Vines, however, can avoid being shaded out (for a while at least) by climbing on the shrubs and trees to maintain their place in the sun.

The dominant trees of Successional Vegetation are fast-growing, light-loving species, most of which are short and do not reach the height of typical canopy forest trees. When taller tree species eventually overtop the shorter ones and shade them out, there is a transition to the next community, secondary forest, but the line between the two is necessarily indistinct. Although classified as a community here, Successional Vegetation can also be viewed as an intermediate stage between Managed Land Vegetation and secondary forest, but this is a problem inherent to the goal of classification of vegetation into discrete units. The most characteristic trees and shrubs of successional vegetation are *Pipturus argenteus* (***sogā***), *Macaranga harveyana* (***lau pata***), *Homalanthus nutans* (***fogāmamala***), *Trema cannabina* (***magele***), *Melochia aristata* (***ma'oui***), *Kleinhovia hospita* (***fu'afu'a***), *Melastoma denticulatum* (***fua lole***), *Morinda citrifolia* (***nonu***, Indian mulberry), and *Hibiscus tiliaceus* (***fau***, beach hibiscus), all of which are native. Other species common in some places are the invasive species *Leucaena leucocephala* (***lusina***, wild tamarind) and *Psidium guajava* (***ku'ava***, guava), both of them alien (non-native) species.

One plot of Successional Vegetation was sampled during the present survey of the Falealupo KBA and is shown in Table 5 in Appendix 1.2. The dominant tree there was *Macaranga harveyi* making up over half of the measured trees and 55% of the relative dominance. The next two dominants are *Rhus taitensis* (***tavai)*** and *Alphitonia zizyphoides* (***toi***) which will probably eventually grow to shade out the *Macaranga harveyi* and dominate future secondary forest. Successional vegetation is described in more detail in Whistler (2002).

3.3.2.3. Secondary Forest

Secondary forest is typically dominated by fast-growing trees with small, easily dispersed seeds that require relatively sunny conditions for germination and/or establishment. It is a successional stage between secondary scrub and primary forest. Although superficially similar in structure to the climax forest types, its population structure and flora are quite different. Secondary forest trees dominate the canopy, but other species—particularly ones that can germinate and become established in shady conditions (and which usually have larger seeds)—typically dominate the smaller size classes. Without further disturbance, the sunny conditions required for germination and establishment of the secondary forest species will no longer be present, and the slower-growing canopy tree species that dominate the smaller size classes will eventually prevail when the larger secondary forest trees of the canopy age and die. After a long period, the climax forest that develops will be virtually indistinguishable from primary forests in the area.

The most common secondary forest tree species include *Rhus taitensis*, *Alphitonia zizyphoides*, *Bischofia javanica* (***ʻoʻa***), *Elattostachys apetala* (***taputoʻi***), *Dysoxylum samoense*, *Dysoxylum maota* (***tufaso***), *Neonauclea forsteri* (***afa***), and *Pometia pinnata*. The first four are typical secondary forest species, while the latter four are also dominant or component species of primary forests. No areas of secondary forest were seen during the brief visit to the area, but it is no doubt present in the area. A look at the population structure of the one plot of successional vegetation (Appendix 1.2 Plot 5) shows that that forest will one day be secondary forest. Secondary forest is described in more detail in *The Samoan Rainforest* (Whistler 2002). A scrubby secondary forest is shown in Fig. 1.3.

Figure 1.3. Scrubby vegetation at Falealupo.

3.4. The Flora

The vascular flora of the Samoa Archipelago is estimated to be about 831 native and naturalized flowering plant species (Whistler data 2017). Naturalized species are non-native ones that have become established and are now a permanent part of the flora. No botanical surveys of the area have been published, so the checklist compiled during the present work includes all species known from the area, and is shown in Appendix 1.1. A total of 143 plant species have been recorded in the Conservation Area (124 dicots and 9 monocots, 10 ferns), 114 (78%) of which are native (106 indigenous and seven endemic) species. The remaining 29 or so species (some are of uncertain provenance) comprise alien species (introductions by early Polynesians and subsequent arrivals). The very low number of ferns recorded is a result of the dry conditions there, as most ferns grow in moist places.

Many more species would undoubtedly be found if further botanical studies were conducted, especially along roadsides (for weeds) and along the coast for littoral species. Compared to the other two KBAs studied during the present work, the number of species present is very small, probably due to the dry conditions at this end of Savaiʻi.

3.5. Discussion

Five permanent plots were established in the Falealupo KBA and all trees in the plot measured. Because the coordinates of the two ends of the survey 100 m survey line were recorded, the plots can be sampled again in the future to see what changes in the flora and dominant species of plot occur. The three plots were all below 135 m elevation on the driest part of the Samoan archipelago. The tree data for these plots is found in Appendix 1.2, along with their precise GPS locations of the plots.

About 80 voucher specimens were also collected, and duplicates of these were divided between MNRE, the Auckland Museum, and the National Tropical Botanical Garden. In addition to the tree plot data, notes were taken on the flora at different elevations in order to better understand the elevation ranges of species. A checklist of the flora of the KBA was compiled and is shown in Appendix 1.1. It is by no means a complete flora checklist, since only small parts of the KBA were studied, mostly in the forests. Notes were also taken on rare plant species present and invasives.

3.5.1. Rare Species

A total of seven species recorded from the KBA were listed by Whistler (2010) as being rare in Samoa. These include *Centipeda minima* (no Samoan name), *Capparis marina* (no Samoan name), *Crateva religiosa* (***pua elo***), *Acacia simplex* (***tatagia***), *Gyrocarpus americanus* (***vili***, ***moa***), *Sida parviflora* (***mautofu***), and *Manilkara samoensis* (***pau***). Of these, only three were seen during the present survey, *Crateva religiosa*, *Gyrocarpus americanus*, and *Manilkara samoensis*, all of them in the forest in the vicinity of Fagalele Bay. The wetland herb *Centipeda minima* has been collected twice in the coastal area of Falealupo, but not for many years. *Acacia simplex* and *Capparis marina* are littoral species that probably still occur in places along the rocky coast that were not visited during the present survey. The *Sida parviflora* is probably an ancient introduction to Samoa that occurs in disturbed coastal places, and may have disappeared from this KBA since its last date of collection there was 1931.

3.5.2. Invasive Species

The most invasive species by far in the KBA is *Adenanthera pavonina*. It was present in the first three plots of dry lowland lava flow forest, with relative dominance figures of 12%, 71%, and 41%. Overall in the three plots it comprised 38% of the trees measured there. A look at the population structure shows that it is common in all size classes, meaning that there are large trees that are successfully reproducing the species. Only two individuals were found in the closed canopy *Pometia pinnata* forest of Plot 5. It would be hard to eliminate this pest from the KBA forests, but its presence in areas where it is missing or at least uncommon should be monitored and newly invading trees removed, if feasible.

Most of the other weedy species in the KBA are sun-loving herbs, but these are most commonly found in open canopy areas. No other species were seen to be an immediate threat to the KBA. A few *Elaeocarpus angustifolius* (***sapatua***, blue-marble tree), the most invasive species in the disturbed forest of Taga and Aʻopo, were found in the Falealupo KBA. They are probably not much of a threat since the site is so dry. It is most common in the eastern portion of the KBA, where it should periodically be monitored to see if it is increasing in frequency. *Clidemia hirta* (Koster's curse), the most invasive species of the montane forest of the Central Savaiʻi KBA, was not recorded in the Falealupo KBA, probably because the conditions there are too dry. One individual of *Castilla elastica* (***pulu mamoe***) was found, but it did not turn up in any of the plots. The record is significant, however, since it shows that the species, which is major invasive species in central ʻUpolu, has finally reached the western end of the archipelago. Hopefully it will not become a major pest on Savaiʻi as it has on ʻUpolu.

3.5.3. Commercial Species

There is probably not much commercial timber left in the KBA, but one individual species is very valuable. *Manilkara samoensis* is endemic to Samoa, and except for a single record near Aʻopo, it is entirely restricted to the Falealupo peninsula (although it is now in cultivation on ʻUpolu). Because of its hard wood, this species is probably only second in importance to *Intsia bijuga* in making handicrafts. It is probably being over-harvested, so studies should be made on the impact that selective logging is having on it.

3.5.4. Climate Change

Because of climate change, the vegetation in these plots can be expected to change. Just what these changes will be is difficult to predict, since few if any of the trees in the KBA have been studied to see what possible changes in their distribution will occur with a warming climate. The whole site is below about 150 m elevation, so is more homogeneous than the other KBA studied during the present survey. Probably the major effect of climate change will be an increase in temperatures, which can adversely affect plant species and their distribution. An increase in rainfall might make the area more hospitable to more lowland forest trees, but there is no way of knowing what will happen to the mix of species that now occurs there, or if new invasive species will arrive and become troublesome.

4. Central Savaii Rainforest KBA

4.1. Introduction

The Central Savaiʻi Key Biodiversity Area (KBA) comprises the upland portion of the island of Savaiʻi, the lower boundary of which roughly, but not exactly, corresponds to the imaginary 600 m elevation contour, and extends up to the highest elevations of the island (1860 m). The total size of the KBA is approximately 72,000 ha (CI 2010). Despite three previous botanical expeditions to the region since 1975 (Whistler 1978, 2012, Schuster *et al*. 1999) and the present one, the whole KBA has only partially been studied. Part of the reason is that all four of these surveys were largely concentrated in the Mt. Silisili to Mata ole Afi area and along a narrow corridor from Aʻopo village to there (the easiest access to the montane region of the island). The two Whistler studies concentrated only on the summit volcanic area, but the Schuster *et al*. survey also included four Savaiʻi plots outside of this area (one at Fogasavaiʻi, one at Asau, and two at Salaʻilua). The present survey included four plots in the KBA on the south side of the mountain, all of them above the village of Taga. The whole area was severely disturbed by two cyclones in the early 1990s, but now, after more than 25 years, the structural damage to the forest is undetectable. The only sign of the cyclone influence is the presence of certain indicator species in the plots. These are species that typically become established when the forest canopy has been knocked down by a cyclone or other events involving wind storms.

The whole KBA is covered with volcanic soil along with some recent volcanic areas (Mata ole Afi and Mauga Mū), but most of the area has an older volcanic surface. There is almost no surface water in the area, except on the eastern end, where a few small lakes occur in volcanic craters. The terrain is marked by rocky soils, and flat areas split by numerous dry stream beds (*alia*) that have flowing water only after heavy rain. Most of the vegetation of the area is montane and cloud forest. Only small areas are covered by wetlands (*Carex* bogs and *Pandanus* Swamp forest) and one area by recent volcanic vegetation. Plantations from villages around the periphery usually do not go up to the 600 m elevation contour except in Aʻopo and ʻAsau, where timber extraction activities have taken place for decades. On the west end, the Government owned Cornwall Estates are covered with plantation forest dominated by alien tree species such as teak, and extends up to at least 900 m elevation.

4.2. Methodology

The survey team worked in the Central Savaiʻi KBA in two separate expeditions. The first, at Taga, was carried out 21–24 July 2016, and the second, at Aʻopo, was carried out from 25–29 July 2016. At Taga, four plots were sampled: 600 m (S 13.71864, W 172.51601 to S 13.71832, W 172.51689), 800 m (S 13.70728, W 172.51280 to S 13.70663, W 172.51377), 1000 m (S 13.69325, W 172.50642 to S 13.69245, W 172.50684), and 1075 (S 13.69100, W 172.50443 to S 13.69179, W 172.50484). All four were located along a new track cut for the purpose. At Aʻopo, six plots were sampled: 1000 m (S 13.58008, W 172.50534 to S 13.58080, W 172.5060), at 1200 m (S 13.58703, W 172.50668 to S 13.58614, W 172.50630), 1400 m (S 13.59276, W 172.50717 to S 13.59216, W 172.50641), 1500 m (S 13.59593, W 172.50557 to S 13.59540, W 172.50487), 1670 m (S 13.61116, W 172.50172 to S 13.61153, W 172.50256), and 1800 m (S 13.61949, W 172.48595 to S 13.61908, W 172.48521). The former plots were all along a newly cut trail from Taga Village to a montane crater rim, and most of the latter were along the long-established access trail from Aʻopo southward to the scenic volcanic area at Mata ole Afi. The methods used in this work are discussed in the introduction. Tree data from the ten plots of the Central Savaiʻi KBA can be found in Appendix 1.4.

4.3. Vegetation

The vegetation of the Central Savaiʻi Key Biodiversity Area was first described in a study of the area by Whistler (1978). The second botanical survey of the area two decades later (Schuster *et al.* 1999) included 23 1000 m^2 plots, nine of which were located in the present day KBA, but no description of the plant communities present in the area were made. A third botanical survey was conducted in the KBA by Atherton and Jefferies (2012), and included a description of the plant communities. All plant communities were described in and adapted from *The Samoan Rainforest* (Whistler 2002).

4.3.1. Undisturbed Vegetation

Vegetation types are often classified into two groups based upon whether or not they are disturbed. If they are relatively undisturbed, they change little in structure and species composition over time. If they are significantly disturbed, they are often changing in both structure and species composition and eventually may revert to what appears to be undisturbed vegetation. Based on Whistler (2002) and Atherton & Jefferies (2012), five relatively undisturbed plant communities occur in the area: *Carex* bog, *Pandanus* swamp forest, volcanic scrub, montane forest, and cloud forest. Also included in the area are three disturbed communities: managed land, successional vegetation, and secondary forest. Secondary forest was studied directly during the present survey, but one plot sampled at 600 m elevation can be classified as this.

4.3.1.1. Carex Bog

This is the herbaceous vegetation that dominates high elevation areas of Savaiʻi having waterlogged soil. The dominant species of the *Carex* bogs are two species of wetland sedges, *Carex graeffeana* and *Carex savaiiensis*. These herbaceous hydrophytes (aquatic plants) dominate areas of waterlogged soil where native trees are unable to grow. In addition to the differences in species composition, bogs typically differ from other types of Samoan marsh by the presence of a layer of peat. They are known from several localities in montane Savaiʻi, mostly inside old volcanic craters. One large area of bog (occurring in two patches) is found in a shallow depression located just south of Mt. Silisili.

The bogs were not visited during the present survey, but a brief description of them was included in Whistler (Whistler 1978): "These meadows occur in the cloud forest in old volcanic craters and poorly drained valleys…The first is the shallow crater of a volcanic cone south of Mt. Silisili at an elevation of 1650 m. The vegetation of the crater floor consists of low herbaceous plants mostly less than 30 cm high. The dominant species are *Carex samoensis*[now called *C. savaiiensis*], *Paspalum orbiculare*, and *Lycopodium cernuum*. It is likely that during heavy rains a shallow lake is formed within the crater. The other, larger meadow is a flat area south of and adjacent to the base of Mt. Silisili…It is dominated almost entirely by a dense cover of the sedge *Carex graeffeana* growing up to 1 m high. In the center of the meadow is a narrow trough [where] there was some standing water." Since this community was not studied during the present survey, it will not be further discussed here.

4.3.1.2.Pandanus Swamp Forest

A second type of vegetation present in the Central Savaiʻi KBA is *Pandanus* swamp forest. It is known to occur in the study area only around montane lakes at high elevation on the eastern part of the KBA, specifically (based on a photo in Atherton & Jefferies 2012) around Lake Mafane. This type of vegetation has not been studied due to its remote location, but it is thought to be dominated by *Pandanus turritus* (***fasa***), an endemic screwpine species. Since it has not been studied, it will not be further discussed here.

4.3.1.3.Volcanic Scrub

Two areas of upland volcanic scrub (Fig. 1.4) are known from montane Savaiʻi, both of them created by eruptions occurring in 1902. Mauga Mū, whose summit reaches about 1600 m elevation, comprises a single large crater and a resulting lava flow that extends down-slope about 3 km. Mata ole Afi comprises a series of smaller craters at about the same elevation as Mauga Mū, and is surrounded by extensive areas of ash virtually devoid of vegetation other than lichens. A lava flow similar to that occurring below Mauga Mū extends down slope about 4 km. These volcanic areas are quite different from lowland volcanic scrub in that they range in elevation from 1150–1670 m elevation, while the lowland volcanic area from Matavanu lies below 650 m (and thus partially in the park).

Figure 1.4. Mata o le Afi lava flow scrub.

Three factors determine what vegetation occurs on them: substrate, age of the flow, and elevation. Two main kinds of lava substrate are recognized, ʻaʻa and pahoehoe. ʻAʻa lava is rough or rubbly, while pahoehoe is smooth, billowy, or ropy. Although the two sometimes intergrade, they are usually fairly distinct and recognizable. Based on the description of Atherton and Jefferies (2012), the vegetation of the Mauga Mū lava flow is dominated by shrubby and herbaceous species, the most prevalent of which is the Samoan blueberry

Vaccinium whitmeei, and to a much lesser extent, *Wikstroemia coriacea* (***fau mū***). Stunted cloud and montane forest trees are also common, but are relatively scattered and do not comprise a forest. The most common tree species are *Spiraeanthemum samoense*, *Glochidion christophersenii* (***masame***), *Coprosma savaiiense*, *Geniostoma rupestre* (***lau mafatifati***), *Reynoldsia pleiosperma* (***vī vao***), and *Metrosideros collina*. The vegetation of the Mata ole Afi lava flow is very similar to that of the Mauga Mū flow, with *Vaccinium whitmeei* being the dominant species. Most of the same trees and shrubs that are common there are the same ones found on the Mauga Mū flow. The most abundant herbaceous species here is probably the grass *Imperata cylindrica*, with lesser amounts of the ferns and fern allies *Lycopodium cernuum*, *Lycopodium venustulum*, *Nephrolepis pseudolauterbachii*, and in some places, *Dicranopteris linearis*.

The vegetation on the two cinder cones is similar to that found on the lava flows, since they are both made of volcanic material (ash and lava). The scrambling shrub *Vaccinium whitmeei* is the dominant species on the slopes of the two cones. Scattered trees, mostly less than 3 m in height, are found throughout the area. The most common species are *Spiraeanthemum samoense*, *Weinmannia affinis*, *Geniostoma rupestre*, *Glochidion christophersenii*, *Wikstroemia coriacea* (more of a shrub), and *Coprosma savaiiense*. The low stature trees of the cinder cone areas provide substrate for a number of epiphytes, including the ferns *Humata serrata*, *Belvisia vaupelii*, and *Selliguea feeoides*, and the orchids *Coelogyne lycastoides, Dendrobium reineckei,* and *Dendrobium mohlianum. Vaccinium whitmeei* also appeared to be a common epiphyte, but it is not clear if this was actually an epiphyte or was growing up from the ground and through the mossy layer covering many of the scrubby trees. Since the present study concentrated on the establishment of permanent forest plots, the Volcanic Flow Scrub vegetation was not studied and will not be further discussed here.

4.3.1.4. Montane Forest

It is virtually impossible to draw boundaries of montane forest that would separate it from the lowland forest below it. It is perhaps best defined as forest that is usually dominated by *Dysoxylum huntii* (***maota mea***), and this generally covers most of the archipelago 600 m elevation. Below 1000 m, it often shares dominance with a number of lowland forest species, such *Syzygium inophylloides,* and *Ficus obliqua* (***'aoa***). Above 1500 m, it is mostly replaced in dominance by the cloud forest tree *Reynoldsia pleiosperma*. Montane forest was described in some detail in Whistler (2002), and by Atherton & Jefferies (2012) for the KBA specifically.

Montane forest (Fig. 1.5) probably has the most diverse flora of any community of Samoa, and is home to more species of trees, lianas, ferns, and orchids than any other vegetation type. The tree plot data for the four Taga and six A'opo plots is shown in Appendix 1.4. A summary of the combined tree plot data collected in montane forest during the present survey (three in Taga and three in A'opo), ranging from 800 to 1400 m elevation, is shown in Appendix 1.5. The table includes all the plots sampled in the KBA below 1500 m elevation during the present survey except for the first Taga plot, which is disturbed forest at 600 m rather than montane forest. Twenty-nine tree species with an average relative dominance of at least 1% (rounded up) are included in this table, a remarkable number compared to any other kind of forest in Samoa. This can be compared to Appendix 1.6, which is a list of species found in ten plots of cloud forest taken from several earlier studies and as well as the present one. The latter comprises only 19 tree species having at least 1% relative dominance (rounded up).

Figure 1.5. Taga montane forest.

The most distinct features of montane forest are the complete dominance of *Dysoxylum huntii*, and the relative absence of *Reynoldsia pleiosperma* compared to cloud forest. *Dysoxylum huntii* was the dominant tree species in five of the six plots with an average relative dominance of 35%. The second overall dominant in this table is *Syzygium samarangense* (***nonu vao***,13%), which is apparently a modern introduction to Samoa that is indistinguishable from native species. The third dominant is the native tree *Bischofia javanica* (***ʻoʻa***, 12%). Other typical montane forest species include *Hedycarya dorstenioides* (no Samoan name) and *Hernandia moerenhoutiana* (***pipi***), which has a wide elevation range. Other species are typical secondary species, such as *Alphitonia zizyphoides* (***toi***) and *Cyathea* spp. (***oliolī***, tree ferns), that become established after the canopy has suffered some severe disturbance, such as may be caused by a cyclone. Some of the trees on the list are more typical of lowland forest, such as *Syzygium inophylloides* (***asi toa***) and *Ficus obliqua*, as noted above.

The forest floor of the montane forest is dominated by shade-loving ferns and, to a lesser extent, seedlings of the component tree species. Epiphytic orchids are probably more common than was recorded, because these are often missed, as they typically grow up in the canopy where they are not visible. Terrestrial orchids and vines are probably not as common as at lower elevations. A more complete description of the montane forest of the Central Savaiʻi KBA is found in Atherton and Jefferies (2012), and the permanent plot locations and tree data from the present survey are shown in Appendix 1.4.

4.3.1.5. Cloud Forest

The cloud forest community is found at the highest elevation on Savaiʻi. It imperceptibly blends into montane forest at its lower boundary, which, based upon the data and delineation of the vegetation communities during the present study, can be placed at about 1500 m elevation. The forest is low in stature compared to the rainforest at lower elevations, with the trees mostly less than 15 m in height (except *Reynoldsia pleiosperma*. The cool, moist conditions promote the profusion of epiphytes that sometimes grow so thickly that tree trunks appear twice their actual diameter. The cool temperatures in the cloud forest account for the presence of certain temperate genera, such as *Weinmannia* (Cunoniaceae), *Vaccinium* (Ericaceae), *Ascarina* (Chloranthaceae), and *Coriaria* (Coriariaceae) that extend to the higher-elevation forest of Samoa. The cloud forest is virtually untouched by man because it is too remote, too wet, and too cool to be used by villagers.

The biggest floral difference between the two communities is the dominance of *Reynoldsia pleiosperma* in cloud forest. In ten plots (Appendix 1.6) above 1500 m elevation surveyed during the present and three previous surveys in this forest, *Reynoldsia pleiosperma* had a relative dominance of 30%. *Reynoldsia pleiosperma* begins as an epiphyte and sends its roots down from their host tree (probably mostly *Dysoxylum huntii*) to the ground. They apparently eventually become "stranglers," comparable to the two banyan trees *Ficus spp.* (***āoa***) or *Fagraea berteroana* (***pualulu***) of lower elevations, and may completely surround and destroy the host tree as they attain a large size. Because of this habit and their high elevation range, they are of no use for timber.

The other dominants included *Spiraeanthemum samoense* (no Samoan name) with 17% average relative dominance, the montane forest dominant *Dysoxylum huntii* with 15%, *Glochidion christophersenii* with 5%, and *Coprosma strigulosa* with 5%. Interestingly, about half of the 19 species lack a Samoan name, since even if they have good timber, they occur too far away from habitations to be of significant cultural use. Most of the species on the list are obligate high elevation species, but a few, such as *Geniostoma rupestre*, *Hernandia moerenhoutiana*, and *Elattostachys apetala* (***taputoʻi***) occur over a wide elevation range and sometimes even to near sea level. Less important but still characteristic species found in this forest include *Scaevola nubigena* (***toʻitoʻi vao***), *Pittosporum samoense* (no Samoan name), *Homalanthus acuminatus* (***fogamamala***), and *Meryta malietoa* (***lau fagufagu***).

At least four species of tree fern (*Cyathea* spp., ***olioli̅***) occur in this forest, but they were not always distinguished from each other in the earlier surveys. This includes *Cyathea medullaris*, *Cyathea decurrens*, *Cyathea affinis*, and *Cyathea whitmeei*. One large endemic palm occurs here too, *Clinostigma savaiiense* (***niu vao***). Its crowns can be seen growing above the canopy on some of the volcanic cones in the area. Epiphytes are abundant in cloud forest, particularly orchids, ferns, and mosses. The number of orchids in the cloud forest is probably less than in the montane and lowland forest, but at least 15 epiphytic Samoan orchids are known to occur at over 1500 m elevation on Savaiʻi. Epiphytes are typically most common in the canopy, but they are often missed during botanical surveys. They can most easily be seen on trees or shrubs in the volcanic scrub community. At least 27 species of epiphytic ferns occur in forest above 1500 m in elevation. A more complete description of the cloud forest of the Central Savaiʻi KBA is found in Atherton and Jefferies (2012), and the permanent plot locations and tree data are shown in Appendix 1.4.

4.3.2. Disturbed Vegetation

This category (also sometimes referred to as "secondary vegetation") includes several different types of vegetation that, because of climatic or human disturbance, have a structure and flora that are in a state of transition. It is described in more detail in Section 3.3.2. above. Three disturbed plant communities occur in the Central Savaiʻi KBA—managed land vegetation, successional vegetation, and secondary forest—but it must be kept in mind that these are interrelated successional stages that blend into each other in space and time.

4.3.2.1. Managed Land Vegetation

Managed land vegetation comprises the vegetation on land actively managed by man for his uses, including paved and unpaved roads, roadsides, village greens (*malae*), plantations, and pastures. It is described in more detail in Section 3.3.2.1 above. In the Central Savaiʻi, KBA, most of the disturbed vegetation comprises agriculture plantations and tree plantations (especially at ʻAsau. Most of the weeds in the checklist of the flora (Appendix 1.3) are found in this vegetation. No permanent plots were sampled here since it is non-woody vegetation. A more complete description of managed land is found in Whistler (2002).

4.3.2.2. Successional Vegetation

This is the scrubby vegetation found on recently disturbed land or recently abandoned managed land. The first stage following abandonment or severe disturbance is dominated by herbaceous adventive plants (i.e., weeds). It is described in more detail in Section 3.3.2.2 above. No plots were sampled in successional vegetation during the present survey. A more complete description of successional vegetation is found in Whistler (2002).

4.3.2.3. Secondary Forest

Secondary forest includes forests that are in a state of flux after some disturbance, mainly from the felling of trees for timber, the establishment of plantations that have subsequently been abandoned, or from cyclone damage. Large areas of secondary forest are found in the Central Savaiʻi KBA, mostly as a result of a half century of logging activities, as well as two devastating cyclones in the 1990s. Most of the secondary forest is below 600 m elevation, since most of the logging has occurred below that area. It has gone to nearly 800 m at ʻAsau, which is the village who land has yield more timber than any other village. Mature secondary forest in Samoa is often dominated by two tree species, *Rhus taitensis* (***tavai***) and *Alphitonia zizyphoides* (***toi***).

One plot of secondary forest vegetation was sampled at 600 m elevation above Taga village. It is not clear if this was originally cleared by logging or by cyclones, but probably by the latter. The dominant tree in that plot was *Elaeocarpus angustifolius* (***sapatua***, blue marble tree), which had 41% relative dominance. Second and third in relative dominance were two tree ferns, *Cyathea whitmeei* (22%) and *Cyathea alta* (13%). Tree ferns are typical of successional vegetation since they become established in sunny conditions, and eventually decrease in importance as the forest ages and becomes shadier. Over half of the trees measured in the plot (118/180) were tree ferns. Two other secondary forest trees species were also significant- *Macaranga stipulosa* (***lau fatu***) with 8% relative dominance, and *Gironniera celtidifolia* (no Samoan name) with 3%.

The changes in secondary forest can occur relatively quickly, which means with the plot data obtained during the present survey, changes in the vegetation from disturbed land to native forest can be recorded in future surveys. It is likely this area was originally lowland forest dominated by *Planchonella samoense* (***mamalava***), which was the fourth most frequent species found in the plot. Nearly all of the other tree species included in the plot (Appendix 1.4 Plot 1) are lowland forest species. A more complete description of the secondary forest is found in *The Samoan Rainforest* (Whistler 2002).

4.4. The Flora

The vascular flora of the Samoa Archipelago is estimated to be about 828 native and naturalized flowering plant species (Whistler data 2017). Several botanical surveys of the area have previously been done (Whistler 1978, 2012; Schuster et al. 1999), for which plots were sampled and checklists prepared, and more species were added to the checklist during the present survey. The checklist for Samoa has been updated to present day nomenclature, so some of the names on the earlier lists will not be found on the present list due to name changes. The up-to-date checklist of the flora of the central Savaiʻi KBA is found in Appendix 1.3. A total of 374 plant species were recorded in the KBA (188 dicots and 83 monocots, 95 ferns, and 8 fern allies), of which 339 (91%) are native (indigenous and endemic) species. Of the native species, 115 are endemic to Samoa. The remaining 9% comprise alien species (early Polynesian and modern introductions). Many more species would undoubtedly be found if further botanical studies were to be conducted, especially alien species in and around villages.

The checklist of the flora of the KBA presented in Appendix 1.3 includes three columns showing where in the KBA they were recorded. "T" represents Taga, "A" represents Aʻopo, and "R" represents species that were not found during the present survey, but were previously recorded in the area in a study of rare plants of Samoa (Whistler 2010) that included locations of where specimens were collected. Only four of the rare species named in that report were found during the present survey, but may be due to the narrow area in which most of the plots were sampled. If plots were established on other areas of the KBA, many more would probably have been found.

There appears to be a difference in the flora in different places around the island, even at the same elevation. For example, no botanical surveys were done in Taga before the present one, and one or two new plant species records were obtained there in the montane forest at 1070 m during the present work. The only botanical surveys known from the KBA have been done only in four villages: Aʻopo (most), Salaʻilua, ʻAsau, and Taga. Thus much of the rest of the montane forest around the island remains unexplored. Additionally, the survey of the Aʻopo area began at about 800 m elevation, so if further surveys were to be done in the plantations between 600 m (the lower elevation line of the KBA) and 800 m, many more species (especially weeds) would be added to the list. Taking all this into consideration, the flora of central Savaiʻi is by far the most botanically diverse area in the whole archipelago, but much more work needs to be done to verify this.

4.5. Discussion

The main purpose of the present survey was to establish a series of permanent plots in the KBA. Ten plots were sampled, ranging from 600 m to 1700 m elevation, and their GPS coordinates were recorded. Four of them were established along a trail above Taga village on the south side of the island, and six along the trail from A'opo village to Mt. Silisili. All of these were in relatively undisturbed montane and cloud forest, except for one plot near Taga at 600m elevation that was in secondary forest. The tree data for these plots is found in Appendix 1.4, along with their precise GPS locations. With this information, the plots can be re-surveyed in the future and the trees counted and measured again to see what changes occur in the forest over time.

A number of voucher specimens were also collected, and these were divided up between MNRE, the Auckland War Memorial Museum, and the National Tropical Botanical Garden (Hawaii). In addition to the tree plot data, notes were taken on the flora at different elevations in order to better understand the elevation ranges of species and hence the context of observations made in the permanent plots. A checklist of the flora of the KBA was compiled and is shown in Appendix 1.3. It is by no means a complete flora checklist for the KBA because only small parts of it were studied, mostly around just two villages and the mountains behind them. Notes were also taken on rare plant species present and invasives.

4.5.1. Rare Species

During the survey, one or two new species were added to the flora of Samoa as noted above. Oddly, all three were found in the same place, on a crater rim above Taga at 1075 m elevation. One, closely related to *Dendrobium macrophyllum*, was recorded by Cribb & Whistler (1996) for 'Upolu based on a specimen collected there in the 1860s, but the new fresh material collected shows it differs significantly in color from the *D. macrophyllum* of Fiji and Vanuatu. In any case, the orchid is a new island record for Savai'i. The other one, *Melicope* sp. nova (Rutaceae), is clearly new to science and has tentatively named *M. apetiolaris*.

Because of the large size of the KBA and the lack of adequate botanical surveys for the large area, a number of species have been collected in previous botanical expeditions over the years. A list of 109 rare native and Polynesian-introduced species was prepared by Whistler (2010). By going through the list, a number of other species can be added to the KBA based on old collections. The 22 species that were not encountered during the present survey, are marked in Appendix 1.3 by an "R" indicating rare and not found during any recent surveys, but known from early (some as far back as over 100 years) collections. No plant species in Samoa have been officially designated as "threatened or endangered" IUCN Red List.

4.5.2. Invasive Species

The native flowering plant flora of Samoa comprises about 543 species, but added to this are about 290 species of "naturalized species." Naturalized species are non-native plants, often called "aliens," that have been brought into Samoa (mostly accidentally) and have become established in a self-perpetuating population. In most cases, they grow in places where they are not wanted, and hence are called "weeds." If they become serious pests and readily spread, they are referred to as being invasive. Invasive species are by nature almost always non-native species. One of these exceptions seems to be *Merremia peltata* (***fue lau tetele***), a native vine that takes over severely disturbed forests. (Note: *Merremia* was in the earliest collections from Samoa and Tahiti, apparently has seawater-dispersed seeds, and has no use or reason to be carried by Polynesians, so is almost certainly native.) Most weeds are sun-loving plants that do most of their damage in agriculture by competing with crop plants. Only a few weeds are shade tolerant species. The vast majority of the Central Savaiʻi KBA is covered with dense native forests whose canopy shades the forest floor. When the forest has an intact canopy, few invasive species are present.

Since most of the survey was done in native forest, a number of weedy species occurring in plantations and villages were missed. A more comprehensive survey of the whole KBA would not doubt more than double the number of alien species. A total of 35 weeds were recorded during the survey. Six of these were Polynesian introductions or plants introduced prior to the arrival of the first Europeans (ca. 1830). The vast majority of the weeds in Samoa are "modern introductions" introduced since *ca*. 1830 from throughout the tropics. These 35 species can be found in Appendix 1.3 marked by a "P" or an "X." Only a single species, *Clidemia hirta* (Koster's curse), was seen to be invasive in the montane and cloud forests. This species was recorded from Samoa only in recent times (1958 in American Samoa, 1978 on ʻUpolu). It has caused immense damage to native forests, especially when the canopy is open. When abundant, the shade it produces is harmful to native ground species that need filtered sunlight to survive, and may have already caused the extinction of some native herbs in Samoa. It extends from near sea level all the way up to montane forest at 1200 m, but does not seem to go above that. In the KBA it is often the only alien species found in plots, but occurs mostly along forest trails or in clearings. This weed should be put on the top of the list for control.

The only other significant invasive species in the KBA is *Elaeocarpus angustifolius* (***sapatua***, blue marble tree). This regional tree was probably introduced to Samoa sometime before 1920 as a possible timber tree, but since then has become invasive on Savaiʻi in disturbed forest from near sea level to 800 m elevation. It occurred in only two plots during the present survey—once in disturbed forest at 600 m elevation (where it was the dominant species), and again in the plots above that at 800m elevation (where it was a minor component). It seems that the tree does not invade closed forest, which is a good thing as long as there are no major disturbances to the forest.

4.5.3. Commercial Species

There is no one species that is of major commercial importance occurring in the canopy of the area. The montane forest above 600 m elevation is composed of many tree species and up to a dozen or so of them that can be used for timber. Illegal milling is perhaps the biggest threat to the KBA other than cyclones.

4.5.4. Effects of Climate Change

The Central Savaiʻi KBA extends from 600 up to 1860 m elevation, and comprises mostly montane and cloud forest vegetation. Probably the major effect of climate change will be an increase in temperature, which can adversely affect plant species and their distribution.

Some of the plants found in the KBA occur only at the cool, high elevations. When the climate warms up, trees that have temperate affinities and cool weather requirements will be the ones most likely to suffer. When the summit area warms up to a temperature out of their survival range, they will disappear because they have no way to escape to higher elevations. Most of the other trees will be less affected, because if they survive at lower elevations and warmer temperatures, then they can just move up in elevation to compensate for the extra heat.

5. Uafato Key Biodiversity Area

5.1. Introduction

The Uafato Key Biodiversity Area Conservation Area (KBA) is located on the northeast corner of ‘Upolu, on land belonging to Uafato village, lying between the villages of Samamea to the west and Ti‘avea to the east (Fig 1.1). It extends from the eastern boundary of Fagaloa Bay eastward through Uafato village about 4 km over several coastal ridges to Cape Utu‘ele before the village of Ti‘avea. The KBA has a total area of 1,306 ha (Martel and Atherton 1997). Virtually all of the study area lies on Fagaloa volcanics, the oldest and most highly eroded of the volcanic series in Samoa (Kear and Wood 1959). The Fagaloa volcanics form a mountain range extending from Falefā eastward to Amaile on the northeast ‘Upolu coast. On its north side it forms parallel, north-south running coastal ridges separated by narrow valleys ending at the coast in small bays. Southward from the ridge top of this range, ridges and valleys extend down to the plateau-like valley through which runs Richardson Road (formerly known as Richardson’s Track).

5.2. Methodology

The survey team worked in the Uafato KBA from 1–3 August 2016. The first day was spent looking for suitable sites for establishing permanent plots, and taking notes on the vegetation and compiling a checklist of the flora. The first of three 100 x 10 m permanent plots (S 13.954690, W 171.497125 to S 13.953862, W 171.497200) was established in Lowland Valley Forest on a gently sloping ridge east of Uafato village at 220 m elevation. A second (S 13.958803, W 171.490490 to S 13.958081 to W 171.490380) was established above that one on a steeper slope in Lowland Ridge Forest at 266 m elevation. The following day, a third and final plot (S13.980103, W 171.506028 to S 13.979661, W 171.506253) was established in lowland ridge forest on a ridge on the southern side of the mountains at 400 m elevation. The methods used in this work are discussed in the introductory portion of this report. Tree data from the three plots of the Uafato KBA can be found in Appendix 1.8.

5.3. Vegetation

A description of the study site was included in two botanical surveys of what was then recognized as the “Uafato Conservation Area” (Whistler 1997, 2000), based upon plant communities recognized in Samoa (Whistler 1992). The classification of the vegetation of all of Samoa was updated by Whistler (2002), and based upon the latter, the following vegetation units are recognized in the Uafato KBA: Undisturbed Vegetation (Littoral Strand, Lowland Forest, Montane Forest) and Disturbed Vegetation (Managed Land Vegetation, Successional Vegetation, and Secondary Forest).

5.3.1. Undisturbed Vegetation

Undisturbed vegetation is relatively stable in structure and flora and changes little over time. Although it is periodically disturbed by natural events, such as fire, cyclones, and drought, and by human events, such as land clearing, it has over time returned to what it looked like before the disturbance ("primary vegetation"). This is in contrast to disturbed vegetation, which is described below. Undisturbed vegetation can be divided into "plant communities" that are similar in structure. One plant community may look structurally like another, but may have an entirely different dominant or set of dominant species, and thus belong to a different "associations." For example, one Littoral Strand forest may be dominated by *Barringtonia asiatica* (***futu***, fish-poison tree) while another may be dominated by *Calophyllum inophyllum* (***fetau***), and thus the two belong to different associations of Littoral Forest.

5.3.1.1. Littoral Strand

This community comprises all types of natural vegetation occurring on the seashore and dominated by plant species whose presence and distribution are affected either directly or indirectly by the sea. It is discussed above in Section 3.3.3.1. No plots were studied in the Littoral Strand during the present study. However, based upon previous observations most of the littoral forest in the area is dominated by *Barringtonia asiatica*, which often forms mono-dominant stands. Other species present include *Hernandia nymphaeifolia* (***pu'a***, Chinese-lantern tree), *Calophyllum inophyllum*, *Guettarda speciosa* (***puapua***), *Erythrina variegata* (***gatae***, coral tree), *Cocos nucifera* (***niu***, coconut), and *Terminalia catappa* (***talie***, tropical almond). The coast from Uafato to the edge of the cliff-bound coast east of the village is mostly a *Barringtonia asiatica* forest. In most places, the *Barringtonia asiatica* trees come right up to the coast, with hardly a trace of any zone of herbaceous vegetation. The coast east of that comprises sheer cliffs, and perhaps only herbaceous or shrubby littoral vegetation occurs on the steep cliffs.

5.3.1.2. Lowland Forest

Lowland rainforest occurs in the lowlands of Samoa, from near sea level to somewhere between 600 and 1000 m elevation, depending upon a number of factors. Lowland forest in Samoa is composed of a great number of tree species, although not nearly as many as in most areas of tropical rainforest in Melanesia and Asia to the west or in tropical America to the east. Because so many tree species are present, each of which acts independently from the others and responds differently to variation in environmental factors (e.g., to soil type, elevation, and exposure), it is nearly impossible to subdivide lowland forest in a meaningful way since natural boundaries are almost non-existent. Even if a forest type can be recognized, it may have a wide elevation range, causing changes in species composition with increasing or decreasing elevation. Nevertheless, it is useful to describe different types, based on different species mixes, even if no distinct boundaries can be recognized. Three variations of lowland forest are recognized here: (1) Coastal Forest; (2) Lowland Valley Forest; and (3) Lowland Ridge Forest. These differ from the Lowland Lavaflow Forest described in the Falealupo KBA.

Coastal forest is the type of forest vegetation situated on exposed portions of some coasts adjacent to, but never directly on, the shore. It differs from littoral forest in being dominated by medium-sized tree species whose seeds, borne in edible fruits, are usually dispersed by birds rather than by sea water, and by its more inland location. It differs from other types of lowland forest by its shorter stature and distinctive flora. It is somewhat intermediate between littoral forest and lowland forest, but is more similar to the latter, and typically occurs on relatively exposed portions of tuff cone craters, and to a lesser extent on steep, rocky coastal slopes.

The most distinctive characteristic of coastal forest is its flora, which is dominated by species of *Diospyros* and *Syzygium*, in numbers of individuals if not relative dominance. Two species related species of ebony, *Diospyros elliptica* (***'anume***) and *Diospyros samoensis* (***'au'auli***), typically predominate in number of individuals. Two other characteristic species belong to the same genus: *Syzygium clusiifolium* and *Syzygium dealatum*, both of which are probably called ***asi vai***. Coastal forest probably occurs on the rugged coasts of the KBA, but no plots were sampled in this type of forest during the present survey, and it will not be discussed further here. A more detailed description of this vegetation can be found in Rainforest Trees of Samoa (Whistler 2002).

Valley forest is the lowland forest typically located on flat to moderately steep slopes of lowland alluvial valleys. It is also often found on coastal talus slopes away from the immediate coast and on protected inland areas of tuff cone islands, but usually not on ridges unless they have a gentle slope. It is dominated by species adapted to the gentle slopes, protected location, and alluvial soils found in small valleys and gentle ridges. The most characteristic tree species present are *Dysoxylum samoense* (***maota***) and *Dysoxylum maota* (***tufaso***), alone or in combination. Lowland Valley Forest in Samoa extends up to 250 or 300 m elevation, where the two species of *Dysoxylum* are gradually replaced at higher elevations (in montane forest) by a third species of the genus, *Dysoxylum huntii* (***maota mea***), or other lowland forest species. In secondary forest, *Dysoxylum* spp. are probably just successional trees that are eventually replaced by other climax forest species. The two species also occur in most of the other types of lowland forest, probably as trees that have exploited areas of disturbance.

During the survey of Uafato, one plot (Plot 1) of Lowland Valley Forest was sampled. The dominant tree in this forest (as expected) was Dysoxylum samoense (31% relative dominance). Second in dominance was *Palaquium stehlinii* (***gasu***, 24%), a common lowland forest tree. Third was *Inocarpus fagifer* (***ifi***, 15%), which is an ancient introduction valued for its large, peanut-like Tahitian chestnut. Forests with large amounts of this are often sites of ancient plantations, since the tree does not spread far from where it planted, but maintains itself in lowland forest once the plantation is abandoned. Two other common trees in the plot were *Myristica inutilis* (***'atone***, 14%), Samoan nutmeg, and *Canarium vitiense* (***ma'ali***, 13%), a typical ridge forest species.

Lowland Ridge Forest is the type of native lowland forest that occurs on the mountainous part of Tutuila and parts of 'Upolu that have the appropriate topography—ridges on highly weathered volcanics. The typical dominant tree species are *Calophyllum neoebudicum* (***tamanu***), *Canarium vitiense*, *Syzygium inophylloides* (***asi toa***), and sometimes *Intsia bijuga* (***ifilele***). Several other tree species are common on these ridges, mostly as subcanopy species.

Three of them—*Diospyros samoensis*, *Canarium harveyi* (***mafoa***), and *Myristica inutilis*—are best classified as subcanopy species.

One noteworthy (based on commercial importance anyway) variation of ridge forest is characterized by the presence or dominance of *Intsia bijuga* (***ifilele***), the most valuable timber tree in Samoa. The best remaining examples of *Intsia* lowland forest in Samoa occur on the ridges of the rugged, uninhabited coast around Uafato, where this slow-growing climax species is harvested commercially to make handicrafts. In the KBA, these trees are most common in forest just to the east of Uafato Village, but none were found in the plots sampled farther east from their main concentration.

Two plots (2 and 3) of Lowland Ridge Forest were sampled during the present study, one at 220 m elevation, the other at 400 m. When the data from these two are combined, the dominant species are *Calophyllum neoebudicum* (16%), *Canarium samoense* (15%), and *Syzygium inophylloides* (13%). Strangely, the two main species were dominant in one plot, but nearly absent from the other. This possibly shows how a difference in elevation (220 vs. 400 m elevation) between different areas of Lowland Ridge Forest can drastically affect which of the typical Lowland Ridge Forest trees dominate. The fourth dominant species in the lower elevation plot was *Intsia bijuga* (18%), an indication that the area may once have been a plantation, as noted above. The other important species were *Myristica inutilis* (8%), *Canarium harveyi* (6%), *Sterculia fanaiho* (***fana'io***, 5%), and *Diospyros samoensis* (3%).

5.3.1.3. Montane Forest

Montane Forest is the rainforest covering the mountain slopes and plateaus, and is characterized by the dominance of *Dysoxylum huntii*. It is discussed above in Section 4.3.1.4. The only real area of Montane Forest in the Uafato KBA probably occurs on Mt. Malata (730 m elevation), but this area was not visited during the present survey, and no botanical collections are known from this area. No plots were sampled in Montane Forest, and nothing further will be said about this type of vegetation in the KBA.

5.3.2. Disturbed Vegetation

This category, also sometimes "secondary vegetation," includes several different types of vegetation that—because of climatic or human disturbance—have a structure and flora that are in a state of transition. It is discussed above in Section 3.3.2. Three disturbed plant communities occur in the Uafato KBA—managed land vegetation, successional vegetation, and secondary forest—but it must be kept in mind that these are interrelated successional stages that blend into each other in space and time.

5.3.2.1. Managed Land Vegetation

Managed land vegetation comprises the vegetation on land actively managed by man for his uses, including paved and unpaved roads, roadsides, village greens (*malae*), plantations, and pastures. It is discussed above in Section 3.3.2.1. In the Uafato KBA, managed land includes all of the village and the plantations around it. Most of the weeds in the checklist of the flora are found in this vegetation. No permanent plots were sampled here, so it will not be discussed further. It is more completely described in Whistler (2002).

5.3.2.2. Successional Vegetation

This is the scrubby vegetation found on recently disturbed land (Fig. 1.5) or recently abandoned managed land. It is discussed above in Section 3.3.2.2. No plots were sampled in successional vegetation in Uafato/Ti'avea.

Figure 1.5. Disturbed vegetation at Uafato.

5.3.2.3. Secondary Forest

Secondary forest includes forests that are in a state of flux after some disturbance, mainly from the felling of trees for timber or the establishment of plantations that have subsequently been abandoned. There has been no commercial harvesting of timber in Uafato other than the taking of individual ***ifilele*** trees, and so secondary forests resulting from this activity are not present. However, the cyclones that have hit Samoa in recent years have caused extensive forest damage, even in Uafato, where at higher elevations most of the trees have been blown down. Active plantations at Uafato extend up the slopes behind the village, and abandoned or neglected ones now covered with high forest can be found in patches in various places. The trees that dominate here are *Rhus taitensis* (***tavai***), *Alphitonia zizyphoides* (***toi***), and *Hibiscus tiliaceus* (***fau***). No plots were sampled secondary forest in Uafato/Ti'avea.

5.4. The Flora

The vascular flora of the Samoa Archipelago is estimated to be about 828 native and naturalized flowering plant species (Whistler data 2017). A checklist of the flora of the Uafato KBA was prepared during previous surveys by the author (Whistler (1997), and additional notes on the flora were taken during the present survey of Uafato/Ti'avea. Only a few new records were added to the checklist based on the present survey, virtually all of them weedy species. The list of native plants has been updated to present day nomenclature, so the two lists do not look exactly the same even discounting the new weedy species. A total of 378 plant species have been recorded in the Uafato KBA (219 dicots, 76 monocots, 79 ferns, and 4 fern allies), 287 (76%) of which are native (indigenous and endemic) species. The remaining 91 (24%) comprise alien species (Polynesian and modern introductions). A checklist of the flora of the KBA is shown in Appendix 1.7. A few more species would undoubtedly be found if further botanical studies were conducted, especially if the montane region of Malata, which reaches an elevation of 730 m, were to be visited and studied in more detail. This size of the flora of the Uafato KBS is relatively rich for such a small area (only 1–2% of the area of Samoa). The area is unique in that it includes a mountain range that is separate from the one forming the central backbone of the island.

5.5. Discussion

Three permanent plots were established in the Uafato KBA and all trees in the plots were measured. Because the coordinates of the two ends of the survey 100 m survey line were recorded, these can be sampled again in the future to see what changes in the flora and dominant species of the plot occur. The three plots were between 200 and 400 m elevation. Because of climate change, the vegetation in these plots can be expected to change. Just what these changes will be are difficult to predict, since few if any of the trees in the KBA have been studied to see what possible changes in their distribution will occur with a warming climate.

The vegetation of the KBA is the best remaining undisturbed lowland forest in Samoa, partly due to the ruggedness of the terrain and partly to its isolation. There is only one road in the KBA, and it is found only on the coast of the western portion of the study area. It will probably remain relatively undisturbed in the future, since there are apparently no plans for development or logging in the area. Since the KBA has a maximum elevation of 730 m, it lacks the high elevation plant communities. It also lacks the volcanic based communities and wetlands found elsewhere in Samoa. It is, however, floristically diverse with 377 vascular plant species, 278 (74%) of which are native (indigenous and native) species. This includes 43 endemic species, species found only in Samoa.

5.5.1. Rare Species

A report on the rare species of Samoa (Whistler 2010) named 109 species that are rare in Samoa. However, none of these species have ever been officially designated as threatened or endangered. Only one species on this list, *Cordia aspera* (***tou***), was at that time reported in the study area. This tree was probably an ancient introduction that was used prior to the European era. Its fruits were used to make a paste for gluing sheets of tapa cloth together. Today it is rare in lowland forest, where it has persisted long after it lost its usefulness and ceased to be cultivated. It was found in the area during one of the previous surveys, but not during the present one. A second species on the rare plant list, *Atuna racemosa* (***ifiifi***) is a new record for the KBA, where it was observed (but not collected) during the survey. It is a Polynesian introduction whose fruit was used to make scented coconut oil. It is no longer cultivated, but persists as a relict in native forest, sometimes forming mono-dominant groves.

Another notable species is a new species of *Aglaia* (***laga'ali***). It has been found in the area several times, including during the present survey. Because the forests are in relatively good condition and are somewhat protected by the area's isolation, habitat degradation does not seem to be an immediate threat to Samoa's plant biodiversity. The only threatened species is *Intsia bijuga*, the commercially important tree whose hard, attractive wood is extensively used for the handicraft trade. A survey on the exploitation of this resource (Martel and Atherton 2007) noted that this tree might be threatened by over-harvesting. It is common on the ridges just to the east of Uafato village, but was not recorded in the three sampled plots farther to the east.

5.5.2. Invasive Species

Invasive species have also been studied in the area (Whistler 2000). In that study nine "indicator" species were selected, but only a few of these are a threat to the KBA. Two of them are native species and two are Polynesian introductions. Neither are significant threats to the KBS's biodiversity. Most of the forests of the Uafato to Ti'avea area are in relatively good shape. In the three forest plots sampled only a few alien tree species were found: *Adenanthera pavonina* (***lopa***), *Inocarpus fagifer* (***ifi***, Tahitian chestnut), and *Artocarpus altilis* (***'ulu***, breadfruit). Only one *Adenanthera pavonina* tree was found in the three plots, but in other places in the KBA it is more common, and is probably the most invasive species present. The Tahitian chestnut was present in two of the plots, probably a relict of former cultivation, but it is not invasive since it spreads so poorly. The presence of nine breadfruit trees in Plot 3 indicates the site was formerly a plantation. It is not invasive since it does not produce seeds. Three other trees, *Canarium harveyi* , *Syzygium samarangense* (***nonu vao***), and *Garcinia myrtifolia* (no Samoan name) may also be alien species, but are not considered to be harmful to native forests. One other tree should be mentioned is *Paraserianthes falcataria* (***tamaligi***). This tree is very invasive in central 'Upolu, and was seen on at least one slope above Uafato Village. A major eradication program of this tree has been undertaken on Tutuila (American Samoa). Its presence in the KBA should be monitored, and the tree removed if feasible. No other weedy species found were seen to be an immediate threat to the vegetation of the KBA, but changes in frequency or distribution of *Adenanthera pavonina* and *Paraserianthes falcataria* should be monitored since these two species can be so invasive.

5.5.3. Commercial Species

The only significant non-food plant found in the KBA is *Intsia bijuga* ***ifilele*** (see above). The village produces more carved handicraft items made of this wood (items such as kava bowls) than any other village, partly because of how common the tree is on the hills east of Uafato. This can be a renewable resource if it is harvested at a sustainable rate, but this may not be the case and should be studied to see how the species can be sustainably harvested.

5.5.4. Effects of Climate Change

The Uafato KBA extends from sea level up to about 700 m elevation, and the natural vegetation for this area is mostly lowland forest, especially lowland ridge forest. Probably the major effect of climate change will be an increase in temperature, which can adversely affect plant species and their distribution. Some of the plants found in the KBA are only found at the cool highest elevations at the top of Mt. Malata, but this peak comprises a very small percentage of the area. When the climate warms up, trees that have temperate affinities will be adversely affected by the warmer conditions. Because of the limited elevation of the KBA, they cannot simply move up in elevation, and will thus probably eventually disappear from the area. Most of the other trees in the KBA are lowland species, and will probably not be affected by climate change in the short run, but only time will tell.

6. Literature Review of botanical information on the Lake Lanoto'o National Park in the Apia Catchments KBA

The Lake Lanotoʻo National Park is located in the central highlands of ʻUpolu above Apia, and covers about 8,500 ha. Most of the park area ranges from 600 to 800 m elevation, but a spur extending north from its northwest corner descends a ridge to about 370 m elevation. The park includes three montane crater lakes—the small Lanoʻataʻata and Lanoʻanea, and the larger Lanotoʻo, as well as the surrounding area that connects them together. A study of the park was undertaken in 2014, but unfortunately the endeavor was not very successful because of the short time devoted to the study (three days), excessive rainfall that stymied the botanical survey, and the inadequacy of the trails cut beforehand. Consequently, not much data was obtained, and no plots were sampled. The report is mostly a description of the vegetation without the benefit of plots, and checklist of the flora. This section describes the current state of botanical knowledge of the Park.

6.1. Vegetation

Several plant communities are known to occur within the boundaries of the park—montane marsh, freshwater swamp forest, and montane rainforest, which are natural communities, and managed land and successional vegetation, which are disturbed communities. These are all described in *The Samoan Rainforest* (Whistler 2002).

6.1.1. Montane Marsh

Montane marsh is herbaceous wetland vegetation that occurs in the mountains, especially in montane craters. Several variations are noted, based upon whether or not there is standing water in the marsh, and/or how long the standing water is there before it drains off or evaporates. Three areas of montane marsh occur in the park. The largest occurs around Lanotoʻo and is entirely dominated by *Eleocharis dulcis* (***ʻutuʻutu***, water chestnut) that grows on the lake margin in the standing water and extends away from the shore into freshwater swamp forest trees. A flat zone between the lake margin and the freshwater swamp forest is dominated mostly by herbaceous weeds, especially *Mikania micrantha* (***fue saina***, mile-a-minute vine), *Kyllinga polyphylla* (Navua sedge), and the native sedge *Rhynchospora corymbosa* (***selesele***), along with a number of less important weedy alien species. Strangely, there is a complete absence of *Cyclosorus interruptus* here, in sharp contrast to Lanoʻanea.

The lake margin of Lanoʻanea is entirely dominated by *Cyclosorus interruptus* (marsh fern), which is unusual because the occurrence of this species in the crater is probably a high-elevation record for Samoa. It usually occurs only in coastal marshes and other inland marshes at low to middle elevation. At the time of the 2012 visit, its lakeside edge appeared to be dead for reasons that are unclear. Lanoʻataʻata differs from the other two lakes in having no natural zone of plants along the sloping lakeside edge. The lake appears to drain relatively rapidly after rains in the dry season, leaving a zone of mud. The only vegetation at the time of the 2014 visit was a thin layer of seedlings of weedy wetland herbs. Neither *Cyclosorus interruptus* nor *Eleocharis dulcis* were seen here. A level zone of wetland herbaceous vegetation between the freshwater swamp forest and the edge of the slope leading down the short distance to the edge of the water is dominated mostly by weedy alien species.

6.1.2. Freshwater Swamp

Associated with the montane marsh is freshwater swamp that is typically dominated by two tree species—*Pandanus turritus* (screwpine, ***fasa***) and *Barringtonia samoensis* (***falagā***). These trees typically predominate in montane areas where the soil is waterlogged, especially in montane craters. At Lanoʻataʻata, *Barringtonia* is by far the dominant species growing on the flat margins of the lake, while *Pandanus* is second. At Lanotoʻo, swamp forest surrounding the lake is in standing water and is entirely dominated by screwpine. At Lanoʻanea, the dominant species around the lake is *Hibiscus tiliaceus* (***fau***, beach hibiscus), which is probably an alien species introduced by Polynesians and presumably planted at the lake since the plant does not seem to reproduce by seeds. Second in dominance there is *Pandanus turritus* but the European-introduced *Psidium guajava* (guava, ***kuava***) is also present in significant amounts. The fact that two of the three dominant species at Lanoʻanea are aliens indicates that the vegetation around this lake, the most accessible of the three, is the most disturbed of the three lakeside vegetation communities.

6.1.3. Montane Rainforest

Prior to arrival of the arrival of the first Polynesians perhaps 3000 years ago, the entire park was covered with montane rainforest, except the crater vegetation described above and the ridge noted above that goes down into lowland forest at 370 m. On ʻUpolu, montane forest starts at between 550 and 700 m and extends up to 1000 m or so, where it is apparently replaced by cloud forest. Fifty years ago the vegetation was much the same, but big changes have happened since then.

No vegetation plots are known to have been done within the park boundaries. Schuster et al. (1999) sampled about a dozen upland plots on the island, but none were in the park boundaries. Whistler (2002) included a number of montane forest plots, but likewise, none were within the park boundaries. Based upon a forest inventory (Chandler et al. 1978) of three sites to the west of the Park at Afiamalu (which was a timber survey not a botanical survey), the forest of the Lake Lanotoʻo region was probably dominated by *Dysoxylum huntii* (***maota mea***), with lesser amounts of *Hernandia moerenhoutiana* (***pipi***), *Homalanthus acuminatus* (***mamala***), *Neonauclea forsteri* (***afa***), *Calophyllum neoebudicum* (tamanu), *Syzygium* spp. (***asi***), and *Planchonella samoensis* (***mamalava***). Another timber survey was recently completed by a Japanese team, but I have not seen the report. It is probably of little use since it is probable that none of the plots they sampled are in the park, it is a timber rather than a botanical survey, and the species identifications are suspect.

If no further significant disturbance occurs in the park, the vegetation can be expected to return to montane forest. In theory, anyway, but the effects of invasive species may have significant impacts on any recovery. The best areas of montane forest seen by the botanical team in 2014 were on the inside slopes of the three crater lakes, although trail cutters reported some areas of forest situated in areas the survey team did not reach.

6.1.4. Managed Land Vegetation

Managed land vegetation comprises the vegetation on land actively managed by human for their uses, including roads, roadsides, village greens (*malae*), plantations, and pastures. It also includes land where timber has just been felled, since this is a form of management (even though the active management may end after the tree felling). When trees are felled, the land may be converted into permanent plantations or utilised for a short while for growing crops. Samoan soils, like others in the tropics, are characteristically poor in minerals, and much of the available mineral content is tied up in the trees. These minerals, suddenly released into the soil, are quickly washed away or are used up by the crop plants when the trees are felled and burned or left to rot. After a few crop cycles, the harvest greatly diminishes and the land is abandoned or planted with permanent tree crops that are less demanding on the soil (compared to taro). Active management prevents disturbed land from returning to its natural plant cover and promotes the dominance of cultivated plants (that are wanted) and weeds (that are not). The amount of management, in the form of weeding (mechanical means, hand-weeding, or herbicides), determines whether the cultivated or weedy plants will dominate; once active management ends, herbaceous weeds soon dominate.

The park's managed land community mostly comprises marginal areas of pasture, since there is no timber felling currently going on. Plant succession into successional vegetation has stopped or is moving very slowly because of the stifling growth of some pasture grasses. Secondary and primary forest species find it difficult to become established in the dense grass. Managed land also includes areas where new plantations are being illegally established, e.g., the newly planted kava plantation on the rim of Lanoʻanea found in 2014.

6.1.5. Successional Vegetation

Successional vegetation, which covers most of the study area, is the scrubby vegetation found on recently disturbed land or recently abandoned managed land. This is a dynamic type of vegetation that is the process of changing from one type to another in a natural process called plant succession. The first stage after abandonment of plantations or following severe disturbance (as is the case with the cyclone damaged forest at this study area) is dominated by herbaceous adventive plants (i.e., weeds, as noted above). This stage, in turn, is followed by one in which new shrub or tree invaders eventually dominate for a while. The dominant trees of successional vegetation are fast-growing, light-loving species, most of which are short and do not reach the height of typical forest trees. There is a transition to the next community, secondary forest, when taller tree species eventually overtop shorter ones and shade them out, but the line between the two is indistinct. The Lanotoʻo study area is unusual in that even though the worst cyclones occurred more than two decades ago, there has been little classical plant succession occurring. Most of the area remains in an open scrub form due to the smothering effects of invasive species, especially *Mikania micrantha*, *Cestrum nocturnum* (***teine ole pō***, night-cestrum), and the worst one, *Clidemia hirta* (Koster's curse, ***vao fulufulu***). Also harmful in some places were four of the worst invasive trees in Samoa—

Paraserianthes falcataria (***tamaligi pa'epa'e***, albizia), *Cinnamomum verum* (***tigāmoni***, cinnamon), *Spathodea campanulata* (***fa'apisī***, African tulip-tree), *Funtumia elastica* (***pulu vao***, African rubber tree), and another rubber tree, *Castilla elastica* (***pulu māmoe***). When successional vegetation matures, it forms secondary forest, which may or may not be present in the park now.

6.2. The Flora

Based upon the three days of hiking in the study area, a checklist of the species known to occur in the Park was compiled during the 2014 survey (Appendix 1.9). Added to this list are a number of other species, noted in the checklist by a (1) after them, that were historically found in the study area, but were not encountered during the present field work. This comprises species that are just uncommon and would be found during further field work, as well as some that are probably extinct or at least extirpated from the site. Most notable are two native wetland herbs, *Centipeda minima* and *Limnophila fragrans* (neither with Samoan or English names), which would most likely be restricted to the margins of the lakes. Neither was found during a concerted search of this habitat in 2012.
The Lanotoʻo Park checklist includes 210 species of vascular plants (flowering plants and ferns), all but 19 of which were found during the present survey. This is undoubtedly only a fraction of the species that actually occur there. A survey of longer duration would certainly come up with scores of additional species, especially epiphytes, which are not readily visible from the ground. The 19 added species are ones included in *The Rare Plants of Samoa* (2010) or more common ones collected at the same time and in the same area as the rare plants (around Lanotoʻo) based upon the notes from previous work by the Consultant. Many more would be added if all the collections of the previous botanists were examined. This, however, would be labour intensive and is beyond the means of the present review.

6.3. Rare Species

The Rare Plants of Samoa (Whistler 2010) includes 108 flowering plant species that the author considered to be rare in Samoa, perhaps best described as difficult to find rather than rare. Five of these are included in the checklist shown in Appendix 1.9. *Cyrtandra mamolea* (***momole'a***) is likely to be extinct in Samoa (and worldwide, since it is endemic to Samoa). *Centipeda minima* (no Samoan or English names) is likely to be extirpated from Samoa. *Limnophila fragrans* (no Samoan or English names) is generally rare in Samoa, but still exists there. The other two species, *Atuna racemosa* (***ifiifi***) and *Amorphophallus paeoniifolius* (***teve***, stink lily) are rare cultigens of ancient introduction.

6.4. Invasive Species

Of the 210 plant species recorded in the Park during the 2012 survey, 38 are aliens, including two cultigens of ancient introduction to Samoa, both of which are now rare. Most of these weeds are commonly found in disturbed areas (managed land) where they complete with crop plants. As far as the native vegetation of Samoa is concerned, these are not a problem, i.e., they are not invasive in native forests. Two species, *Elaeocarpus graeffei* (formerly called *Elaeocarpus ulianus*) and *Endiandra elaeocarpa* (neither of which have Samoan or English names), were probably introduced from Fiji by German foresters. These are not seen to be a problem since they are indistinguishable from native species and are a good source of food for fruit-eating birds.

Eight species are considered to be invasive in Samoa native vegetation—one vine, two shrubs, and six trees. The invasive vine is *Mikania micrantha*. It is probably the most common weed in Samoa but it is probably only marginally harmful to native vegetation since it is herbaceous and is easily shaded out in maturing forest. Many people consider *Merremia peltata* (***fue lau tetele***) to be an invasive weed. However, it is a native rainforest species and a natural part of plant succession. In any case, it was not found in the study area.

Clidemia hirta is probably the most damaging weed present. It was first collected in the country in 1978, presumably introduced accidentally from Tutuila, but has now spread throughout the archipelago. It is often the dominant shrub layer species of somewhat open forests; it does not survive in dense shade. Nearly equally damaging is *Cestrum nocturnum*, which is mostly a weed of the mountains of central 'Upolu. It can form dense impenetrable thickets, but does not do well in the shade of native forests.
The worst invasive tree in Samoa is probably *Funtumia elastica*, a subcanopy species that forms nearly pure stands in the forests of central and western 'Upolu. It is not clear how damaging this species is in the study area since little forest was found and no plots were sampled. *Castilla elastica*, another invasive rubber tree, is probably less common in the study area than it is in the lowlands and thus is probably less of a problem. *Paraserianthes falcataria* can be invasive and grows into a huge tree. However, it is more common east of the study area where it was planted in the montane forest after the cyclones of two decades ago during an ill-conceived replanting scheme by FAO. *Spathodea campanulata* is likewise more common elsewhere in Samoa at lower elevations, and only scattered individuals were seen during hikes into the study area. Even fewer individuals of *Cinnamomum verum* were seen; this tree is more common east of the Park.

6.5. Research Needed

What is most needed in the park is vegetation data. Apparently, no forest plot data within the park has ever been published, and the closest thing to this comprises old timber surveys from adjacent areas. However, the problem is that there is very little forest remaining in the park. A review of aerial photos should be done to see if there is some remaining forest, perhaps in valleys where the forest has been protected from damaging cyclonic winds. The best chance of finding intact forest is on the slopes of the three crater lakes, where good forest was noted during the 2014 visits. Perhaps two plots could be done on these slopes for each crater, and these six could possibly be augmented by plots in other areas of forest found by a review of the aerial photos. To complete the flora, the literature (Christophersen 1935, 1938; Rechinger 1907–1915; Reinecke 1896, 1898) could be reviewed for collections near Lanotoʻo, since all three of these authors noted location of collection in their publications. The largest collection of the Samoa (that of the author) could also be included, but since this information has not been published, the field books with location information could be reviewed. It is a pity that the park does not have a real botanical survey.

7. Recommendations

1. Resurveys

The Falealupo KBA has a relatively poor flora because of its lowland locations. It has been relatively well surveyed and few additional native species, other than indigenous coastal species and weeds, would be likely to turn up during further work. The Uafato KBA has been surveyed several times now, and the flora is pretty well known. The only area that would be useful to resurvey would be the highest elevations, i.e., Mt. Malata, which apparently has never been visited by a botanist. The Central Savaiʻi KBA is in definite need of additional surveys. Most of the surveys done so far have been along the Aʻopo to Mt. Silisili corridor, leaving the vast remainder of the area unsurveyed.

2. Orchid Survey

With nearly 100 native species, the largest family of flowering plants in the Samoan flora is the Orchidaceae. Many of these species, especially the terrestrial ones, are threatened by destruction of the forest canopy and by invasive weeds, especially *Clidemia hirta* (Koster's curse), that covers the floor of disturbed montane forest. Several Samoan orchids have not been collected in over a century and are in danger of going extinct, if they haven't already. A survey of the montane regions of the archipelago is needed, particularly for epiphytic orchids, and would involve climbing forest trees to find the species.

3. Research on Invasive Species

Research is needed on how to eliminate some of the worst invasive species in Samoa, particularly *Adenanthera pavonina*, *Castilla elastica*, *Funtumia elastica* (***pulu vao***), *Spathodea campanulata* (tulip tree), *Elaeocarpus angustifolius,* and *Clidemia hirta.*

4. Effective Legislation

Samoa needs effective legislation that can protect the forests. Most of what exists is not enforced by the government or understood by the villagers. There seems to be little regard for the future of the forests, especially when unscrupulous individuals bribe village chiefs to allow illegal cutting on their land. A good example is a bulldozer track that runs from Aʻopo to Mata ole Afi that has severely damaged the scenic volcanic area at the top of the island. The road was probably illegal and certainly needless, and has allowed for some new weedy species to enter the area. Apparently, nothing has been done to inform the people responsible. Formulating effective legislation is very difficult, and getting villagers to completely understand that it is their benefit even harder, but it is critical to the survival of Samoa's forests.

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Appendix 1.1. Checklist of the Vascular Flora of the Falealupo KBA

FAMILY	Species	Authors	Status	Samoan Name	Rare[1]
	DICOTYLEDONAE				
ACANTHACEAE	*Ruellia prostrata*	Poir.	X	*vao uli*	
ANACARDIACEAE	*Rhus taitensis*	Guillemin	I	*tavai*	
ANNONACEAE	*Cananga odorata*	(Lam.) Hook. f. & Thoms.	P	*moso'oi*	
APOCYNACEAE	*Alyxia bracteolosa*	Rich ex A. Gray	I	*lau maile*	
APOCYNACEAE	*Alyxia stellata*	(Forst.) Roem. & Schult.	I	*gau*	
APOCYNACEAE	*Cerbera manghas*	L.	I	*leva*	
APOCYNACEAE	*Funtumia elastica*	(Preuss) Stapf	X	*pulu vao*	
APOCYNACEAE	*Tabernaemontana pandacaqui*	Lam.	I	*pulu*	
ARALIACEAE	*Meryta macrophylla*	(W. Rich ex A. Gray) Seem.	I	*lau fagufagu*	
ASCLEPIADACEAE	*Hoya australis*	R. Br. in Traill	I	*lau mafiafia*	
ASCLEPIADACEAE	*Hoya betchei*	(Schltr.) Schltr.	E		
ASCLEPIADACEAE	*Hoya samoensis*	Seem.	E		
ASTERACEAE	*Centipeda minima*	(L.) A. Braun & Ascherson	I		X
ASTERACEAE	*Mikania micrantha*	Kunth	X	*fue saina*	
ASTERACEAE	*Pseudelephantopus spicatus*	(B. Juss. ex Aubl.) Rohr	X		
BARRINGTONIACEAE	*Barringtonia asiatica*	(L.) Kurz	I	*futu*	
BORAGINACEAE	*Cordia subcordata*	Lam.	I	*tauanave*	
BURSERACEAE	*Canarium harveyi*	Seem.	X	*mafoa*	
BURSERACEAE	*Canarium vitiense*	A. Gray	I	*ma'ali*	
BURSERACEAE	*Garuga floribunda*	Decne.	I	*magaui*	
CAPPARIDACEAE	*Capparis marina*	L.	I		X
CAPPARIDACEAE	*Crateva religiosa*	Forst. f.	I	*pua elo*	X
CASSYTHACEAE	*Cassytha filiformis*	L.	I	*fetai*	
CELASTRACEAE	*Gymnosporia vitiensis*	(A. Gray) Seem.	I		
CLUSIACEAE	*Calophyllum inophyllum*	L.	I	*fetau*	
CLUSIACEAE	*Calophyllum neoebudicum*	Guillaumin	I	*tamanu*	
CLUSIACEAE	*Mammea glauca*	(Merr.) Kosterm.	E	*manapau*	
COMBRETACEAE	*Terminalia glabrata*	Forst. f.	I	*talie*	
COMBRETACEAE	*Terminalia richii*	A. Gray	E	*malili*	
CONNARACEAE	*Santaloides samoensis*	(Lauterb.) Schellenb.	I		
CONVOLVULACEAE	*Ipomoea pes-caprae*	(L.) R. Br.	I	*fue moa*	
EBENACEAE	*Diospyros elliptica*	(Forst.) P.S. Green	I	*'anume*	
EBENACEAE	*Diospyros samoensis*	A. Gray	I	*'au'auli*	
ELAEOCARPACEAE	*Elaeocarpus angustifolius*	Bl.	X	*sapatua*	
ELAEOCARPACEAE	*Elaeocarpus floridanus*	Hemsley	X	*a'amati'e*	
EUPHORBIACEAE	*Aleurites moluccanus*	(L.) Willd.	P	*lama*	
EUPHORBIACEAE	*Drypetes vitiensis*	Croizat	I		
EUPHORBIACEAE	*Flueggea flexuosa*	Müll. Arg.	X	*poumuli*	
EUPHORBIACEAE	*Glochidion ramiflorum*	Forst. f.	I	*masame*	
EUPHORBIACEAE	*Homalanthus nutans*	(Forst. f.) Guill.	I	*fogāmamala*	
EUPHORBIACEAE	*Macaranga harveyana*	(Müll. Arg.) Müll. Arg.	I	*lau pata*	
EUPHORBIACEAE	*Ricinus communis*	L.	X		
FABACEAE	*Acacia simplex*	(Sparr.) L. Pedley	I	*tatagia*	X
FABACEAE	*Adenanthera pavonina*	L.	X	*lopā*	
FABACEAE	*Caesalpinia bonduc*	(L.) Roxb.	I	*'anaoso, seu pe'a*	

FAMILY	Species	Authors	Status	Samoan Name	Rare[1]
FABACEAE	*Caesalpinia major*	(Medik.) Dandy & Exell	I	*'anaoso, seu pe'a*	
FABACEAE	*Dendrolobium umbellatum*	(L.) Benth.	I	*lala*	
FABACEAE	*Desmodium triflorum*	(L.) DC.	X		
FABACEAE	*Erythrina variegata*	L.	I	*gātae*	
FABACEAE	*Inocarpus fagifer*	(Parkinson) Fosb.	P	*ifi*	
FABACEAE	*Intsia bijuga*	(Colebr.) Kuntze	I?	*ifilele*	
FABACEAE	*Leucaena leucocephala*	(Lam.) de Wit	X	*lusina*	
FABACEAE	*Mimosa pudica*	L.	X	*vao fefe*	
FABACEAE	*Mucuna gigantea*	(Willd.) DC.	I	*tupe*	
FABACEAE	*Vigna marina*	(Burm.) Merr.	I	*fue sina*	
FLACOURTIACEAE	*Erythrospermum acuminatissimum*	(A. Gray) A.C. Sm.	I		
FLACOURTIACEAE	*Flacourtia rukam*	Zoll. & Mor.	I	*filimoto*	
FLACOURTIACEAE	*Homalium whitmeeanum*	St. John	I		
GOODENIACEAE	*Scaevola taccada*	(Gaertn.) Vahl	I	*to'ito'i*	
HERNANDIACEAE	*Gyrocarpus americanus*	Jacq.	I	*vili, moa*	X
HERNANDIACEAE	*Hernandia nymphaeifolia*	(J. Presl) Kub.	I	*pu'a*	
LAURACEAE	*Cryptocarya turbinata*	Gillespie	X?		
LOGANIACEAE	*Geniostoma rupestre*	Forst.	I	*lau mafatifati*	
MALVACEAE	*Hibiscus tiliaceus*	L.	P	*fau*	
MALVACEAE	*Sida acuta*	Burm. f.	X	*mautofu*	
MALVACEAE	*Sida parviflora*	DC.	P	*mautofu*	X
MALVACEAE	*Thespesia populnea*	(L.) Sol. ex Corrêa	I	*milo*	
MELIACEAE	*Aglaia samoensis*	A. Gray	I	*laga'ali*	
MELIACEAE	*Dysoxylum maota*	Reinecke	I	*tufaso*	
MELIACEAE	*Dysoxylum samoense*	A. Gray	I	*maota mamala*	
MORACEAE	*Castilla elastica*	Sessé	X	*pulu māmoe*	
MORACEAE	*Ficus obliqua*	Forst. f.	I	*āoa*	
MORACEAE	*Ficus prolixa*	Forst. f.	I	*āoa*	
MORACEAE	*Ficus scabra*	Forst. f.	I	*mati mageso*	
MORACEAE	*Ficus tinctoria*	Forst. f.	I	*mati molemole*	
MYRISTICACEAE	*Myristica inutilis*	W. Rich ex A. Gray	I	*'atone*	
MYRSINACEAE	*Rapanea myricifolia*	(A. Gray) Mez	I	*togo vao*	
MYRTACEAE	*Eugenia reinwardtiana*	(Bl.) Cunn. ex DC.	I	*unuoi*	
MYRTACEAE	*Psidium guajava*	L.	X	*ku'ava*	
MYRTACEAE	*Syzygium clusiifolium*	(A. Gray) Müll. Stuttg.	I	*asi vao?*	
MYRTACEAE	*Syzygium inophylloides*	(A. Gray) Müll. Stuttg.	I	*asi toa*	
MYRTACEAE	*Syzygium samarangense*	(Bl.) Merr. & L.M. Perry	X	*nonu vao*	
NYCTAGINACEAE	*Pisonia grandis*	R. Br.	I	*pu'avai*	
NYCTAGINACEAE	*Pisonia umbellifera*	(Forst.) Seem.	I	*fa'apala?*	
OLACACEAE	*Anacolosa insularis*	Christoph.	E		
OLEACEAE	*Jasminum betchei*	F. Müll.	I		
OLEACEAE	*Jasminum didymum*	Forst. f.	I		
OXALIDACEAE	*Oxalis barrelieri*	L.	X	*vine?*	
PASSIFLORACEAE	*Passiflora foetida*	L.	X	*pasio vao*	
PASSIFLORACEAE	*Passiflora laurifolia*	L.	X	*pasio vao*	
PIPERACEAE	*Peperomia leptostachya*	Hooker & Arnott	I		

FAMILY	Species	Authors	Status	Samoan Name	Rare[1]
PIPERACEAE	*Piper macropiper*	Pennant	I	*fue manogi*	
RHAMNACEAE	*Alphitonia zizyphoides*	(Spreng.) A. Gray	I	*toi*	
RHAMNACEAE	*Colubrina asiatica*	(L.) Brongn.	I	*fīsoa*	
RUBIACEAE	*Aidia racemosa*	(Cav.) Tirveng.	I	*ola mea, aso*	
RUBIACEAE	*Antirhea inconspicua*	(Seem.) Christoph.	I		
RUBIACEAE	*Cyclophyllum barbatum*	(Forst. f.) Hallé & Florence	I		
RUBIACEAE	*Guettarda speciosa*	L.	I	*puapua*	
RUBIACEAE	*Gynochthodes epiphytica*	(Rech.) A.C. Sm. & S. Darwin	I		
RUBIACEAE	*Ixora samoensis*	A. Gray	I	*filofiloa*	
RUBIACEAE	*Morinda citrifolia*	L.	I	*nonu*	
RUBIACEAE	*Morinda myrtifolia*	A. Gray	I		
RUBIACEAE	*Psychotria insularum*	A. Gray	I	*matalafi*	
RUBIACEAE	*Psydrax merrillii*	(Setch.) Whistler	I	*ola sina*	
RUTACEAE	*Micromelum minutum*	(Forst. f.) Wight & Arn.	I	*talafalu*	
SAPINDACEAE	*Allophylus timoriensis*	(DC.) Bl.	I		
SAPINDACEAE	*Arytera brackenridgei*	(A. Gray) Radlk.	I	*taputo'i?*	
SAPINDACEAE	*Elattostachys apetala*	(Labill.) Radlk.	I	*taputo'i*	
SAPINDACEAE	*Harpullia arborea*	(Blanco) Radlk.	I	*fa'aili*	
SAPINDACEAE	*Pometia pinnata*	Forst.	I	*tava*	
SAPINDACEAE	*Sapindus vitiensis*	A. Gray	I		
SAPOTACEAE	*Manilkara samoensis*	H. J. Lam & B. Meeuse	E	*pau*	X
SAPOTACEAE	*Planchonella garberi*	Christoph.	I	*'ala'a*	
SAPOTACEAE	*Planchonella grayana*	St. John	I		
SAPOTACEAE	*Planchonella samoensis*	H.J. Lam ex Christoph.	I	*mamalava*	
STERCULIACEAE	*Heritiera ornithocephala*	Kostermans	X?	*mā*	
STERCULIACEAE	*Kleinhovia hospita*	L.	I	*fu'afu'a*	
STERCULIACEAE	*Sterculia fanaiho*	Setch.	I	*faga'io*	
THYMELAEACEAE	*Phaleria acuminata*	(A. Gray) Gilg.	I	*suni vao*	
TILIACEAE	*Grewia crenata*	(Forst.) Schinz & Guillaumin	I	*fauui*	
ULMACEAE	*Celtis harperi*	Horne ex Baker	I		
VERBENACEAE	*Clerodendrum inerme*	(L.) Gaertn.	I	*aloalo tai*	
VERBENACEAE	*Faradaya amicorum*	Seem.	I	*mamalupe*	
VERBENACEAE	*Stachytarpheta cayennensis*	(Rich.) Vahl	X	*vaopepe*	
	MONOCOTYLEDONAE				
ARACEAE	*Epipremnum pinnatum*	(L.) Engl.	I	*fue laofao*	
ARECACEAE	*Cocos nucifera*	L.	I	*niu*	
ASPARAGACEAE	*Cordyline fruticosa*	(L.) Chev.	I	*tī vao*	
CYPERACEAE	*Scleria lithosperma*	(L.) Sw.	I		
DIOSCOREACEAE	*Dioscorea bulbifera*	L.	P	*soi*	
FLAGELLARIACEAE	*Flagellaria gigantea*	Hook. f.	I	*lafo*	
PANDANACEAE	*Freycinetia storckii*	Seem.	I	*'ie'ie*	
POACEAE	*Oplismenus compositus*	(L.) Beauv.	I		
POACEAE	*Pennisetum purpureum*	Schumacher	X	*vao elefane*	
	FERNS				
ASPLENIACEAE	*Asplenium nidus*	L.	I	*laugapāpā*	
ASPLENIACEAE	*Asplenium polyodon*	Forst. f.	I		
DAVALLIACEAE	*Davallia denticulata*	(Burm. f.) Mett. ex Kuhn	I	*laugasēsē*	
DAVALLIACEAE	*Davallia solida*	(Forst. f.) Sw.	I	*laugasēsē*	

FAMILY	*Species*	Authors	Status	*Samoan Name*	Rare[1]
NEPHROLEPIDACEAE	*Arthropteris repens*	(Brackenridge) Christensen	I		
NEPHROLEPIDACEAE	*Nephrolepis biserrata*	(Sw.) Schott	I		
NEPHROLEPIDACEAE	*Nephrolepis hirsutula*	(Forst. f.) Presl	I	*vao tuaniu*	
POLYPODIACEAE	*Phymatosorus grossus*	(Langsd. & Fisch.) Brownlie	I	*lauautā*	
POLYPODIACEAE	*Pyrrosia lanceolata*	(L.) Farwell	I	*lau tasi*	
VITTARIACEAE	*Antrophyum plantagineum*	(Cav.) Kaulf.	I		

Appendix 1.2. Tree Data for the Falealupo KBA Forest Plots

	Falealupo Plot 1 (16 m)	S 13.50114 W 172.77551 to S 13.50167 W 172.77617				
	Species	***Samoan Name***	**No.**	**No. >15 cm**	**Basal Area**	**Rel. Dom.**
1	*Syzygium inophylloides*	*asi toa*	8	7	14163	29%
2	*Aleurites moluccanus*	*lama*	19	11	7419	15%
3	*Adenanthera pavonina*	*lopa*	30	12	5892	12%
4	*Dysoxylum samoense*	*maota*	8	4	3670	7%
5	*Planchonella grayana*	(none)	3	3	2783	6%
6	*Diospyros samoensis*	*'au'auli*	5	1	2656	5%
7	*Hibiscus tiliaceus*	*fau*	5	5	2581	5%
8	*Rhus taitensis*	*tavai*	4	3	2050	4%
9	*Syzygium clusiifolium*	*asi vai*	16	3	1789	4%
10	*Mammea glauca*	*manapau*	15	4	1381	3%
11	*Cananga odorata*	*moso'oi*	1	1	804	2%
12	*Canarium harveyi*	*mafoa*	1	0	615	1%
13	*Anacolosa lutea*	(none)	8	1	606	1%
14	*Dysoxylum maota*	*tufaso*	5	0	471	1%
15	*Meryta macrophylla*	*lau fagufagu*	5	0	399	1%
16	*Elattostachys apetala*	*taputo'i*	4	0	382	1%
17	*Sterculia fanaiho*	*faga'io*	4	0	241	+
18	*Aglaia samoensis*	*laga'ali*	7	0	204	+
19	*Cryptocarya elegans*	*anoso vao*	1	0	154	+
20	*Morinda citrifolia*	*nonu*	3	0	149	+
21	*Inocarpus fagifer*	*ifi*	1	0	95	+
22	*Planchonella garberi*	*ala'a*	3	0	86	+
23	*Erythrospermum acuminatissimum*	(none)	1	0	70	+
24	*Aidia racemosa*	*ola mea*	3	0	60	+
25	*Homalium whitmeeanum*	(none)	1	0	38	+
26	*Ixora samoensis*	*filofiloa*	1	0	20	+
27	*Ficus tinctoria*	*mati*	1	0	20	+
			163	**55**	**48798**	100%

	Falealupo Plot 2 (27 m)	S 13.49818 W 172.76419 to S 13.49894 W 172.7646				
	Species	***Samoan Name***	**No.**	**No. >15 cm**	**Basal Area**	**Rel. Dom.**
1	*Adenanthera pavonina*	*lopa*	90	30	15959	71%
2	*Diospyros samoensis*	*'au'auli*	39	4	2744	12%
3	*Garuga floribunda*	*manaui*	2	1	634	3%
4	*Syzygium clusiifolium*	*asi vai*	6	1	570	3%
5	*Homalium whitmeeanum*	*manuesi?*	5	1	417	2%
6	*Dysoxylum maota*	*tufaso*	3	1	390	2%
7	*Morinda citrifolia*	*nonu*	3	0	256	1%
8	*Planchonella grayana*	(none)	4	0	221	1%
9	*Mammea glauca*	*manapau*	4	0	189	1%
10	*Harpullia arborea*	*fa'aili*	3	0	181	1%
11	*Gyrocarpus americanus*	*moa*	1	1	177	1%
12	*Grewia crenata*	*fau ui*	2	0	161	1%
13	*Cryptocarya elegans*	*anoso vao*	1	0	154	1%
14	*Drypetes vitiensis*	(none)	4	0	106	+
15	*Ixora samoensis*	*filofiloa*	4	0	88	+
16	*Planchonella garberi*	*'ala'a*	4	0	80	+
17	*Anacolosa lutea*	(none)	3	0	60	+
18	*Meryta macrophylla*	*lau fagufagu*	2	0	40	+
19	*Cryptocarya elegans*	*anoso vao*	1	0	28	+
			181	**39**	**22455**	**100%**

	Falealupo Plot 3 (ca. 20m)	S 13.50114 W 172.75742 to S 13.50106 W 172.75647				
	Species	**Samoan Name**	**No.**	**No. >15 cm**	**Basal Area**	**Rel. Dom.**
1	*Adenanthera pavonina*	*lopa*	70	20	9479	44%
2	*Garuga floribunda*	*manaui*	3	3	4471	21%
3	*Homalium whitmeeanum*	*manuesi?*	19	1	1287	6%
4	*Hibiscus tiliaceus*	*fau*	1	1	1017	5%
5	*Erythrina variegata*	*gatae*	1	1	904	5%
6	*Syzygium clusiifolium*	*asi vai*	6	2	861	4%
7	*Morinda citrifolia*	*nonu*	6	2	645	3%
8	*Meryta macrophylla*	*lau fagufagu*	10	1	643	3%
9	*Mammea glauca*	*manapau*	2	1	426	2%
10	*Cerbera manghas*	*leva*	1	1	346	2%
11	*Diospyros elliptica*	*'anume*	2	1	256	1%
12	*Grewia crenata*	*fau ui*	3	0	194	1%
13	*Ficus scabra*	*mati mageso*	5	0	156	1%
14	*Planchonella garberi*	*'ala'a*	6	0	154	1%
15	*Psydrax merrillii*	*olasina*	10	0	124	1%
16	*Guettarda speciosa*	*puapua*	1	1	79	+

17	*Glochidion ramiflorum*	*masame*	2	0	66	+
18	*Psychotria insularum*	*matalafi*	1	0	64	+
19	*Planchonella grayana*	(none)	2	0	48	+
20	*Ixora samoensis*	*filofiloa*	2	0	48	+
21	*Rapanea myricifolia*	*togo vao*	2	0	48	+
22	*Aidia racemosa*	*olamea*	2	0	48	+
23	*Dysoxylum maota*	*tufaso*	1	0	28	+
24	*Micromelum minutum*	*tamafalu*	1	0	26	+
25	*Elattostachys apetala*	*taputo'i*	1	0	20	+
			160	**35**	**21438**	**100%**

	Falealupo Plot 4 (141 m)	**S 13.52482 W 172.74799 to S 13.52565 W 172.74803**				
	Species	***Samoan Name***	**No.**	**No. >15 cm**	**Basal Area**	**Rel. Dom.**
1	*Pometia pinnata*	*tava*	33	15	15363	45%
2	*Dysoxylum samoense*	*maota*	4	2	5111	15%
3	*Elaeocarpus angustifolius*	*sapatua*	1	1	2550	7%
4	*Dysoxylum maota*	*tufaso*	10	4	2421	7%
5	*Intsia bijuga*	*ifilele*	9	3	2301	7%
6	*Macaranga harveyana*	*lau pata*	2	2	1460	4%
7	*Planchonella samoense*	*mamalava*	13	1	857	3%
8	*Cananga odorata*	*moso'oi*	1	1	615	2%
9	*Ficus scabra*	*mati mageso*	3	1	521	2%
10	*Harpullia arborea*	*fa'aili*	5	1	515	2%
11	*Morinda citrifolia*	*nonu*	6	1	457	1%
12	*Cryptocarya elegans*	*anoso vao*	3	1	416	1%
13	*Artocarpus altilis*	*'ulu*	3	1	407	1%
14	*Adenanthera pavonina*	*lopa*	2	1	282	1%
15	*Alphitonia zizyphoides*	*toi*	2	1	278	1%
16	*Syzygium samarangense*	*nonu vao*	3	0	161	+
17	*Ficus tinctoria*	*mati*	2	0	143	+
18	*Anacolosa lutea*	(none)	2	0	70	+
19	*Sterculia fanaiho*	*fana'io*	1	0	64	+
20	*Syzygium savaiiense*	*asi vai*	2	1	40	+
21	*Elattostachys apetala*	*taputo'i*	1	0	38	+
22	*Syzygium inophylloides*	*asi toa*	1	0	38	+
23	*Pisonia umbellifera*	*fa'apala?*	1	0	38	+
24	*Kleinhovia hospita*	*fu'afu'a*	1	0	28	+
25	*Myristica inutilis*	*'atone*	1	0	20	+
			111	**36**	**34194**	**100%**

	Falealupo Plot 5 (135 m)	S 13.52416 W 172.74551 to S 13.52367 W 172.74632				
	Species	***Samoan Name***	**No.**	**No. >15 cm**	**Basal Area**	**Rel. Dom.**
1	*Macaranga harveyana*	*lau pata*	66	30	10633	55%
2	*Garuga floribunda*	*manaui*	3	1	4015	21%
3	*Alphitonia zizyphoides*	*toi*	8	6	2607	13%
4	*Rhus taitensis*	*tavai*	2	1	472	2%
5	*Morinda citrifolia*	*nonu*	13	0	470	2%
6	*Cananga odorata*	*moso'oi*	4	1	449	2%
7	*Elaeocarpus angustifolius*	*sapatua*	3	1	267	1%
8	*Pometia pinnata*	*tava*	2	0	161	1%
9	*Trema cannabina*	*magele*	1	0	95	+
10	*Dysoxylum maota*	*tufaso*	3	0	84	
11	*Syzygium samarangense*	*nonu vao*	2	0	48	+
12	*Calophyllum neoebudicum*	*tamanu*	1	0	28	+
			109	**40**	**19413**	**100%**

Appendix 1.3. Checklist of the Vascular Flora of the Central Savai'i KBA

FAMILY	*Species*	Authors	Status	*Samoan Name*		Sites[1]	
	DICOTYLEDONAE						
ACANTHACEAE	*Dicliptera samoensis*	Seem.	E			A	
AMARANTHACEAE	*Cyathula prostrata*	(L.) Bl.	P			A	
APOCYNACEAE	*Alstonia godeffroyi*	Reinecke	I			A	
APOCYNACEAE	*Alyxia bracteolosa*	Rich ex A. Gray	I	*lau maile*	T	A	
APOCYNACEAE	*Alyxia samoensis*	(Christoph.) A.C. Sm.	E	*lau maile*		A	
APOCYNACEAE	*Alyxia stellata*	(Forst.) Roem. & Schult.	I	*gau*		A	
APOCYNACEAE	*Funtumia elastica*	(Preuss) Stapf	X	*pulu vao*	T		
ARALIACEAE	*Meryta macrophylla*	(W. Rich ex A. Gray) Seem.	I	*lau fagufagu*	T		
ARALIACEAE	*Meryta malietoa*	Cox	E	*lau fagufagu*		A	
ARALIACEAE	*Polyscias reineckei*	Harms	E	*tagitagi vao*		A	
ARALIACEAE	*Reynoldsia pleiosperma*	A. Gray	E	*vī vao*	T	A	
ARALIACEAE	*Schefflera samoensis*	(A. Gray) Harms	E		T	A	
ASCLEPIADACEAE	*Hoya australis*	R. Br. in Traill	I	*lau mafiafia*	T		
ASCLEPIADACEAE	*Hoya betchei*	(Schltr.) Schltr.	E		T		
ASCLEPIADACEAE	*Hoya filiformis*	Rech.	E			A	
ASCLEPIADACEAE	*Hoya samoensis*	Seem.	E		T	A	
ASCLEPIADACEAE	*Tylophora samoensis*	A. Gray	I		T	A	
ASTERACEAE	*Adenostemma viscosum*	Forst.	I?			A	
ASTERACEAE	*Ageratum conyzoides*	L.	X		T		
ASTERACEAE	*Bidens pilosa*	L.	X			A	
ASTERACEAE	*Crassocephalum crepidioides*	(Benth.) S. Moore	X	*fua lele*		A	
ASTERACEAE	*Emilia sonchifolia*	(L.) DC. ex DC.	X		T	A	
ASTERACEAE	*Erechtites valerianifolia*	(Link ex Wolf) Less. ex DC.	X	*fua lele*		A	
ASTERACEAE	*Mikania micrantha*	Kunth	X	*fue saina*	T	A	
BARRINGTONIACEAE	*Barringtonia samoensis*	A. Gray	I	*falagā*	T		
CELASTRACEAE	*Gymnosporia vitiensis*	(A. Gray) Seem.	I		T		
CHLORANTHACEAE	*Ascarina diffusa*	A.C. Sm.	I	*afia?*		A	
CLUSIACEAE	*Calophyllum neoebudicum*	Guillaumin	I	*tamanu*	T	A	
CLUSIACEAE	*Mammea glauca*	(Merr.) Kosterm.	E	*manapau*	T	A	
COMBRETACEAE	*Terminalia richii*	A. Gray	E	*malili*	T	A	
CONNARACEAE	*Santaloides samoensis*	(Lauterb.) Schellenb.	I		T		
CONVOLVULACEAE	*Merremia peltata*	(L.) Merr.	I	*fue lautetele*	T	A	
CONVOLVULACEAE	*Operculina ventricosa*	(Bertero) Peter	I?	*tagamimi?, pālulu?*			
CONVOLVULACEAE	*Stictocardia tiliifolia*	(Desr.) Hallier f.	X	*pālulu*		A	
CORIARIACEAE	*Coriaria ruscifolia*	L.	I			A	
CUCURBITACEAE	*Trichosanthes reineckeana*	Cogn.	E			A	

FAMILY	*Species*	Authors	Status	*Samoan Name*		Sites[1]	
CUCURBITACEAE	*Zehneria mucronata*	(Bl.) Miq.	I		T	A	
CUCURBITACEAE	*Zehneria samoensis*	(A. Gray) Fosb. & Sachet	I				
CUNONIACEAE	*Spiraeanthemum samoense*	A. Gray	E			A	
CUNONIACEAE	*Weinmannia affinis*	A. Gray	I		T	A	
DICHAPETALACEAE	*Dichapetalum vitiense*	(Seem.) Engl.	I		T		
EBENACEAE	*Diospyros major*	(Forst. f.) Bakh.	I		T	A	
ELAEOCARPACEAE	*Elaeocarpus angustifolius*	Bl.	X	*sapatua*	T	A	
ELAEOCARPACEAE	*Elaeocarpus floridanus*	Hemsley	X	*a'amati'e*	T	A	
ELAEOCARPACEAE	*Elaeocarpus magnifolius*	Christoph.	E		T	A	
ELAEOCARPACEAE	*Elaeocarpus tuasivicus*	Christoph.	E			A	
ERICACEAE	*Vaccinium whitmeei*	F. Muell.	E			A	
EUPHORBIACEAE	*Bischofia javanica*	Bl.	I	*'o'a*	T	A	
EUPHORBIACEAE	*Chamaesyce chamissoni*	(Klotzsch & Garcke) F.C. Ho	I	*pulu tai*			
EUPHORBIACEAE	*Claoxylon samoense*	Pax & K. Hoffm.	E			A	
EUPHORBIACEAE	*Euphorbia reineckei*	Pax	I			A	
EUPHORBIACEAE	*Glochidion christophersenii*	Croizat	E			A	
EUPHORBIACEAE	*Glochidion cuspidatum*	(Müll. Arg.) Pax	I	*masame vao*		A	
EUPHORBIACEAE	*Glochidion samoanum*	(Müll. Arg.) Whistler	I	*masame*	T	A	
EUPHORBIACEAE	*Homalanthus acuminatus*	(Müll. Arg.) Pax	E	*fogāmamala*	T	A	
EUPHORBIACEAE	*Homalanthus nutans*	(Forst. f.) Guill.	I	*fogāmamala*		A	
EUPHORBIACEAE	*Macaranga monostyla*	Whistler	E			A	
EUPHORBIACEAE	*Macaranga savaiiense*	(sp. nova)	E			A	
EUPHORBIACEAE	*Macaranga stipulosa*	Müll. Arg.	E	*lau fatu*	T		
FABACEAE	*Caesalpinia major*	(Medik.) Dandy & Exell	I	*'anaoso, seu pe'a*		A	
FABACEAE	*Calopogonium mucunoides*	Desv.	X			A	
FABACEAE	*Mucuna glabra*	(Reinecke) Wilmot-Dear	I	*tupe*	T	A	
FABACEAE	*Strongylodonrubra*	(sp. nova)	I			A	
FLACOURTIACEAE	*Homalium whitmeeanur*	St. John	I			A	
FLACOURTIACEAE	*Xylosma samoense*	Sleumer	E		T	A	
GENTIANACEAE	*Fagraea berteroana*	A. Gray ex Benth.	I	*pualulu*	T	A	
GESNERIACEAE	*Cyrtandra aurantiicarpa*	Gillette	E			A	
GESNERIACEAE	*Cyrtandra campanulata*	Reinecke	E				R
GESNERIACEAE	*Cyrtandra guerkeana*	Lauterb.	E				R
GESNERIACEAE	*Cyrtandra nitens*	C.B. Clarke	E			A	
GESNERIACEAE	*Cyrtandra nudiflora*	C.B. Clarke	E		T	A	
GESNERIACEAE	*Cyrtandra pogonantha*	A. Gray	E		T		
GESNERIACEAE	*Cyrtandra richii*	A. Gray	E		T	A	
GOODENIACEAE	*Scaevola nubigena*	Lauterb.	E			A	

FAMILY	*Species*	Authors	Status	*Samoan Name*	Sites[1]		
HERNANDIACEAE	*Hernandia moerenhoutiana*	Guillemin	I	*pipi*	T	A	
ICACINACEAE	*Citronella samoensis*	(A. Gray) Howard	I			A	
ICACINACEAE	*Medusanthera samoensis*	(Reinecke) Howard	E	*matamō*	T	A	
LAMIACEAE	*Hyptis pectinata*	(L.) Poir.	X		T	A	
LAURACEAE	*Cryptocarya samoensis*	Christoph.	E		T	A	
LAURACEAE	*Endiandra elaeocarpa*	Gillespie	X		T	A	
LAURACEAE	*Litsea samoensis*	(Christoph.) A.C. Sm.	E	*papaono*	T	A	
LOGANIACEAE	*Geniostoma rupestre*	Forst.	I	*lau mafatifati*	T	A	
LORANTHACEAE	*Amyema artensis*	(Mont.) Danser	I	*tapuna*		A	
LYTHRACEAE	*Cuphea carthagenensis*	(Jacq.) J.F. Macbr.	X		T		
MALVACEAE	*Abutilon whistleri*	Fosb.	E		T	A	
MELASTOMACEAE	*Astronidium samoense*	(S. Moore) Markgraf	E		T		
MELASTOMACEAE	*Astronidium subcordatum*	(A. Gray) Christoph.	E				
MELASTOMACEAE	*Clidemia hirta*	(L.) D. Don	X	*vao fulu*	T	A	
MELASTOMACEAE	*Medinilla samoensis*	(Hochr.) Christoph.	I		T	A	
MELIACEAE	*Aglaia samoensis*	A. Gray	I	*laga'ali*		A	
MELIACEAE	*Dysoxylum huntii*	Merr. ex Setch.	E	*maota mea*	T	A	
MENISPERMACEAE	*Stephania forsteri*	(DC.) A. Gray	I			A	
MONIMIACEAE	*Hedycarya dorstenioides*	A. Gray	I	*fatimatao?*	T	A	
MORACEAE	*Ficus godeffroyi*	Warb.	E		T	A	
MORACEAE	*Ficus hygrophila*	Rech.	E			A	
MORACEAE	*Ficus longicuspidata*	Warb.	E			A	
MORACEAE	*Ficus obliqua*	Forst. f.	I	*āoa*	T	A	
MORACEAE	*Ficus samoensis*	Summerh.	E		T	A	
MORACEAE	*Ficus scabra*	Forst. f.	I	*mati mageso*	T	A	
MORACEAE	*Ficus uniauriculata*	Warb.	E	*mati lautaliga*	T	A	
MORACEAE	*Streblus anthropophagorum*	(Seem.) Corner	I			A	
MYRISTICACEAE	*Myristica hypargyraea*	A. Gray	I	*'atone ulu*	T		
MYRISTICACEAE	*Myristica inutilis*	W. Rich ex A. Gray	I	*'atone*	T		
MYRSINACEAE	*Ardisia elliptica*	Thunb.	X		T	A	
MYRSINACEAE	*Embelia vaupelii*	Mez	I			A	
MYRSINACEAE	*Rapanea longipes*	A.C. Sm.	E		T	A	
MYRTACEAE	*Decaspermum fruticosum*	Forst.	I	*nu'anu'a*			
MYRTACEAE	*Metrosideros collina*	(Forst.) A. Gray	I		T	A	
MYRTACEAE	*Metrosideros gregoryi*	Christoph.	E				R
MYRTACEAE	*Psidium cattleianum*	L.	X				
MYRTACEAE	*Syzygium christophersenii*	Whistler	E				R
MYRTACEAE	*Syzygium graeffei*	Whistler	E				R

FAMILY	*Species*	Authors	Status	*Samoan Name*	Sites[1]		
MYRTACEAE	*Syzygium inophylloides*	(A. Gray) Müll. Stuttg.	I	*asi toa*	T	A	
MYRTACEAE	*Syzygium patentinerve*	Christoph.	E			A	
MYRTACEAE	*Syzygium samarangense*	(Bl.) Merr. & L.M. Perry	X	*nonu vao*	T	A	
MYRTACEAE	*Syzygium samoense*	(Burkill) Whistler	E	*fena vao*	T		
MYRTACEAE	*Syzygium vaupelii*	Whistler	E				R
NYCTAGINACEAE	*Pisonia merytafolia*	Whistler	E		T		
OLEACEAE	*Chionanthus vitiensis*	(Seem.) A.C. Sm.	I			A	
OLEACEAE	*Jasminum betchei*	F. Muell.	I			A	
OLEACEAE	*Jasminum didymum*	Forst. f.	I		T	A	
ONAGRACEAE	*Ludwigia octovalvis*	(Jacq.) Raven	X			A	
PASSIFLORACEAE	*Passiflora aurantia*	Forst. f.	I			A	
PIPERACEAE	*Macropiper puberulum*	Benth.	I	*'ava'avaaitu*	T	A	
PIPERACEAE	*Peperomia rechingerae*	C. DC.	E			A	
PIPERACEAE	*Peperomia reineckei*	C. DC.	I		T	A	
PIPERACEAE	*Peperomia samoensis*	Warb.	E			A	
PIPERACEAE	*Peperomia savaiiensis*	(sp. nova)	E		T	A	
PIPERACEAE	*Piper macropiper*	Pennant	I	*fue manogi*	T	A	
PIPERACEAE	*Piper rechingeri*	C. DC.	E		T	A	
PITTOSPORACEAE	*Pittosporum samoense*	Christoph.	E			A	
POLYGALACEAE	*Polygala paniculata*	L.	X	*pulunamulole*	T		
RHAMNACEAE	*Alphitonia zizyphoides*	(Spreng.) A. Gray	I	*toi*		A	
RUBIACEAE	*Calycosia sessilis*	A. Gray	E		T	A	
RUBIACEAE	*Coprosma savaiiensis*	Rech.	E			A	
RUBIACEAE	*Coprosma strigulosa*	Lauterb.	E			A	
RUBIACEAE	*Geophila repens*	(L.) I. M. Johnston	I	*tono*	T	A	
RUBIACEAE	*Gynochthodes epiphytic*	(Rech.) A.C. Sm. & S. Darwi	I		T	A	
RUBIACEAE	*Morinda bucidifolia*	A. Gray	I		T		
RUBIACEAE	*Neonauclea forsteri*	(Seem. ex Havil.) Merr.	I	*afa*	T		
RUBIACEAE	*Nertera granadensis*	(Mutis ex L. f.) Druce	I			A	
RUBIACEAE	*Psychotria apodantha*	A. Gray	E		T	A	
RUBIACEAE	*Psychotria bristolii*	Whistler	E		T	A	
RUBIACEAE	*Psychotria christophersenii*	Whistler	E			A	
RUBIACEAE	*Psychotria closterocarpc*	A. Gray	E			A	
RUBIACEAE	*Psychotria gigantopus*	K. Schum.	E			A	
RUBIACEAE	*Psychotria grandistipulata*	(Lauterb.) Whistler	E		T	A	
RUBIACEAE	*Psychotria insularum*	A. Gray	I	*matalafi*	T	A	
RUBIACEAE	*Psychotria juddii*	Christoph.	E				R
RUBIACEAE	*Psychotria pacifica*	K. Schum.	E		T	A	
RUBIACEAE	*Psychotria samoana*	K. Schum.	E		T	A	
RUBIACEAE	*Psychotria vaupelii*	Whistler	E			A	

FAMILY	*Species*	Authors	Status	*Samoan Name*	Sites[1]		
RUBIACEAE	*Sarcopygme pacifica*	(Reinecke) Setch. & Christoph.	E	*u'unu*	T	A	
RUBIACEAE	*Sarcopygme ramosa*	(Lauterb.) Setch. & Christoph.	E	*u'unu*		A	
RUTACEAE	*Citrus macroptera*	Montr.	P	*moli u'u*			
RUTACEAE	*Melicope albiflora*	(Rech.) T.G. Hartley	E		T		
RUTACEAE	*Melicope lauterbachii*	T.G. Hartley	E			A	
RUTACEAE	*Melicope savaiiensis*	T.G. Hartley	E			A	
RUTACEAE	*Melicope apetiolaris*	(sp. nova)	E		T		
RUTACEAE	*Melicope sulcata*	T. G. Hartley	E			A	
RUTACEAE	*Melicope sulcata*	T. G. Hartley	E				R
SAPINDACEAE	*Alectryon samoensis*	Christoph.	E			A	
SAPINDACEAE	*Cupaniopsis samoensis*	Christoph.	E		T	A	
SAPINDACEAE	*Elattostachys apetala*	(Labill.) Radlk.	I	*taputo'i*	T	A	
SAPOTACEAE	*Palaquium stehlinii*	Christoph.	E	*gasu*	T	A	
SAPOTACEAE	*Planchonella samoensis*	H.J. Lam ex Christoph.	I	*mamalava*	T	A	
SOLANACEAE	*Physalis angulata*	L.	X	*vī vao*		A	
SOLANACEAE	*Solanum americanum*	Mill.	P	*magalo*		A	
SOLANACEAE	*Solanum vitiense*	Seem.	I	*uagani*	T	A	
THEACEAE	*Eurya fosbergii*	Whistler	E			A	
THYMELAEACEAE	*Phaleria acuminata*	(A. Gray) Gilg.	I	*suni vao*	T		
THYMELAEACEAE	*Wikstroemia coriacea*	Sol. ex Forst. f.	I	*fau mū*		A	
ULMACEAE	*Gironniera celtidifolia*	Gaud.	I		T	A	
ULMACEAE	*Trema cannabina*	Lour.	I	*magele*		A	
URTICACEAE	*Boehmeria virgata*	(Forst. f.) Guillemin	I		T	A	
URTICACEAE	*Cypholophus macrocephalus*	Wedd.	E	*fau pata?*	T	A	
URTICACEAE	*Dendrocnide harveyi*	(Seem.) Chew	I	*salato*	T	A	
URTICACEAE	*Elatostema basiandrum*	Reinecke	E			A	
URTICACEAE	*Elatostema cupreo-virid*	Rech.	E			A	
URTICACEAE	*Elatostema grandifolium*	Reinecke	E		T	A	
URTICACEAE	*Elatostema savaiiense*	(sp. nova)	E			A	
URTICACEAE	*Pipturus polynesicus*	Skottsb.	E			A	
URTICACEAE	*Procris pedunculata*	(Forst.) Wedd.	I	*fualole*		A	
VERBENACEAE	*Faradaya amicorum*	Seem.	I	*mamalupe*	T	A	
VERBENACEAE	*Stachytarpheta cayennensis*	(Rich.) Vahl	X	*vaopepe*		A	
VIOLACEAE	*Melicytus samoensis*	(Christoph.) A.C. Sm.	E		T	A	
VISCACEAE	*Korthalsella taenioides*	(Juss.) Endl.	I				R
VITACEAE	*Cayratia acuminata*	(A. Gray) A.C. Sm.	I			A	
	MONOCOTYLEDONAE						
ARACEAE	*Amorphophallus paeoniifolius*	(Dennst.) Nicholson	P	*teve*			R

FAMILY	*Species*	Authors	Status	*Samoan Name*		Sites[1]	
ARACEAE	*Rhaphidophora spuria*	(Schott) Nicholson	E	*tuafaga?*	T	A	
ARECACEAE	*Balaka tahitensis*	(Wendl.) Becc.	E	*māniuniu*		A	
ARECACEAE	*Clinostigma savaiiense*	Becc.	E	*niu vao*	T	A	
ARECACEAE	*Solfia whitmeeana*	(Becc.) Becc.	E	*māniuniu*	T	A	
ASPARAGACEAE	*Cordyline fruticosa*	(L.) Chev.	I	*tī vao*	T	A	
ASTELIACEAE	*Astelia samoense*	(Skottsb.) Birch	E		T	A	
CYPERACEAE	*Carex graeffeana*	Boeck.	I			A	
CYPERACEAE	*Carex maculata*	Boot.	E			A	
CYPERACEAE	*Kyllinga polyphylla*	Willd. ex Kunth	X			A	
CYPERACEAE	*Mariscus cyperinus*	(Retz.) Vahl	P?			A	
CYPERACEAE	*Pycreus polystachyos*	(Rottb.) Beauv.	X			A	
CYPERACEAE	*Rhynchospora corymbosa*	(L.) Britten	I	*selesele*	T		
FLAGELLARIACEAE	*Flagellaria gigantea*	Hook. f.	I	*lafo*	T	A	
HELICONIACEAE	*Heliconia laofao*	Kress	E	*laufao*	T	A	
JOINVILLEACEAE	*Joinvillea plicata*	(Hook. f.) Newell & B.C. Stone	I			A	
MUSACEAE	*Musa x paradisiaca*	L.	I?	*taemanu*	T	A	
ORCHIDACEAE	*Agrostophyllum megalurum*	Rchb. f.	I		T	A	
ORCHIDACEAE	*Bulbophyllum aphanopetalum*	Schltr.	I			A	
ORCHIDACEAE	*Bulbophyllum betchei*	F. Muell.	I			A	
ORCHIDACEAE	*Bulbophyllum pachyanthum*	Schltr.	I				R
ORCHIDACEAE	*Calanthe alta*	Rchb. f.	I				R
ORCHIDACEAE	*Calanthe hololeuca*	Rchb. f.	I				R
ORCHIDACEAE	*Calanthe triplicata*	(Wille. f.) Ames	I			A	
ORCHIDACEAE	*Calanthe ventilabrum*	Rchb. f.	I			A	
ORCHIDACEAE	*Calanthe whistleri*	P.J. Cribb & D.A. Clayton	E			A	
ORCHIDACEAE	*Chrysoglossum ornatum*	Bl.	I			A	R
ORCHIDACEAE	*Coelogyne lycastoides*	F. Muell. and Kraenzl.	I		T	A	
ORCHIDACEAE	*Corymborkis veratrifolia*	(Reinw.) Bl.	I		T		
ORCHIDACEAE	*Crepidium reineckeanun*	(Kraenzl.) Clem. & Jones	I		T	A	
ORCHIDACEAE	*Dendrobium biflorum*	(Forst. f.) Sw.	I		T	A	
ORCHIDACEAE	*Dendrobium dactylodes*	Rchb. f.	I			A	
ORCHIDACEAE	*Dendrobium flammeus*	(sp. nova)	E			A	
ORCHIDACEAE	*Dendrobium macrophyllum*	A. Rich.	I		T		
ORCHIDACEAE	*Dendrobium reineckei*	Schltr.	E			A	
ORCHIDACEAE	*Dendrobium vagans*	Schltr.	I			A	
ORCHIDACEAE	*Diplocaulobium fililobun*	(F. Muell.) Kraenzl.	E			A	
ORCHIDACEAE	*Earina valida*	Rchb. f.	I			A	
ORCHIDACEAE	*Epiblastus sciadanthus*	(F. Muell.) Schltr.	I			A	

FAMILY	*Species*	Authors	Status	*Samoan Name*		Sites[1]	
ORCHIDACEAE	*Eria robusta*	(Bl.) Lindl.	I			A	
ORCHIDACEAE	*Eria rostriflora*	Rchb. f.	I			A	
ORCHIDACEAE	*Erythrodes oxyglossa*	Schltr.	I		T	A	
ORCHIDACEAE	*Glomera montana*	Rchb. f.	I			A	
ORCHIDACEAE	*Habenaria samoensis*	F. Muell. & Kraenzl.	E			A	
ORCHIDACEAE	*Liparis condylobulbon*	Rchb. f.	I		T	A	
ORCHIDACEAE	*Liparis layardii*	F. Muell.	I			A	
ORCHIDACEAE	*Liparis phyllocardia*	Schltr.	E			A	
ORCHIDACEAE	*Mediocalcar paradoxum*	(Kraenzl.) Schltr.	I			A	
ORCHIDACEAE	*Microtatorchis samoensis*	Schltr.	I				R
ORCHIDACEAE	*Nervilia grandiflora*	Schltr.	E				R
ORCHIDACEAE	*Oberonia bifida*	Schltr.	I		T	A	
ORCHIDACEAE	*Oberonia equitans*	(Forst. f.) Mutel	I		T	A	
ORCHIDACEAE	*Oberonia heliophila*	Rchb. f.	I			A	
ORCHIDACEAE	*Peristylus tradescantifolius*	(Rchb. f.) Kores	I				R
ORCHIDACEAE	*Phaius flavus*	(Bl.) Lindl.	I			A	
ORCHIDACEAE	*Phaius terrestris*	(L.) Ormerod	I		T	A	
ORCHIDACEAE	*Phreatia micrantha*	(A. Rich.) Schltr.	I		T	A	
ORCHIDACEAE	*Phreatia minima*	Schltr.	I				R
ORCHIDACEAE	*Platylepis heteromorphc*	Rchb. f.	E		T	A	
ORCHIDACEAE	*Pristiglottis longiflora*	(Rchb. f.) Kores	I		T		
ORCHIDACEAE	*Spathoglottis plicata*	Bl.	I			A	
ORCHIDACEAE	*Spiranthes sinensis*	(Pers.) Ames	I			A	
ORCHIDACEAE	*Stichorkis gibbosa*	(Finet) J.J. Wood	I				R
ORCHIDACEAE	*Vrydagzynea vitiensis*	Rchb. f.	I			A	
ORCHIDACEAE	*Zeuxine plantaginea*	Rchb. f.) Benth. & Hook. f.	E				R
PANDANACEAE	*Freycinetia arborea*	Gaud.	E	*'ie'ie*		A	
PANDANACEAE	*Freycinetia hombronii*	Mart.	I	*'ie'ie*	T	A	
PANDANACEAE	*Freycinetia reineckei*	Warb.	E	*'ie'ie*	T	A	
PANDANACEAE	*Freycinetia storckii*	Seem.	I	*'ie'ie*	T	A	
PANDANACEAE	*Pandanus reineckei*	Warb.	E	*fasa*			R
POACEAE	*Centosteca lappacea*	(L.) Desv.	I		T	A	
POACEAE	*Cyrtococcum oxyphyllun*	(Hochst. ex Steud.) Stapf	I			A	
POACEAE	*Eleusine indica*	(L.) Gaertn.	P	*ta'a ta'a*		A	
POACEAE	*Imperata conferta*	(J. Presl) Ohwi	I			A	
POACEAE	*Microstegium glabratun*	(Brongn.) A. Camus	I			A	
POACEAE	*Oplismenus compositus*	(L.) Beauv.	I		T	A	
POACEAE	*Panicum maximum*	Jacq.	X			A	
POACEAE	*Paspalum conjugatum*	P.J. Bergius	X	*vao lima*	T	A	
POACEAE	*Paspalum paniculatum*	L.	X		T		

FAMILY	*Species*	Authors	Status	*Samoan Name*		Sites[1]	
POACEAE	*Paspalum scrobiculatum*	L.	I			A	
POACEAE	*Pennisetum purpureum*	Schumacher	X	*vao elefane*		A	
ZINGIBERACEAE	*Alpinia samoensis*	Reinecke	E			A	
ZINGIBERACEAE	*Etlingera cevuga*	(Seem.) R.M. Smith	X		T		
	FERNS						
ADIANTACEAE	*Adiantum diaphanum*	Bl.	I			A	
ANGIOPTERIDACEAE	*Angiopteris evecta*	(Forst. f.) Hoffman	I	*gase*	T	A	
ASPIDIACEAE	*Arachniodes aristata*	(Forst. f.) Tindale	I		T		
ASPIDIACEAE	*Dryopteris arborescens*	(Baker) Kuntze	I			A	
ASPIDIACEAE	*Dryopteris hirtipes*	(Bl.) Kuntze	I			A	
ASPIDIACEAE	*Pleocnemia cumingiana*	Presl	I		T	A	
ASPIDIACEAE	*Tectaria crenata*	Cav.	I			A	
ASPIDIACEAE	*Tectaria decurrens*	(Presl) Copeland	I		T	A	
ASPLENIACEAE	*Asplenium cuneatum*	Lam.	I			A	
ASPLENIACEAE	*Asplenium excisum*	Presl	I			A	
ASPLENIACEAE	*Asplenium feejeense*	Brackenridge	I			A	
ASPLENIACEAE	*Asplenium horridum*	Kaulf.	I		T	A	
ASPLENIACEAE	*Asplenium insiticium*	Brackenridge	I			A	
ASPLENIACEAE	*Asplenium laserpitiifolium*	Lam.	I		T	A	
ASPLENIACEAE	*Asplenium lobulatum*	Mett.	I		T	A	
ASPLENIACEAE	*Asplenium multifidum*	Brackenridge	I		T	A	
ASPLENIACEAE	*Asplenium nidus*	L.	I	*laugapāpā*	T	A	
ASPLENIACEAE	*Asplenium tenerum*	Forst. f.	I			A	
ATHYRIACEAE	*Athyrium oosorum*	(Baker) Christ	E?			A	
ATHYRIACEAE	*Diplaziopsis javanica*	(Bl.) Christensen	I		T	A	
ATHYRIACEAE	*Diplazium dilatatum*	Bl.	I		T	A	
ATHYRIACEAE	*Diplazium echinatum*	Christensen	I		T	A	
ATHYRIACEAE	*Diplazium harpeodes*	Moore	I		T	A	
ATHYRIACEAE	*Diplazium proliferum*	(Lam.) Thouars	I		T	A	
ATHYRIACEAE	*Lunathyrium japonicum*	(Thunb.) Kurata	I		T	A	
BLECHNACEAE	*Blechnum doodioides*	(Brackenridge) Brownlie	I		T	A	
BLECHNACEAE	*Blechnum orientale*	L.	I			A	
BLECHNACEAE	*Blechnum procerum*	(Forst. f.) Swartz	I			A	
BLECHNACEAE	*Blechnum vulcanicum*	(Bl.) Kuhn	I			A	
CULCITACEAE	*Culcita straminea*	(Labill.) Maxon	I		T	A	
CYATHEACEAE	*Cyathea affinis*	(Forst. f.) Sw.	I	*olioli*		A	
CYATHEACEAE	*Cyathea alta*	Copeland	I	*olioli*		A	
CYATHEACEAE	*Cyathea decurrens*	(Hook.) Copeland	I	*olioli*		A	
CYATHEACEAE	*Cyathea lunulata*	(Hook.) Copeland	I	*olioli*	T	A	
CYATHEACEAE	*Cyathea medullaris*	(Forst. f.) Sw.	I	*olioli*	T	A	
CYATHEACEAE	*Cyathea vaupelii*	Copeland	E	*olioli*		A	

FAMILY	*Species*	Authors	Status	*Samoan Name*		Sites[1]	
CYATHEACEAE	*Cyathea whitmeei*	Baker	E	*oliolī*	T	A	
DAVALLIACEAE	*Davallia graeffei*	Luerssen	I			A	
DAVALLIACEAE	*Davallia heterophylla*	J. Sm.	I			A	
DAVALLIACEAE	*Davallia plumosa*	Baker	E			A	
DAVALLIACEAE	*Davallia solida*	(Forst. f.) Sw.	I	*laugasēsē*		A	
DAVALLIACEAE	*Humata serrata*	Brackenridge	I			A	
DAVALLIACEAE	*Leucostegia pallida*	(Mett.) Copeland	I		T	A	
DENNSTAEDTIACEAE	*Dennstaedtia flaccida*	(Forst. f.) Bernh.	I			A	
DENNSTAEDTIACEAE	*Dennstaedtia scandens*	(Bl.) Moore	I		T	A	
DENNSTAEDTIACEAE	*Microlepia speluncae*	(L.) Moore	I			A	
DENNSTAEDTIACEAE	*Orthiopteris tenuis*	(Brackenridge) Brownlie	I			A	
DICKSONIACEAE	*Dicksonia brackenridgei*	Mett.	I			A	
ELAPHOGLOSSACEAE	*Elaphoglossum feejeens*	Brackenridge	I			A	
GLEICHENIACEAE	*Dicranopteris linearis*	(Burm.) Underw.	I	*'asaua*		A	
GRAMMITIDACEAE	*Ctenopteris contigua*	(Forst. f.) Holttum	I			A	
GRAMMITIDACEAE	*Ctenopteris seemannii*	(J. Smith) Copeland	I			A	
GRAMMITIDACEAE	*Ctenopteris tenuisecta*	(Bl.) S. Sm.	I			A	
GRAMMITIDACEAE	*Grammitis hookeri*	(Brackenridge) Copeland	I			A	
GRAMMITIDACEAE	*Scleroglossum sulcatum*	(Kuhn) v. Alder.	I			A	
HEMIONITIDACEAE	*Coniogramme fraxinea*	(Don) Diels	I			A	
HYMENOPHYLLACEAE	*Hymenophyllum flabellatum*	Labill.	I			A	
HYMENOPHYLLACEAE	*Hymenophyllum imbricatum*	Bl.	I			A	
HYMENOPHYLLACEAE	*Trichomanes apiifolium*	Presl	I			A	
HYMENOPHYLLACEAE	*Trichomanes bipunctatum*	Poiret	I			A	
HYMENOPHYLLACEAE	*Trichomanes intermedium*	Bosch	I			A	
HYMENOPHYLLACEAE	*Trichomanes maximum*	Bl.	I			A	
HYPOLEPIDACEAE	*Histiopteris incisa*	(Thunb.) J. Sm.	I		T	A	
HYPOLEPIDACEAE	*Hypolepis tenuifolia*	(Forst. f.) Bernh.	I			A	
LOMARIOPSIDACEAE	*Bolbitis palustris*	(Brackenridge) Hennipman	I		T	A	
LOMARIOPSIDACEAE	*Lomagramma cordipinn*	Holttum	I		T	A	
LOXOGRAMMACEAE	*Loxogramme parksii*	Copeland	I		T	A	
NEPHROLEPIDACEAE	*Arthropteris repens*	(Brackenridge) Christensen	I			A	
NEPHROLEPIDACEAE	*Nephrolepis biserrata*	(Sw.) Schott	I			A	
NEPHROLEPIDACEAE	*Nephrolepis hirsutula*	(Forst. f.) Presl	I	*vao tuaniu*		A	
NEPHROLEPIDACEAE	*Nephrolepis pseudolaute*	Miyam.	I			A	
OLEANDRACEAE	*Oleandra neriiformis*	Cav.	I		T	A	
OLEANDRACEAE	*Oleandra sibbaldii*	Grev.	I			A	
OPHIOGLOSSACEAE	*Ophioglossum pendulun*	L.	I		T	A	
OPHIOGLOSSACEAE	*Ophioglossum reticulatum*	L.	I		T	A	

FAMILY	*Species*	Authors	Status	*Samoan Name*	Sites[1]		
OSMUNDACEAE	*Leptopteris wilkesiana*	(Brackenridge) Christ	I		T	A	
POLYPODIACEAE	*Belvisia vaupelii*	(Christensen) Copel.	E?			A	
POLYPODIACEAE	*Drynaria rigidula*	(Sw.) Beddome	I		T	A	
POLYPODIACEAE	*Lemmaphyllum acceden*	(Bl.) Donk	I			A	
POLYPODIACEAE	*Phymatosorus commutatus*	(Bl.) P. Serm.	I		T	A	
POLYPODIACEAE	*Phymatosorus grossus*	(Langsd. & Fisch.) Brownlie	I	*lauautā*		A	
POLYPODIACEAE	*Phymatosorus nigrescen*	(Bl.) P. Serm.	I			A	
POLYPODIACEAE	*Phymatosorus powellii*	(Baker) P. Serm.	I			A	
POLYPODIACEAE	*Polypodium subauriculatum*	Bl.	I		T	A	
POLYPODIACEAE	*Pyrrosia lanceolata*	(L.) Farwell	I	*lau tasi*	T		
POLYPODIACEAE	*Selliguea feeoides*	Copeland	I			A	
PTERIDACEAE	*Pteris tripartita*	Sw.	I			A	
THELYPTERIDACEAE	*Coryphopteris pubirachi*	(Baker) Holttum	E			A	
THELYPTERIDACEAE	*Sphaerostephanos reineckei*	(Christensen) Holttum	E			A	
VITTARIACEAE	*Antrophyum alatum*	Brackenridge	I		T	A	
VITTARIACEAE	*Antrophyum plantagineum*	(Cav.) Kaulf.	I			A	
VITTARIACEAE	*Antrophyum subfalcatur*	Brackenridge	I			A	
VITTARIACEAE	*Vaginularia angustissim*	(Brackenridge) Mett.	I		T		
VITTARIACEAE	*Vittaria elongata*	Sw.	I			A	
VITTARIACEAE	*Vittaria scolopendrina*	(Bory) Thwaites	I			A	
	FERN ALLIES						
LYCOPODIACEAE	*Lycopodium carinatum*	Desv.	I			A	
LYCOPODIACEAE	*Lycopodium cernuum*	L.	I			A	
LYCOPODIACEAE	*Lycopodium phlegmaria*	L.	I			A	
LYCOPODIACEAE	*Lycopodium phyllanthur*	H. & A.	I			A	
LYCOPODIACEAE	*Lycopodium squarrosum*	Forst. f.	I			A	
LYCOPODIACEAE	*Lycopodium venustulum*	Gaud.	I			A	
LYCOPODIACEAE	*Lycopodium verticillatur*	L.	I		T	A	
SELAGINACEAE	*Selaginella whitmeei*	Baker	I		T	A	

[1] T = Taga; A = A'opo; R = elsewhere, from rare plant report (Whistler 2010).

Appendix 1.4. Tree Data for the Central Savai'i KBA Forest Plots.

	Taga Plot 1 (600 m)	S 13.71864 W 172.51601 to S 13.71832 W 172.51689				
	Species	***Samoan Name***	**No.**	**No. >15 cm**	**Basal Area**	**Rel. Dom.**
1	*Elaeocarpus angustifolius*	*sapatua*	7	5	16143	41%
2	*Cyathea whitmeei*	*oliolī*	48	20	8871	22%
3	*Cyathea alta*	*oliolī*	70	5	4974	13%
4	*Macaranga stipulosa*	*lau fatu*	4	3	3607	9%
5	*Planchonella samoense*	*mamalava*	9	4	2518	6%
6	*Gironniera celtidifolia*	(none)	17	1	1006	3%
7	*Hernandia moerenhoutiana*	*pipi*	2	1	453	1%
8	*Calophyllum neoebudicum*	*tamanu*	1	1	452	1%
9	*Syzygium samarangense*	*nonu vao*	3	1	304	1%
10	*Sarcopygme pacifica*	*ma'ulu'ulu*	2	0	290	1%
11	*Ficus scabra*	*mati mageso*	3	0	252	+
12	*Elaeocarpus magnifolius*	(none)	1	1	227	+
13	*Myristica inutilis*	*'atone*	2	0	161	+
14	*Bischofia javanica*	*'o'a*	5	0	132	+
15	*Cyathea vaupelii*	*oliolī*	3	0	130	+
16	*Syzygium cf. savaiiense*	*asi vai*	2	0	48	+
17	*Pisonia umbellifera*	*fa'apala?*	1	0	20	+
			180	**42**	**39588**	**100%**

	Taga Plot 2 (800 m)	S 13.70728 W 172.51280 to S 13.70663 W 172.51377				
	Species	***Samoan Name***	**No.**	**No. >15 cm**	**Basal Area**	**Rel. Dom.**
1	*Dysoxylum huntii*	*maota mea*	17	8	11263	25%
2	*Syzygium samarangense*	*nonu vao*	10	7	10550	23%
3	*Cyathea whitmeei*	*oliolī*	35	23	9791	22%
4	*Macaranga stipulosa*	*lau fatu*	4	4	3736	8%
5	*Neonauclea forsteri*	*afa*	1	1	1661	4%
6	*Elattostachys apetala*	*taputo'i*	1	1	1520	3%
7	*Cyathea vaupelii*	*oliolī*	17	1	1166	3%
8	*Bischofia javanica*	*'o'a*	10	2	1085	2%
9	*Elaeocarpus angustifolius*	*sapatua*	1	1	1075	2%
10	*Gironniera celtidifolia*	(none)	6	1	609	1%
11	*Hernandia moerenhoutiana*	*pipi*	2	1	529	1%
12	*Homalanthus acuminatus*	*fogamamala*	2	1	367	1%
13	*Elaeocarpus magnifolius*	(none)	2	1	293	1%
14	*Solfia whitmeeana*	*maniuniu*	3	0	292	1%
15	*Hedycarya dorstenioides*	(none)	1	1	227	+
16	*Ficus uniauriculata*	*mata lau taliga*	1	1	201	+
17	*Psychotria bristolii*	(none)	2	0	174	+

18	*Psychotria grandistipulata*	(none)	4	0	173	+
19	*Funtumia elastica*	*pulu vao*	2	0	117	+
20	*Sarcopygme pacifica*	*ma'ulu'ulu*	1	0	113	+
21	*Cyathea cf. alta*	*oliolī*	2	0	99	+
22	*Aglaia samoensis*	*laga'ali*	1	0	95	+
23	*Astronidium cf. samoense*	(none)	1	0	64	+
24	*Syzygium samoense*	*fena vao*	1	0	64	+
25	*Cryptocarya samoensis*	(none)	1	0	28	+
26	*Ficus godeffroyi*	(none)	1	0	20	+
27	*Diospyros major*	(none)	1	1	20	+
			132	**56**	**45332**	

	Taga Plot 3 (1000 m)	S 13.69325 W 172.50642 to S 13.69245 W 172.50684				
	Species	***Samoan Name***	**No.**	**No. >15 cm**	**Basal Area**	**Rel. Dom.**
1	*Dysoxylum huntii*	*maota mea*	19	10	26952	37%
2	*Bischofia javanica*	*'o'a*	5	4	23187	32%
3	*Syzygium samarangense*	*nonu vao*	22	13	14512	20%
4	*Cyathea whitmeei*	*oliolī*	8	7	2670	4%
5	*Hernandia moerenhoutiana*	*pipi*	1	1	1520	2%
6	*Rapanea longipes*	*togo vao*	1	0	1075	1%
7	*Endiandra elaeocarpa*	(none)	4	1	651	1%
8	*Cyathea medullaris*	*oliolī*	1	1	572	1%
9	*Geniostema rupestre*	*lau mafatifati*	5	0	344	+
10	*Hedycarya dorstenioides*	(none)	1	1	254	+
11	*Melicytus samoensis*	(none)	1	1	254	+
12	*Solanum vitiense*	*uanani*	3	0	183	+
13	*Litsea samoensis*	*papaono*	1	0	154	+
14	*Cyathea vaupelii*	*oliolī*	2	0	114	+
15	*Gironniera celtidifolia*	(none)	2	0	114	+
16	*Psychotria bristolii*	(none)	2	0	133	+
17	*Cyrtandra richii*	*momole'a*	2	0	112	+
18	*Elattostachys apetala*	*taputo'i*	1	0	50	+
19	*Ficus godeffroyi*	(none)	1	0	20	+
20	*Ficus scabra*	(none)	1	1	20	+
			83	**39**	**72891**	**100%**

	Taga Plot 4 (1070 m)	S 13.69100 W 172.50443 to S 13.69179 W 172.50484				
	Species	***Samoan Name***	**No.**	**No. >15 cm**	**Basal Area**	**Rel. Dom.**
1	*Dysoxylum huntii*	*maota mea*	10	4	11498	19%
2	*Bischofia javanica*	*'o'a*	30	5	10442	18%
3	*Elaeocarpus magnifolius*	(none)	16	7	5548	10%
4	*Syzygium samarangense*	*nonu vao*	3	1	5303	9%
5	*Metrosideros collina*	(none)	8	6	4569	8%
6	*Syzygium inophylloides*	*asi toa*	6	3	2927	5%
7	*Mammea glauca*	*manapau*	4	3	2463	4%
8	*Hedycarya dorstenioides*	(none)	29	3	2148	4%
9	*Litsea samoensis*	*papaono*	14	4	1956	3%
10	*Elattostachys apetala*	*taputo'i*	9	4	1834	3%
11	*Reynoldsia pleiosperma*	*vī vao*	1	1	1661	3%
12	*Hernandia moerenhoutiana*	*pipi*	3	1	1646	3%
13	*Glochidion ramiflorum*	*masame*	10	6	1494	2%
14	*Geniostema rupestre*	*lau mafatifati*	18	0	1010	2%
15	*Phaleria disperma*	*suni vao*	13	0	636	1%
16	*Planchonella samoensis*	*mamalava*	5	1	554	1%
17	*Cyathea whitmeei*	*oliolī*	3	1	443	1%
18	*Cordyline fruticosa*	*tī vao*	9	0	323	1%
19	*Cyathea vaupelii*	*oliolī*	8	0	316	1%
20	*Rapanea longipes*	*togo vao*	5	0	217	+
21	*Cyathea medullaris*	*oliolī*	1	1	201	+
22	*Medusanthera samoensis*	*matamo*	2	0	183	+
23	*Melicope albiflora*	(none)	2	0	123	+
24	*Ficus scabra*	(none)	5	0	116	+
25	*Meryta macrophylla*	*lau fagufagu*	1	1	95	+
26	*Melicytus samoensis*	(none)	1	0	79	+
27	*Solfia whitmeeana*	*māniuniu*	1	0	50	+
28	*Xylosma samoense*	(none)	2	0	48	+
			219	**52**	**57833**	**100%**

	A'opo Plot 1 (1000 m)	S 13.58008 W 172.50534 to S 13.58080 W 172.5060				
	Species	***Samoan Name***	**No.**	**No. >15 cm**	**Basal Area**	**Rel. Dom.**
1	*Syzygium inophylloides*	*asi toa*	10	6	16669	28%
2	*Ficus obliqua*	*āoa fāfine*	1	1	11304	19%
3	*Dysoxylum huntii*	*maota mea*	14	6	6834	11%
4	*Alphitonia zizyphoides*	*toi*	5	5	5088	9%
5	*Syzygium samoense*	*fena vao*	16	2	3353	6%
6	*Pittosporum samoense*	(none)	3	3	2032	3%
7	*Syzygium samarangense*	*nonu vao*	25	1	1870	3%
8	*Litsea samoensis*	*papaono*	9	3	1753	3%
9	*Mammea glauca*	*manapau*	5	5	1677	3%

10	*Homalanthus acuminatus*	*fogamamala vao*	5	3	1531	3%
11	*Hernandia moerenhoutiana*	*pipi*	5	2	1313	2%
12	*Cyathea medullaris*	*oliolī*	3	2	1000	2%
13	*Bischofia javanica*	*'o'a*	5	1	824	2%
14	*Cyathea whitmeeanus*	*oliolī*	7	2	717	1%
15	*Endiandra elaeocarpa*	(none)	5	1	499	1%
16	*Elaeocarpus magnifolius*	(none)	5	1	469	1%
17	*Cupaniopsis samoensis*	(none)	3	1	383	1%
18	*Ficus godeffroyi*	(none)	7	1	363	1%
19	*Glochidion cuspidatum*	*masame vao*	1	1	314	1%
20	*Macaranga monostyla*	(none)	8	1	263	+
21	*Hedycarya dorstenioides*	(none)	5	0	215	+
22	*Rapanea longipes*	*togo vao*	1	1	201	+
23	*Psychotria pacifica*	(none)	7	0	174	+
24	*Solanum vitiense*	*uanani*	4	0	148	+
25	*Geniostema rupestre*	*laumafatifati*	5	0	142	+
26	*Sarcopygme pacifica*	*ma'ulu'ulu*	1	0	133	+
27	*Solfia whitmeeana*	*maniuniu*	2	0	102	+
28	*Ficus samoensis*	(none)	1	0	50	+
29	*Melicytus samoensis*	*(none)*	1	0	28	+
30	*Cyathea vaupelii*	*oliolī*	1	0	28	+
31	*Polyscias reineckei*	*tagitagi*	1	0	28	+
32	*Cyrtandra richii*	*momole'a*	1	0	20	+
33	*Reynoldsia pleiosperma*	*vī vao*	1	0	20	+
			173	**49**	**59495**	**100%**

	A'opo Plot 2 (1200 m)	**S 13.58703 W 172.50668 to S 13.58614 W 172.50630**				
	Species	***Samoan Name***	**No.**	**No. >15cm**	**Basal Area**	**Rel. Dom.**
1	*Dysoxylum huntii*	*maota mea*	11	6	13721	40%
2	*Hedycarya dorstenioides*	(none)	41	7	4991	14%
3	*Syzygium samarangense*	*nonu vao*	1	1	2462	7%
4	*Bischofia javanica*	*'o'a*	5	1	2237	6%
5	*Glochidion cuspidatum*	*masame vao*	5	3	2231	6%
6	*Pittosporum samoense*	(none)	4	7	1581	5%
7	*Hernandia moerenhoutiana*	*pipi*	6	2	1525	4%
8	*Homalanthus acuminatus*	*fogāmamala vao*	2	2	1300	4%
9	*Ficus samoensis*	(none)	8	0	701	2%
10	*Macaranga monostyla*	(none)	2	1	541	2%
11	*Melicytus samoensis*	(none)	5	1	513	2%
12	*Elaeocarpus floridanus*	*a'amati'e*	1	1	491	1%
13	*Sarcopygme pacifica*	*ma'ulu'ulu*	9	0	334	1%

14	*Cyathea medullaris*	*oliolī*	1	1	319	1%
15	*Cyathea cf. alta*	*oliolī*	7	0	312	1%
16	*Geniostema rupestre*	*lau mafatifati*	7	0	302	1%
17	*Schefflera samoensis*	(none)	5	0	220	1%
18	*Ficus godeffroyi*	(none)	6	0	172	+
19	*Diospyros major*	(none)	1	0	133	+
20	*Litsea samoensis*	*papaono*	3	0	127	+
21	*Rapanea longipes*	*togo vao*	1	0	113	+
22	*Solanum vitiense*	*uanani*	3	0	96	+
23	*Solfia whiteeanus*	*maniuniu*	1	0	64	+
24	*Psychotria insularum*	*matalafi*	1	0	20	+
25	*Syzygium samoense*	*fena vao*	1	0	20	+
26	*Melicope albiflora*	(none)	1	0	20	+
			138	**33**	**34546**	**100%**

	A'opo Plot 3 (1400 m)	**S 13.59276 W 172.50717 to S 13.59216 W 172.50641**				
	Species	***Samoan Name***	**No.**	**No. >15 cm**	**Basal Area**	**Rel. Dom.**
1	*Dysoxylum huntii*	*maota mea*	50	22	23114	51%
2	*Hedycarya dorstenioides*	(none)	52	5	3506	8%
3	*Macaranga monostyla*	(none)	33	1	2802	6%
4	*Homalanthus acuminatus*	*fogāmamala vao*	17	3	2660	6%
5	*Litsea samoensis*	*papaono*	8	2	1688	4%
6	*Hernandia moerenhoutiana*	*pipi*	6	2	1601	4%
7	*Spiraeanthemum samoense*	*(none)*	7	4	1475	3%
8	*Syzygium samarangense*	*nonu vao*	4	1	1382	3%
9	*Cyathea medullaris*	*oliolī*	6	3	1134	2%
10	*Sarcopygme pacifica*	*ma'ulu'ulu*	14	0	882	2%
11	*Schefflera samoensis*	(none)	12	2	870	2%
12	*Weinmannia affinis*	(none)	3	2	766	2%
13	*Clinostigma warburgii*	*niu vao*	2	2	694	2%
14	*Reynoldsia pleiospterma*	*vi vao*	1	1	442	1%
15	*Medusanthera samoense*	*matamo*	7	0	433	1%
16	*Melicytus samoensis*	(none)	12	0	387	1%
17	*Cyathea whitmeeanus*	*oliolī*	4	1	387	1%
18	*Coprosma savaiiense*	(none)	1	1	346	1%
19	*Psychotria bristolii*	(none)	7	0	303	1%
20	*Melicope albiflora*	(none)	6	0	206	+
21	*Citronella samoense*	(none)	2	1	197	+
22	*Abutilon whistleri*	(none)	4	0	138	+
23	*Geniostema rupestre*	*lau mafatifati*	4	0	98	+
24	*Ficus godeffroyi*	(none)	1	0	28	+
			263	**53**	**45539**	**100%**

	A'opo Plot 4 (1500 m)	S 13.59593 W 172.50557 to S 13.59540 W 172.50487				
	Species	***Samoan Name***	**No.**	**No. >15 cm**	**Basal Area**	**Rel. Dom.**
1	*Dysoxylum huntii*	*maota mea*	35	7	10905	21%
2	*Homalanthus acuminatus*	*fogāmamala vao*	47	22	7838	17%
3	*Reynoldsia pleiosperma*	*vī vao*	2	1	6313	14%
4	*Hedycarya dorstenioides*	(none)	51	4	4748	10%
5	*Pittosporum samoense*	(none)	11	9	3731	8%
6	*Spiraeanthemum samoense*	(none)	5	2	2062	5%
7	*Macaranga monostyla*	(none)	12	5	1787	4%
8	*Psychotria christophersenii*	(none)	3	3	1284	3%
9	*Meryta malietoai*	*lau fagufagu*	3	6	843	2%
10	*Sarcopygme pacifica*	*ma'ulu'ulu*	6	3	843	2%
11	*Litsea samoensis*	*papaono*	4	2	838	2%
12	*Cyathea whitmeei*	*oliolī*	6	1	728	2%
13	*Alphitonia zizyphoides*	*toi*	1	1	615	1%
14	*Melicope albiflora*	(none)	8	1	571	1%
16	*Psychotria grandistipulata*	(none)	4	2	496	1%
15	*Schefflera samoense*	(none)	14	0	436	1%
17	*Medusanthera samoense*	*matamō*	12	0	431	1%
18	*Glochidion christophersenii*	(none)	2	2	428	1%
19	*Geniostoma rupestre*	*lau mafatifati*	11	0	426	1%
20	*Syzygium samarangense*	*nonu vao*	1	1	369	1%
21	*Cyathea medullaris*	*oliolī*	3	0	307	1%
22	*Abutilon whistleri*	(none)	2	1	229	+
23	*Melicytus samoensis*	(none)	3	0	106	+
24	*Cordyline fruticosa*	*tī vao*	2	0	88	+
25	*Rapanea longipes*	*togo vao*	1	0	38	+
26	*Psychotria cf. samoana*	(none)	1	0	38	+
27	*Hernandia moerenhoutiana*	*pipi*	1	0	20	+
			251	**73**	**46518**	**100%**

	A'opo Plot 5 (1670 m)	S 13.61116 W 172.50172 to S 13.61153 W 172.50256				
	Species	***Samoan Name***	**No.**	**No. >15 cm**	**Basal Area**	**Rel. Dom.**
1	*Reynoldsia pleiosperma*	*vī vao*	9	5	8691	20%
2	*Spiraeanthemum samoense*	(none)	47	11	6221	14%
3	*Weinmannia affinis*	(none)	4	1	4829	11%
4	*Cyathea medullaris*	*oliolī*	15	10	4707	11%
5	*Pittosporum samoense*	(none)	38	4	3684	8%

6	*Glochidion christophersenii*	*masame*	32	5	3443	8%
7	*Dysoxylum huntii*	*maota mea*	34	2	2683	6%
8	*Meryta malietoa*	*lau fagufagu*	36	2	2206	5%
9	*Hernandia moerenhoutiana*	*pipi*	5	2	1183	3%
10	*Elattostachys apetala*	*taputo'i*	13	2	1168	3%
11	*Coprosma savaiiense*	(none)	13	1	1158	3%
12	*Psychotria christophersenii*	(none)	13	3	1077	2%
13	*Scaevola nubigena*	*to'ito'i vao*	9	2	772	2%
14	*Geniostema rupestre*	*lau mafatifati*	14	0	590	1%
15	*Homalanthus acuminatus*	*fogāmamala vao*	9	0	481	1%
16	*Hedycarya dorstenioides*	(none)	9	1	469	1%
17	*Citronella samoense*	(none)	1	0	38	+
18	*Melicytus samoensis*	(none)	1	0	20	+
			302	**51**	**43420**	**100%**

	A'opo Plot 6 (1800 m)	**S 13.61949 W 172.48595 to S 13.61908 W 172.48521**				
	Species	***Samoan Name***	**No.**	**No. >15 cm**	**Basal Area**	**Rel. Dom.**
1	*Spiraeanthemum samoense*	(none)	24	10	6523	18%
2	*Dysoxylum huntii*	*maota mea*	35	7	6288	17%
3	*Meryta malietoa*	*lau fagufagu*	65	3	3992	11%
4	*Psychotria christophersenii*	(none)	15	7	3839	10%
5	*Pittosporum samoense*	(none)	6	7	3824	10%
6	*Cyathea medullaris*	*olioli*	20	10	3270	9%
7	*Ficus cf. godeffroyi*	(none)	6	4	1653	4%
8	*Scaevola nubigena*	*to'ito'i vao*	5	4	1506	4%
9	*Homalanthus acuminatus*	*fogāmamala vao*	14	2	1397	4%
10	*Glochidion christophersenii*	(none)	13	4	1378	4%
11	*Hedycarya dorstenioides*	(none)	13	2	1030	3%
12	*Coprosma savaiiense*	(none)	2	1	823	2%
13	*Medusanthera samoense*	*matamō*	2	1	724	1%
14	*Hernandia moerenhoutiana*	*pipi*	2	1	333	1%
15	*Schefflera samoense*	(none)	3	0	149	+
16	*Melicope albiflora*	(none)	3	0	142	+
			228	**63**	**36871**	**100%**

Appendix 1.5. Combined Montane Forest Tree Plot Data for the Central Savaii KBA

		Plot Locality→	Taga	Taga	A'opo	Taga	A'opo	A'opo	Totals
		Elevation (m) →	**800**	**1000**	**1000**	**1075**	**1200**	**1400**	
	Species	***Samoan name***							
1	*Dysoxylum huntii*	*maota mea*	25%	37%	11%	19%	40%	51%	35%
2	*Syzygium samarangense*	*nonu vao*	23%	20%	3%	9%	7%	3%	13%
3	*Bischofia javanica*	*'o'a*	2%	32%	2%	18%	6%	--	12%
4	*Syzygium inophylloides*	*asi toa*	--	--	28%	5%	--	--	7%
5	*Cyathea whitmeei*	*olioli*	22%	4%	1%	1%	--	1%	6%
6	*Hedycarya dorstenioides*	(none)	+	+	+	4%	14%	8%	6%
7	*Ficus obliqua*	*āoa fāfine*	--	--	19%	--	--	--	4%
8	*Hernandia moerenhoutiana*	*pipi*	1%	2%	2%	3%	4%	4%	3%
9	*Homalanthus acuminatus*	*fogāmamala*	1%	--	3%	--	4%	6%	3%
10	*Elaeocarpus magnifolius*	(none)	1%	--	1%	10%	--	--	2%
11	*Litsea samoensis*	*papaono*	--	+	3%	3%	+	4%	2%
12	*Macaranga monostyla*	(none)	--	--	+		2%	6%	2%
13	*Alphitonia zizyphoides*	*toi*	--	--	9%	--	--	--	2%
14	*Macaranga stipulosa*	*lau fatu*	8%	--	--	--	--	--	2%
15	*Metrosideros collina*	(none)	--	--	--	8%	--	--	2%
16	*Cyathea medullaris*	*oliolī*	--	1%	2%	+	1%	2%	1%
17	*Elattostachys apetala*	*taputo'i*	3%	+	--	3%	--	--	1%
18	*Glochidion cuspidatum*	*masame vao*	--	--	1%		6%	--	1%
19	*Mammea glauca*	*manapau*	--	--	3%	4%	--	--	1%
20	*Syzygium samoense*	*fena vao*	+	--	6%	--	+	--	1%
21	*Reynoldsia pleiosperma*	*vi vao*	--	--	+	3%	--	1%	1%
22	*Pittosporum samoense*	(none)	--	--	--	--	5%	--	1%
23	*Cyathea vaupelii*	*oliolī*	3%	+	+	1%	--	--	1%
24	*Melicytus samoensis*	(none)		+	+	+	2%	1%	1%
25	*Gironniera celtidifolia*	(none)	1%	+		2%	--	--	1%
26	*Sarcopygme pacifica*	*ma'ulu'ulu*	+	--	+		1%	2%	1%
27	*Neonauclea forsteri*	*afa*	4%	--	--	--	--	--	1%
28	*Spiraeanthemum samoense*	(none)	--	--	--	--	--	3%	1%
29	*Schefflera samoensis*	(none)	--	--	--	--	1%	2%	1%
30	*Geniostoma rupestre*	*lau mafatifati*	--	+	+		1%	+	+
31	*Ficus samoensis*	(none)	--	--	+		2%	--	+
32	*Rapanea longipes*	*togo vao*	--	1%	+	+	+	--	+
33	*Solfia whitmeeana*	*māniuniu*	1%	--	+	+	+	--	+

Appendix 1.6. Table of Combined Cloud Forest tree data from 10 Plots above 1500m Elevation

	Plot locality	A'opo	Upland	SPREP	Upland	SPREP	SPREP	PACSCI	A'opo	Upland	A'opo	Totals
	Elevation (m) →	**1500**	**1500**	**1550**	**1560**	**1580**	**1600**	**1600**	**1670**	**1700**	**1800**	
Species	**Samoan name**											
Reynoldsia pleiosperma	*vī vao*	14%	65%	49%	47%	60%	18%	19%	20%	--	--	**30%**
Spiraeanthemum samoense	*(none)*	5%	12%	27%	15%	7%	3%	44%	14%	19%	18%	**17%**
Dysoxylum huntii	*maota mea*	21%	5%	1%	5%	9%	42%	8%	6%	35%	17%	**15%**
Glochidion christophersenii	*(none)*	1%	2%	2%	5%	6%	2%	1%	8%	14%	4%	**5%**
Coprosma strigulosa	*(none)*	--	5%	5%	8%	5%	18%	--	--	6%	--	**5%**
Weinmannia affinis	*(none)*	--	6%	8%	9%	1%	--	--	11%	--	--	**4%**
Pittosporum samoense	*(none)*	8%	--	--	4%	--	7%	1%	8%	5%	10%	**4%**
Homalanthus acuminatus	*fogāmamala*	17%	--		--	--	5%	9%	1%	1%	4%	**4%**
Cyathea medullaris	*oliolī*	1%	1%		--	--	+	+	11%	--	9%	**2%**
Meryta malietoa	*lau fagufagu*	2%	--	a	+	--	a	+	5%	--	11%	**2%**
Hedycarya dorstenioides	*(none)*	10%	--	--	--	1%	--	1%	1%	2%	3%	**2%**
Psychotria christophersenii	(none)	3%	--	--	--		--	--	2%	--	10%	**2%**
Hernandia moerenhoutiana	*pipi*	+	--	--	1%	1%	--	1%	3%	6%	1%	**2%**
Streblus anthropophagorum	(none)	--	--	--	--	+	+	5%	--	8%	--	**2%**
Elattostachys apetala	*taputo'i*	--	+	1%	3%	4%	2%	--	3%	--	--	**1%**
Geniostema rupestre	*lau mafatifati*	1%	1%	+	+	1%	+	2%	1%	+	--	**1%**
Scaevola nubigena	*to'ito'i vao*	--	--	+	1%	2%	--	1%	--	--	4%	**1%**
Coprosma savaiiense	(none)	--	1%	--	--	--	--	7%	3%	+	2%	**1%**
Cyathea affinis	*oliolī*	--	--	5%	--	--	--	--	--	--	--	**1%**

PACSCI = Whistler (1978); Upland = (Schuster et. al. 1999); SPREP= Atherton & Jefferies (2012); all other ones are from present survey

Appendix 1.7. Checklist of the Vascular Flora of the Uafato KBA

FAMILY	*Species*	Authors	Status	Samoan Name	Rare[1]
	DICOTYLEDONAE				
ACANTHACEAE	*Blechum pyramidatum*	(Lam.) Urb.	X		
ACANTHACEAE	*Justicia procumbens*	L.	X		
ACANTHACEAE	*Ruellia prostrata*	Poir.	X	*vao uli*	
ANACARDIACEAE	*Buchanania merrillii*	Christoph.	E		
ANACARDIACEAE	*Rhus taitensis*	Guillemin	I	*tavai*	
ANNONACEAE	*Cananga odorata*	(Lam.) Hook. f. & Thoms.	P	*moso'oi*	
APIACEAE	*Centella asiatica*	(L.) Urb.	P?	*togotogo*	
APOCYNACEAE	*Alstonia godeffroyi*	Reinecke	I		
APOCYNACEAE	*Alyxia bracteolosa*	Rich ex A. Gray	I	*lau maile*	
APOCYNACEAE	*Alyxia samoensis*	(Christoph.) A.C. Sm.	E	*lau maile*	
APOCYNACEAE	*Alyxia stellata*	(Forst.) Roem. & Schult.	I	*gau*	
APOCYNACEAE	*Cerbera manghas*	L.	I	*leva*	
APOCYNACEAE	*Cerbera odollam*	Gaertn.	P?	*leva*	
APOCYNACEAE	*Ochrosia oppositifolia*	(Lam.) K. Schum.	I	*fao*	
ARALIACEAE	*Meryta macrophylla*	(W. Rich ex A. Gray) Seem.	I	*lau fagufagu*	
ARALIACEAE	*Polyscias reineckei*	Harms	E	*tagitagi vao*	
ARALIACEAE	*Polyscias samoensis*	(A. Gray) Harms	I	*tagitagi vao*	
ARALIACEAE	*Reynoldsia lanutoensis*	Hochr.	E	*vī vao*	
ARISTOLOCHIACEAE	*Aristolochia cortinata*	Reinecke	E		
ASCLEPIADACEAE	*Hoya australis*	R. Br. in Traill	I	*lau mafiafia*	
ASCLEPIADACEAE	*Hoya betchei*	(Schltr.) Schltr.	E		
ASCLEPIADACEAE	*Hoya filiformis*	Rech.	E		
ASCLEPIADACEAE	*Hoya samoensis*	Seem.	E		
ASTERACEAE	*Ageratum conyzoides*	L.	X		
ASTERACEAE	*Crassocephalum crepidioides*	(Benth.) S. Moore	X	*fua lele*	
ASTERACEAE	*Eleutheranthera ruderalis*	(Sw.) Schultz-Bip.	X		
ASTERACEAE	*Emilia sonchifolia*	(L.) DC.	X	*fua lele*	
ASTERACEAE	*Erechtites valerianifolia*	(Link ex Wolf) Less. ex DC.	X	*fua lele*	
ASTERACEAE	*Melanthera biflora*	(L.) Willd.	I	*ateate*	
ASTERACEAE	*Mikania micrantha*	Kunth	X	*fue saina*	
ASTERACEAE	*Struchium sparganophorum*	(L.) Kuntze	X		
ASTERACEAE	*Synedrella nodiflora*	(L.) Gaertn.	X		

FAMILY	*Species*	Authors	Status	Samoan Name	Rare[1]
BARRINGTONIACEAE	*Barringtonia asiatica*	(L.) Kurz	I	*futu*	
BARRINGTONIACEAE	*Barringtonia samoensis*	A. Gray	I	*falagā*	
BORAGINACEAE	*Cordia aspera*	Forst. f.	P	*tou*	X
BORAGINACEAE	*Cordia subcordata*	Lam.	I	*tauanave*	
BRASSICACEAE	*Rorippa sarmentosa*	(DC.) Macbr.	P		
BURSERACEAE	*Canarium harveyi*	Seem.	X	*mafoa*	
BURSERACEAE	*Canarium vitiense*	A. Gray	I	*ma'ali*	
CARICACEAE	*Carica papaya*	L.	X	*esi*	
CELASTRACEAE	*Gymnosporia vitiensis*	(A. Gray) Seem.	I		
CHRYSOBALANACEAE	*Atuna racemosa*	Raf.	P	*ifiifi*	X
CLUSIACEAE	*Calophyllum inophyllum*	L.	I	*fetau*	
CLUSIACEAE	*Calophyllum neoebudicum*	Guillaumin	I	*tamanu*	
CLUSIACEAE	*Garcinia myrtifolia*	A.C. Sm.	X		
CLUSIACEAE	*Mammea glauca*	(Merr.) Kosterm.	E	*manapau*	
COMBRETACEAE	*Terminalia catappa*	L.	I?	*talie*	
COMBRETACEAE	*Terminalia richii*	A. Gray	E	*malili*	
CONNARACEAE	*Santaloides samoensis*	(Lauterb.) Schellenb.	I		
CONVOLVULACEAE	*Ipomoea pes-caprae*	(L.) R. Br.	I	*fue moa*	
CONVOLVULACEAE	*Ipomoea violacea*	L.	I		
CONVOLVULACEAE	*Merremia peltata*	(L.) Merr.	I	*fue lautetele*	
CONVOLVULACEAE	*Operculina turpethum*	(L.) A. Silva Manso	I	*tagamimi?, pālulu?*	
CONVOLVULACEAE	*Stictocardia tiliifolia*	(Desr.) Hallier f.	X	*pālulu*	
CUCURBITACEAE	*Zehneria mucronata*	(Bl.) Miq.	I		
CUNONIACEAE	*Spiraeanthemum samoense*	A. Gray	E		
CUNONIACEAE	*Weinmannia affinis*	A. Gray	I		
DICHAPETALACEAE	*Dichapetalum vitiense*	(Seem.) Engl.	I		
EBENACEAE	*Diospyros elliptica*	(Forst.) P.S. Green	I	*'anume*	
EBENACEAE	*Diospyros major*	(Forst. f.) Bakh.	I		
EBENACEAE	*Diospyros samoensis*	A. Gray	I	*'au'auli*	
ELAEOCARPACEAE	*Elaeocarpus floridanus*	Hemsley	X	*a'amati'e*	
ELAEOCARPACEAE	*Elaeocarpus graeffei*	Seem.	X		
EUPHORBIACEAE	*Acalypha lanceolata*	Willd.	P		
EUPHORBIACEAE	*Antidesma excavatum*	Miq.	I		
EUPHORBIACEAE	*Baccaurea taitensis*	Müll. Arg.	E		
EUPHORBIACEAE	*Bischofia javanica*	Bl.	I	*'o'a*	

FAMILY	*Species*	Authors	Status	Samoan Name	Rare[1]
EUPHORBIACEAE	*Chamaesyce hirta*	(L.) Millsp.	X	*vao āpulupulu*	
EUPHORBIACEAE	*Chamaesyce hypericifolia*	(L.) Millsp.	X		
EUPHORBIACEAE	*Chamaesyce thymifolia*	(L.) Millsp.	X		
EUPHORBIACEAE	*Flueggea flexuosa*	Müll. Arg.	X	*poumuli*	
EUPHORBIACEAE	*Glochidion cuspidatum*	(Müll. Arg.) Pax	I	*masame vao*	
EUPHORBIACEAE	*Glochidion samoanum*	(new combination)	I	*masame*	
EUPHORBIACEAE	*Homalanthus nutans*	(Forst. f.) Guill.	I	*fogāmamala*	
EUPHORBIACEAE	*Macaranga harveyana*	(Müll. Arg.) Müll. Arg.	I	*lau pata*	
EUPHORBIACEAE	*Macaranga stipulosa*	Müll. Arg.	E	*lau fatu*	
EUPHORBIACEAE	*Phyllanthus amarus*	Schumach. & Thonn.	X		
EUPHORBIACEAE	*Phyllanthus urinaria*	L.	X		
FABACEAE	*Abrus precatorius*	L.	I	*matamoso*	
FABACEAE	*Adenanthera pavonina*	L.	X	*lopā*	
FABACEAE	*Caesalpinia major*	(Medik.) Dandy & Exell	I	*ʻanaoso, seu peʻa*	
FABACEAE	*Canavalia cathartica*	Thou.	I		
FABACEAE	*Canavalia rosea*	(Sw.) DC.	I	*fue fai vaʻa*	
FABACEAE	*Dendrolobium umbellatum*	(L.) Benth.	I	*lala*	
FABACEAE	*Desmodium heterophyllum*	(Willd.) DC.	X		
FABACEAE	*Entada phaseoloides*	(L.) Merr.	I	*fue inu, tifa*	
FABACEAE	*Erythrina subumbrans*	(Hassk.) Merr.	X	*gātae palagi*	
FABACEAE	*Erythrina variegata*	L.	I	*gātae*	
FABACEAE	*Inocarpus fagifer*	(Parkinson) Fosb.	P	*ifi*	
FABACEAE	*Intsia bijuga*	(Colebr.) Kuntze	I?	*ifilele*	
FABACEAE	*Mimosa pudica*	L.	X	*vao fefe*	
FABACEAE	*Mucuna gigantea*	(Willd.) DC.	I	*tupe*	
FABACEAE	*Paraserianthes falcataria*	(L.) I. Nielsen	X	*tamaligi paʻepaʻe*	
FABACEAE	*Pueraria lobata*	(Willd.) Ohwi	P	*aʻa*	
FABACEAE	*Senna tora*	(L.) Roxb.	X	*vao pinati*	
FABACEAE	*Strongylodon rubra*	(sp. nova)	I		
FABACEAE	*Vigna marina*	(Burm.) Merr.	I	*fue sina*	
FLACOURTIACEAE	*Erythrospermum acuminatissimum*	(A. Gray) A.C. Sm.	I		
FLACOURTIACEAE	*Flacourtia rukam*	Zoll. & Mor.	I	*filimoto*	
FLACOURTIACEAE	*Homalium whitmeeanum*	St. John	I		
GENTIANACEAE	*Fagraea berteroana*	A. Gray ex Benth.	I	*pualulu*	

FAMILY	*Species*	Authors	Status	Samoan Name	Rare[1]
GESNERIACEAE	*Cyrtandra compressa*	C.B. Clarke	E		
GESNERIACEAE	*Cyrtandra graeffei*	C.B. Clarke	E		
GESNERIACEAE	*Cyrtandra pogonantha*	A. Gray	E		
GESNERIACEAE	*Cyrtandra richii*	A. Gray	E		
GOODENIACEAE	*Scaevola taccada*	(Gaertn.) Vahl	I	*to'ito'i*	
HERNANDIACEAE	*Hernandia moerenhoutiana*	Guillemin	I	*pipi*	
HERNANDIACEAE	*Hernandia nymphaeifolia*	(J. Presl) Kub.	I	*pu'a*	
ICACINACEAE	*Citronella samoensis*	(A. Gray) Howard	I		
LAMIACEAE	*Hyptis capitata*	Jacq.	X	*vao miniti*	
LAURACEAE	*Cinnamomum verum*	J. Presl	X	*tigamoni*	
LAURACEAE	*Endiandra elaeocarpa*	Gillespie	X		
LOGANIACEAE	*Geniostoma rupestre*	Forst.	I	*taipoipo, lau mafatifati*	
MALVACEAE	*Abelmoschus moschatus*	Medik.	P	*fau Tagaloa*	
MALVACEAE	*Hibiscus tiliaceus*	L.	I?	*fau*	
MALVACEAE	*Sida acuta*	Burm. f.	X	*mautofu*	
MALVACEAE	*Sida rhombifolia*	L.	P	*mautofu*	
MALVACEAE	*Thespesia populnea*	(L.) Sol. ex Corrêa	I	*milo*	
MALVACEAE	*Urena lobata*	L.	P	*mautofu*	
MELASTOMACEAE	*Astronidium samoense*	(S. Moore) Markgraf	E		
MELASTOMACEAE	*Clidemia hirta*	(L.) D. Don	X	*vao fulu*	
MELASTOMACEAE	*Medinilla samoensis*	(Hochr.) Christoph.	I		
MELASTOMACEAE	*Melastoma denticulatum*	Labill.	I	*fua lole*	
MELIACEAE	*Aglaia samoensis*	A. Gray	I	*laga'ali*	
MELIACEAE	*Aglaia rufous*	(sp. nova)	E	*laga'ali*	
MELIACEAE	*Dysoxylum huntii*	Merr. ex Setch.	E	*maota mea*	
MELIACEAE	*Dysoxylum maota*	Reinecke	I	*tufaso*	
MELIACEAE	*Dysoxylum samoense*	A. Gray	I	*maota mamala*	
MENISPERMACEAE	*Stephania forsteri*	(DC.) A. Gray	I		
MONIMIACEAE	*Hedycarya dorstenioides*	A. Gray	I	*fatimatao?*	
MORACEAE	*Ficus godeffroyi*	Warb.	E	*mati*	
MORACEAE	*Ficus obliqua*	Forst. f.	I	*āoa*	
MORACEAE	*Ficus prolixa*	Forst. f.	I	*āoa*	
MORACEAE	*Ficus scabra*	Forst. f.	I	*mati mageso*	
MORACEAE	*Ficus tinctoria*	Forst. f.	I	*mati lau molemole*	

FAMILY	*Species*	Authors	Status	Samoan Name	Rare[1]
MORACEAE	*Ficus uniauriculata*	Warb.	E	*mati lautaliga*	
MORACEAE	*Streblus anthropophagorum*	(Seem.) Corner	I		
MYRISTICACEAE	*Myristica hypargyraea*	A. Gray	I	*'atone ulu*	
MYRISTICACEAE	*Myristica inutilis*	W. Rich ex A. Gray	I	*'atone*	
MYRSINACEAE	*Maesa tabacifolia*	Mez	I		
MYRSINACEAE	*Rapanea myricifolia*	(A. Gray) Mez	I	*togo vao*	
MYRTACEAE	*Metrosideros collina*	(Forst.) A. Gray	I		
MYRTACEAE	*Psidium guajava*	L.	X	*ku'ava*	
MYRTACEAE	*Syzygium clusiifolium*	(A. Gray) Müll. Stuttg.	I	*asi vao?*	
MYRTACEAE	*Syzygium curvistylum*	(Gillespie) Merr. & L.M. Perry	I		
MYRTACEAE	*Syzygium dealatum*	(Burkill) A.C. Sm.	I	*asi vao?*	
MYRTACEAE	*Syzygium inophylloides*	(A. Gray) Müll. Stuttg.	I	*asi toa*	
MYRTACEAE	*Syzygium neurocalyx*	(A. Gray) Christoph.	I	*fena, 'oli*	
MYRTACEAE	*Syzygium samarangense*	(Bl.) Merr. & L.M. Perry	X	*nonu vao*	
MYRTACEAE	*Syzygium samoense*	(Burkill) Whistler	E	*fena vao*	
MYRTACEAE	*Syzygium savaiiense*	(A. Gray) Müll. Stuttg.	E	*asi vai*	
NYCTAGINACEAE	*Pisonia umbellifera*	(Forst.) Seem.	I	*fa'apala?*	
OLACACEAE	*Anacolosa insularis*	Christoph.	E		
OLEACEAE	*Jasminum betchei*	F. Muell.	I		
OLEACEAE	*Jasminum didymum*	Forst. f.	I		
ONAGRACEAE	*Ludwigia hyssopifolia*	(G. Don) Exell	X		
ONAGRACEAE	*Ludwigia octovalvis*	(Jacq.) Raven	X		
OXALIDACEAE	*Oxalis barrelieri*	L.	X		
OXALIDACEAE	*Oxalis corniculata*	L.	P	*'i'i*	
PASSIFLORACEAE	*Passiflora foetida*	L.	X	*pasio vao*	
PASSIFLORACEAE	*Passiflora laurifolia*	L.	X	*pasio vao*	
PIPERACEAE	*Macropiper puberulum*	Benth.	I	*'ava'avaaitu*	
PIPERACEAE	*Peperomia pellucida*	L.	X	*vao vai*	
PIPERACEAE	*Peperomia reineckei*	C. DC.	I		
PIPERACEAE	*Piper macropiper*	Pennant	I	*fue manogi*	
PIPERACEAE	*Piper rechingeri*	C. DC.	E		
POLYGALACEAE	*Polygala paniculata*	L.	X	*pulunamulole*	
RHAMNACEAE	*Alphitonia zizyphoides*	(Spreng.) A. Gray	I	*toi*	
RHAMNACEAE	*Colubrina asiatica*	(L.) Brongn.	I	*fisoa*	
RHIZOPHORACEAE	*Crossostylis biflora*	Forst.	I	*saitamu?*	
RUBIACEAE	*Aidia racemosa*	(Cav.) Tirveng.	I	*ola mea, aso*	

FAMILY	*Species*	Authors	Status	Samoan Name	Rare[1]
RUBIACEAE	*Antirhea inconspicua*	(Seem.) Christoph.	I		
RUBIACEAE	*Calycosia sessilis*	A. Gray	E		
RUBIACEAE	*Geophila repens*	(L.) I. M. Johnston	I	*tono*	
RUBIACEAE	*Guettarda speciosa*	L.	I	*puapua*	
RUBIACEAE	*Gynochthodes epiphytica*	(Rech.) A.C. Sm. & S. Darwin	I		
RUBIACEAE	*Ixora amplifolia*	A. Gray	E	*filofiloa*	
RUBIACEAE	*Morinda bucidifolia*	A. Gray	I		
RUBIACEAE	*Morinda citrifolia*	L.	I	*nonu*	
RUBIACEAE	*Neonauclea forsteri*	(Seem. ex Havil.) Merr.	I	*afa*	
RUBIACEAE	*Psychotria insularum*	A. Gray	I	*matalafi*	
RUBIACEAE	*Psychotria pacifica*	K. Schum.	E		
RUBIACEAE	*Psydrax merrillii*	(Setch.) Whistler	I	*ola sina*	
RUBIACEAE	*Sarcopygme pacifica*	(Reinecke) Setch. & Christoph.	E	*u'unu*	
RUBIACEAE	*Spermacoce remota*	(L.O. Williams) C. Adams	X		
RUBIACEAE	*Timonius affinis*	A. Gray	I		
RUTACEAE	*Euodia hortensis*	Forst.	P	*usi*	
RUTACEAE	*Melicope latifolia*	(DC.) T.G. Hartley	E	*so'opine*	
SAPINDACEAE	*Allophylus timoriensis*	(DC.) Bl.	I		
SAPINDACEAE	*Elattostachys apetala*	(Labill.) Radlk.	I	*taputo'i*	
SAPINDACEAE	*Pometia pinnata*	Forst.	I	*tava*	
SAPOTACEAE	*Palaquium stehlinii*	Christoph.	E	*gasu*	
SAPOTACEAE	*Planchonella garberi*	Christoph.	I	*'ala'a*	
SAPOTACEAE	*Planchonella grayana*	St. John	I		
SAPOTACEAE	*Planchonella samoensis*	H.J. Lam ex Christoph.	I	*mamalava*	
SOLANACEAE	*Capsicum frutescens*	L.	X	*polo feū*	
SOLANACEAE	*Physalis angulata*	L.	X	*vī vao*	
STERCULIACEAE	*Commersonia bartramia*	(L.) Merr.	I		
STERCULIACEAE	*Kleinhovia hospita*	L.	I	*fu'afu'a*	
STERCULIACEAE	*Melochia aristata*	A. Gray	I	*ma'ouli*	
STERCULIACEAE	*Sterculia fanaiho*	Setch.	I	*faga'io*	
THYMELAEACEAE	*Phaleria acuminata*	(A. Gray) Gilg.	I	*suni vao*	
THYMELAEACEAE	*Wikstroemia coriacea*	Sol. ex Forst. f.	I	*fau mū*	
TILIACEAE	*Trichospermum richii*	(A. Gray) Seem.	I	*ma'osina*	
ULMACEAE	*Gironniera celtidifolia*	Gaud.	I		
ULMACEAE	*Trema cannabina*	Lour.	I	*magele*	
URTICACEAE	*Boehmeria virgata*	(Forst. f.) Guillemin	I		

FAMILY	*Species*	Authors	Status	Samoan Name	Rare[1]
URTICACEAE	*Cypholophus macrocephalus*	Wedd.	E	*fau pata?*	
URTICACEAE	*Laportea interrupta*	(L.) Chew	P	*ogoogo*	
URTICACEAE	*Leucosyke corymbulosa*	(Wedd.) Wedd.	I		
URTICACEAE	*Maoutia australis*	Wedd.	I		
URTICACEAE	*Pilea microphylla*	(L.) Lieb.	X		
URTICACEAE	*Pipturus argenteus*	(Forst. f.) Wedd.	I	*fau sogā*	
URTICACEAE	*Procris pedunculata*	(Forst.) Wedd.	I	*fualole*	
VERBENACEAE	*Clerodendrum inerme*	(L.) Gaertn.	I	*aloalo tai*	
VERBENACEAE	*Faradaya amicorum*	Seem.	I	*mamalupe*	
VERBENACEAE	*Lantana camara*	L.	X	*latana*	
VERBENACEAE	*Premna serratifolia*	L.	I	*aloalo*	
	MONOCOTYLEDONAE				
ARACEAE	*Alocasia macrorrhzos*	(Schott) G. Don	P	*ta'amu*	
ARACEAE	*Epipremnum pinnatum*	(L.) Engl.	I	*fue laofao*	
ARACEAE	*Rhaphidophora spuria*	(Schott) Nicolson	E	*tuafaga?*	
ARECACEAE	*Balaka tahitensis*	(Wendl.) Becc.	E	*māniuniu*	
ARECACEAE	*Clinostigma warburgii*	Becc.	E	*niu vao*	
ARECACEAE	*Cocos nucifera*	L.	I	*niu*	
ASPARAGACEAE	*Cordyline fruticosa*	(L.) Chev.	I	*tī vao*	
CANNACEAE	*Canna indica*	L.	X	*fana manu*	
COMMELINACEAE	*Aneilema vitiense*	Seem.	I		
CYPERACEAE	*Cyperus compressus*	L.	X		
CYPERACEAE	*Cyperus rotundus*	L.	X	*mumuta*	
CYPERACEAE	*Fimbristylis dichotoma*	(L.) Vahl	X	*tuisē*	
CYPERACEAE	*Kyllinga nemoralis*	Dandy ex Hutch. & Dalziel	X		
CYPERACEAE	*Kyllinga polyphylla*	Willd. ex Kunth	X		
CYPERACEAE	*Mapania macrocephala*	(Gaud.) K. Schum.	I		
CYPERACEAE	*Mariscus cyperinus*	(Retz.) Vahl	I?		
CYPERACEAE	*Mariscus seemannianus*	(Boeckler) Palla	I		
CYPERACEAE	*Scleria lithosperma*	(L.) Sw.	I		
CYPERACEAE	*Scleria polycarpa*	Boeck.	I	*selesele*	
DIOSCOREACEAE	*Dioscorea bulbifera*	L.	P	*soi*	
DIOSCOREACEAE	*Dioscorea pentaphylla*	L.	P	*lena, pilita*	
FLAGELLARIACEAE	*Flagellaria gigantea*	Hook. f.	I	*lafo*	
HELICONIACEAE	*Heliconia laofao*	Kress	E	*laufao*	
JOINVILLEACEAE	*Joinvillea plicata*	(Hook. f.) Newell & B.C. Stone	I		

FAMILY	*Species*	Authors	Status	Samoan Name	Rare[1]
MUSACEAE	*Musa x paradisiaca*	L.	I?	*taemanu*	
ORCHIDACEAE	*Bulbophyllum apodum*	Hook. f.	I		
ORCHIDACEAE	*Bulbophyllum longiscapum*	Rolfe	I		
ORCHIDACEAE	*Bulbophyllum membranaceum*	Teijsm. & Binnend.	I		
ORCHIDACEAE	*Bulbophyllum samoanum*	Schltr.	I		
ORCHIDACEAE	*Coelogyne lycastoides*	F. Muell. and Kraenzl.	I		
ORCHIDACEAE	*Crepidium resupinatum*	(Forst. f.) Szach.	I		
ORCHIDACEAE	*Crepidium samoense*	(Schltr.) Marg.	I		
ORCHIDACEAE	*Crepidium cf. taurina*	(Rchb. f.) Szlach.	I		
ORCHIDACEAE	*Dendrobium biflorum*	(Forst. f.) Sw.	I		
ORCHIDACEAE	*Dendrobium calcaratum*	A. Rich.	I		
ORCHIDACEAE	*Dendrobium dactylodes*	Rchb. f.	I		
ORCHIDACEAE	*Dendrobium goldfinchii*	F. Muell.	I		
ORCHIDACEAE	*Dendrobium sladei*	J.J. Wood and P.J. Cribb	I		
ORCHIDACEAE	*Didymoplexis micradenia*	(Rchb. f.) Hemsley	I		
ORCHIDACEAE	*Eria robusta*	(Bl.) Lindl.	I		
ORCHIDACEAE	*Eria rostriflora*	Rchb. f.	I		
ORCHIDACEAE	*Flickingeria comata*	(Bl.) A. Hawkes	I		
ORCHIDACEAE	*Glomera montana*	Rchb.f.	I		
ORCHIDACEAE	*Mediocalcar paradoxum*	(Kraenzl.) Schltr.	I		
ORCHIDACEAE	*Oberonia heliophila*	Rchb. f.	I		
ORCHIDACEAE	*Phaius terrestris*	(L.) Ormerod	I		
ORCHIDACEAE	*Phreatia matthewsii*	Rchb. f.	I		
ORCHIDACEAE	*Phreatia micrantha*	(A. Rich.) Schltr.	I		
ORCHIDACEAE	*Phreatia minima*	Schltr.	I		
ORCHIDACEAE	*Spathoglottis plicata*	Bl.	I		
ORCHIDACEAE	*Taeniophyllum fasciola*	(Forst. f.) Rchb. f.	I		
PANDANACEAE	*Freycinetia reineckei*	Warb.	E	*'ie'ie*	
PANDANACEAE	*Freycinetia storckii*	Seem.	I	*'ie'ie*	
PANDANACEAE	*Pandanus tectorius*	Parkinson	I	*fasa*	
POACEAE	*Axonopus compressus*	(Sw.) P. Beauv.	X		
POACEAE	*Brachiaria mutica*	(Forssk.) Stapf	X		
POACEAE	*Centosteca lappacea*	(L.) Desv.	I		
POACEAE	*Cynodon dactylon*	(L.) Pers.	X		
POACEAE	*Cyrtococcum oxyphyllum*	(Hochst. ex Steud.) Stapf	I		

FAMILY	*Species*	Authors	Status	Samoan Name	Rare[1]
POACEAE	*Cyrtococcum trigonum*	(Retz.) A. Camus	X		
POACEAE	*Dactyloctenium aegyptium*	(L.) Willd.	X		
POACEAE	*Digitaria setigera*	Roth ex Roem. & Schult.	I		
POACEAE	*Echinochloa colona*	(L.) Link	X		
POACEAE	*Eleusine indica*	(L.) Gaertn.	P	*ta'ata'a*	
POACEAE	*Eragrostis amabilis*	(L.) Wight & Arn.	X		
POACEAE	*Miscanthus floridulus*	(Labill.) Warb.	I	*ū*	
POACEAE	*Oplismenus compositus*	(L.) Beauv.	I		
POACEAE	*Paspalum conjugatum*	P.J. Bergius	X	*vao lima*	
POACEAE	*Paspalum paniculatum*	L.	X		
POACEAE	*Paspalum vaginatum*	Sw.	X		
POACEAE	*Pennisetum purpureum*	Schumach.	X		
POACEAE	*Schizostachyum glaucifolium*	(Rupr.) Munro	P	*'ofe sāmoa*	
POACEAE	*Setaria pumila*	(Poir.) Roem. & Schult.	X		
POACEAE	*Sorghum x drummondii*	(Steud.) Millsp. & Chase	X		
POACEAE	*Sporobolus diandrus*	(Retz.) P. Beauv.	X		
ZINGIBERACEAE	*Zingiber zerumbet*	(L.) Smith	X		
	FERNS				
ANGIOPTERIDACEAE	*Angiopteris evecta*	(Forst. f.) Hoffman	I	*gase*	
ASPIDIACEAE	*Arachniodes aristata*	(Forst. f.) Tindale	I		
ASPIDIACEAE	*Pleocnemia cumingiana*	Presl	I		
ASPIDIACEAE	*Pleocnemia irregularis*	(Presl) Holttum	X		
ASPIDIACEAE	*Tectaria crenata*	Cav.	I		
ASPIDIACEAE	*Tectaria decurrens*	(Presl) Copeland	I		
ASPIDIACEAE	*Tectaria dissecta*	(Forst. f.) Lellinger	I		
ASPIDIACEAE	*Tectaria setchellii*	Maxon	E		
ASPLENIACEAE	*Asplenium australasicum*	Hooker	I		
ASPLENIACEAE	*Asplenium feejeense*	Brackenridge	I		
ASPLENIACEAE	*Asplenium laserpitiifolium*	Lam.	I		
ASPLENIACEAE	*Asplenium multifidum*	Brackenridge	I		
ASPLENIACEAE	*Asplenium nidus*	L.	I	*laugapāpā*	
ASPLENIACEAE	*Asplenium polyodon*	Forst. f.	I		
ATHYRIACEAE	*Diplazium bulbiferum*	Brackenridge	I		
ATHYRIACEAE	*Diplazium dilatatum*	Bl.	I		
ATHYRIACEAE	*Diplazium proliferum*	(Lam.) Thouars	I		

FAMILY	*Species*	Authors	Status	Samoan Name	Rare[1]
BLECHNACEAE	*Blechnum orientale*	L.	I		
CULCITACEAE	*Culcita straminea*	(Labill.) Maxon	I		
CYATHEACEAE	*Cyathea affinis*	(Forst. f.) Sw.	I	*oliolī*	
CYATHEACEAE	*Cyathea alta*	Copeland	I	*oliolī*	
CYATHEACEAE	*Cyathea decurrens*	(Hook.) Copeland	I	*oliolī*	
CYATHEACEAE	*Cyathea lunulata*	(Hook.) Copeland	I	*oliolī*	
CYATHEACEAE	*Cyathea truncata*	(Brackenridge) Copeland	I	*oliolī*	
CYATHEACEAE	*Cyathea vaupelii*	Copeland	E	*oliolī*	
CYATHEACEAE	*Cyathea whitmeei*	Baker	E	*oliolī*	
DAVALLIACEAE	*Davallia denticulata*	(Burm. f.) Mett. ex Kuhn	I	*laugasēsē*	
DAVALLIACEAE	*Davallia graeffei*	Luerssen	I		
DAVALLIACEAE	*Davallia heterophylla*	J. Sm.	I		
DAVALLIACEAE	*Davallia solida*	(Forst. f.) Sw.	I	*laugasēsē*	
DAVALLIACEAE	*Humata polypodioides*	Brackenridge	I		
DAVALLIACEAE	*Humata serrata*	Brackenridge	I		
DAVALLIACEAE	*Leucostegia pallida*	(Mett.) Copeland	I		
DENNSTAEDTIACEAE	*Orthiopteris tenuis*	(Brackenridge) Brownlie	I		
ELAPHOGLOSSACEAE	*Elaphoglossum feejeense*	Brackenridge	I		
GLEICHENIACEAE	*Dicranopteris linearis*	(Burm.) Underw.	I	*ʻasaua*	
GRAMMITIDACEAE	*Ctenopteris blechnoides*	(Greville) Wagner & Grether	I		
GRAMMITIDACEAE	*Prosaptia alata*	(Bl.) Christ	I		
HEMIONITIDACEAE	*Coniogramme fraxinea*	(Don) Diels	I		
HYMENOPHYLLACEAE	*Hymenophyllum imbricatum*	Bl.	I		
HYMENOPHYLLACEAE	*Hymenophyllum polyanthos*	Sw.	I		
HYMENOPHYLLACEAE	*Hymenophyllum praetervisum*	Christ	E		
HYMENOPHYLLACEAE	*Trichomanes assimile*	Mett.	I		
HYMENOPHYLLACEAE	*Trichomanes bipunctatum*	Poiret	I		
HYMENOPHYLLACEAE	*Trichomanes boryanum*	Kuntze	I		
HYMENOPHYLLACEAE	*Trichomanes caudatum*	Brackenridge	I		
HYMENOPHYLLACEAE	*Trichomanes dentatum*	Bosch	I		
HYMENOPHYLLACEAE	*Trichomanes humile*	Forst. f.	I		
HYMENOPHYLLACEAE	*Trichomanes saxifragoides*	Presl	I		
HYMENOPHYLLACEAE	*Trichomanes taeniatum*	Copeland	I		
HYMENOPHYLLACEAE	*Trichomanes tahitense*	Nadeaud	I		

FAMILY	*Species*	Authors	Status	Samoan Name	Rare[1]
LINDSAEACEAE	*Lindsaea harveyi*	Carruthers ex Seem.	I		
LOMARIOPSIDACEAE	*Lomagramma cordipinna*	Holttum	I		
MARATTIACEAE	*Marattia smithii*	Mett.	I		
NEPHROLEPIDACEAE	*Arthropteris repens*	(Brackenridge) Christensen	I		
NEPHROLEPIDACEAE	*Nephrolepis biserrata*	(Sw.) Schott	I		
NEPHROLEPIDACEAE	*Nephrolepis hirsutula*	(Forst. f.) Presl	I	*vao tuaniu*	
OLEANDRACEAE	*Oleandra neriiformis*	Cav.	I		
OPHIOGLOSSACEAE	*Ophioglossum pendulum*	L.	I		
POLYPODIACEAE	*Lemmaphyllum accedens*	(Bl.) Donk	I		
POLYPODIACEAE	*Phymatosorus commutatus*	(Bl.) P. Serm.	I		
POLYPODIACEAE	*Phymatosorus grossus*	(Langsd. & Fisch.) Brownlie	I	*lauautā*	
POLYPODIACEAE	*Phymatosorus nigrescens*	(Bl.) P. Serm.	I		
POLYPODIACEAE	*Polypodium subauriculatum*	Bl.	I		
POLYPODIACEAE	*Pyrrosia lanceolata*	(L.) Farwell	I	*lau tasi*	
POLYPODIACEAE	*Selliguea feeoides*	Copeland	I		
PTERIDACEAE	*Pteris ensiformis*	Burm.	I		
PTERIDACEAE	*Pteris mertensioides*	Willd.	I		
PTERIDACEAE	*Pteris pacifica*	Hier.	I		
SCHIZAEACEAE	*Schizaea dichotoma*	(L.) Smith	I		
THELYPTERIDACEAE	*Christella harveyi*	(Mett.) Holttum	I		
THELYPTERIDACEAE	*Christella parasitica*	(L.) Leveille	I		
THELYPTERIDACEAE	*Sphaerostephanos heterocarpus*	(Bl.) Holttum	I		
THELYPTERIDACEAE	*Sphaerostephanos unitus*	(L.) Holttum	I		
VITTARIACEAE	*Antrophyum alatum*	Brackenridge	I		
VITTARIACEAE	*Antrophyum plantagineum*	(Cav.) Kaulf.	I		
VITTARIACEAE	*Vaginularia angustissima*	(Brackenridge) Mett.	I		
VITTARIACEAE	*Vittaria elongata*	Sw.	I		
VITTARIACEAE	*Vittaria scolopendrina*	(Bory) Thwaites	I		
	FERN ALLIES				
LYCOPODIACEAE	*Lycopodium carinatum*	Desv.	I		
LYCOPODIACEAE	*Lycopodium phlegmaria*	L.	I		

FAMILY	*Species*	Authors	Status	Samoan Name	Rare[1]
LYCOPODIACEAE	*Lycopodium squarrosum*	Forst. f.	I		
SELAGINACEAE	*Selaginella whitmeei*	Baker	I		

Appendix 1.8. Tree Plot Data for the Uafato Forest Plots

	Uafato Plot 1 (220 m)	S 13.954690 W 171.497125 to S 13.953862 W 171.497200				
	Species	***Samoan name***	**No.**	**No. >15 cm**	**Basal Area**	**Rel. Dom.**
1	*Dysoxylum samoense*	*maota*	3	3	12737	27%
2	*Palaquium stehlinii*	*gasu*	9	7	11275	24%
3	*Inocarpus fagifer*	*ifi*	5	2	6790	15%
4	*Myristica inutilis*	*'atone*	41	15	6289	14%
5	*Canarium vitiense*	*ma'ali*	4	4	5986	13%
6	*Syzygium inophylloides*	*asi toa*	2	1	1872	4%
7	*Sterculia fanaiho*	*faga'io*	6	1	635	1%
8	*Canarium harveyi*	*mafoa*	3	0	278	1%
9	*Cyathea lunulata*	*olioli*	1	0	154	+
10	*Adenanthera pavonina*	*lopa*	1	1	201	+
11	*Polyscias cf. samoense*	*tagitagi vao*	3	0	75	+
12	*Flacourtia rukam*	*filimoto*	2	0	70	+
			80	**34**	**46362**	**100**

	Uafato 2 (266 m)	S13.958803 W171.490490 to S13.958081 W 171.490380				
	Species	***Samoan name***	**No.**	**No. >15 cm**	**Basal Area**	**Rel. Dom.**
1	*Canarium vitiense*	*ma'ali*	7	7	19757	29%
2	*Syzygium inophylloides*	*asi toa*	7	3	15973	23%
3	*Inocarpus fagifer*	*ifi*	2	1	12361	18%
4	*Myristica inutilis*	*'atone*	63	8	5663	8%
5	*Canarium harveyi*	*mafoa*	41	6	4234	6%
6	*Sterculia fanaiho*	*faga'io*	6	3	3584	5%
7	*Diospyros samoensis*	*'au'auli*	9	3	1809	3%
8	*Planchonella garberi*	*'ala'a*	5	1	796	1%
9	*Artocarpus altilis*	*'ulu*	9	1	769	1%
10	*Macaranga stipulosa*	*lau fatu*	4	2	756	1%
11	*Neonauclea forsteri*	*afa*	2	1	726	1%
12	*Syzygium clusiifolium*	*asi vai*	3	1	649	1%
13	*Aglaia samoensis*	*laga'ali*	6	0	285	+
14	*Calophyllum neoebudicum*	*tamanu*	1	1	283	+
15	*Polyscias cf. sameonse*	*tagitagi vao*	6	0	242	+
16	*Psydrax merrillii*	*ola sina*	2	1	227	+
17	*Meryta macrophylla*	*lau fagufagu*	2	0	114	+
18	*Anacolosa lutea*	*(none)*	1	0	95	+

19	*Rhus taitensis*	*tavai*	1	0	95	+
20	*Syzygium samarangense*	*nonu vao*	8	0	50	+
			185	**39**	**68468**	**100%**

	Uafato Plot 3 (400 m)	**S13.980103 W 171.506028 to S 13.979661 W 171.506253**				
	Species	***Samoan name***	**No.**	**No. >15 cm**	**Basal Area**	**Rel. Dom.**
1	*Calophyllum neoebudicum*	*tamanu*	12	7	8374	31%
2	*Fagraea berteroana*	*pualulu*	9	3	2822	11%
3	*Rhus taitensis*	*tavai*	2	2	1944	7%
4	*Clinostigma samoense*	*niu vao*	5	3	1793	7%
5	*Crosssostylis biflora*	*saitamu*	10	3	1739	6%
6	*Reynoldsia lanutoensis*	*vī vao*	1	1	1734	6%
7	*Myristica hypargyraea*	*'atone ulu*	6	3	1212	5%
8	*Hernandia moerenhoutiana*	*pipi*	3	3	1197	4%
9	*Cyathea vaupelii*	*oliolī*	11	4	1159	4%
10	*Cyathea lunulata*	*oliolī*	6	3	1084	4%
11	*Canarium harveyi*	*mafoa*	1	1	962	4%
12	*Syzygium inophylloides*	*asi toa*	6	1	708	3%
13	*Elaeocarpus floridanus*	*a'amati'e*	2	1	705	3%
14	*Maesa tabacifolia*	*(none)*	7	0	385	1%
15	*Garcinia myrtifolia*	*(none)*	1	1	346	1%
16	*Glochihdion ramiflorum*	*masame*	1	1	283	1%
17	*Palaquium stehlinii*	*gasu*	1	0	133	+
18	*Dysoxylum maota*	*maota*	1	0	133	+
19	*Psydrax merrillii*	*olasina*	3	0	98	+
20	*Cordyline fruticosa*	*tī vao*	1	0	20	+
			89	**37**	**26831**	**100**

Appendix 1.9. Checklist of the Flora of Lake Lanoto'o National Park

FAMILY	*Species*	Authors	Samoan Name
	DICOTS		
AMARANTHACEAE	*Alternanthera sessilis*	(L.) R. Br. ex DC.	
ANACARDIACEAE	***Rhus taitensis***	Guillemin	*tavai*
APIACEAE	*Centella asiatica*	(L.) Urb.	*togotogo*
APOCYNACEAE	***Alstonia pacifica***	(Seem.) A.C. Smith	
APOCYNACEAE	***Alyxia bracteolosa***	Rich	*lau maile*
APOCYNACEAE	*Funtumia elastica*	(Preuss) Stapf	*pulu vao*
APOCYNACEAE	***Melodinus vitiense*** (1)	Rolfe	*vī vao*
ARALIACEAE	***Reynoldsia lanutoensis***	Hochreut.	*vī vao*
ASCLEPIADACEAE	***Hoya australis***	R. Br. in Traill	*lau mafiafia*
ASCLEPIADACEAE	***Hoya betchei***	(Schlechter) Schlechter	
ASCLEPIADACEAE	***Hoya samoensis***	Seem.	
ASTERACEAE	*Ageratum conyzoides*	L.	
ASTERACEAE	***Centipeda minima*** (1)	(L.) A. Braun & Aschers.	
ASTERACEAE	*Crassocephalum crepidioides*	(Benth.) S. Moore	*fua lele*
ASTERACEAE	*Erechtites valerianifolia*	(Wolf) DC.	*fua lele*
ASTERACEAE	*Mikania micrantha*	Kunth	*fue saina*
ASTERACEAE	*Struchium sparganophorum*	(L.) Kuntze	
BARRINGTONIACEAE	***Barringtonia samoensis***	A. Gray	*falagā*
BEGONIACEAE	*Begonia xsemperflorens-cultorum*	Hort.	
BIGNONIACEAE	*Spathodea campanulata*	Beauv.	*fa'apasī*
CAMPANULACEAE	*Lobelia zeylanica*	L.	
CHRYSOBALANACEAE	*Atuna racemosa*(1)	Raf.	*ifiifi*
CLUSIACEAE	***Calophyllum neoebudicum***	Guillaumin	*tamanu*
COMBRETACEAE	***Terminalia richii***	A. Gray	*malili*
CONVOLVULACEAE	***Ipomoea littoralis***	Bl.	*pālulu*
CUCURBITACEAE	***Zehneria mucronata***	(Bl.) Miq.	
CUNONIACEAE	***Spiraeanthemum samoense***	A. Gray	
CUNONIACEAE	***Weinmannia affinis***	A. Gray	
EBENACEAE	***Diospyros samoensis***	A. Gray	*'au'auli*
ELAEOCARPACEAE	***Elaeocarpus floridanus***	Hemsley	*a'amati'e*
ELAEOCARPACEAE	*Elaeocarpus* cf. *graeffei*	Seem.	
EUPHORBIACEAE	***Baccaurea taitensis***	Muell. Arg.	
EUPHORBIACEAE	***Bischofia javanica***	Bl.	*'o'a*

FAMILY	*Species*	Authors	Samoan Name
EUPHORBIACEAE	***Glochidion cuspidatum***	Pax	*masame vao*
EUPHORBIACEAE	***Glochidion ramiflorum***	Forst.	*masame*
EUPHORBIACEAE	***Homalanthus acuminatus***	(Muell. Arg.) Pax	*fogāmamala*
EUPHORBIACEAE	***Macaranga grayana***	Muell. Arg.	
EUPHORBIACEAE	***Macaranga stipulosa***	Muell. Arg.	*lau fatu*
EUPHORBIACEAE	*Phyllanthus urinaria*	L.	
FABACEAE	*Paraserianthes falcataria*	(L.) I. Nielsen	*tamaligi*
FABACEAE	***Strongylodon* sp. nova**		
GENTIANACEAE	***Fagraea berteroana***	A. Gray ex Benth.	*pualulu*
GESNERIACEAE	***Cyrtandra mamolea* (1)**	Reinecke	*momolea*
GESNERIACEAE	***Cyrtandra pogonantha***	A. Gray	*momolea*
HERNANDIACEAE	***Hernandia moerenhoutiana***	Guillemin	*pipi*
LAMIACEAE	*Hyptis pectinata*	(L.) Poiret	
LAMIACEAE	*Hyptis rhomboidea*	Mart. & Gal.	*vao miniti*
LAMIACEAE	*Pogostemon cablin*	(Blanco) Benth.	
LAURACEAE	*Cinnamomum verum*	J. Presl	*tigamoni*
LAURACEAE	*Endiandra elaeocarpa*	Gill.	
LOGANIACEAE	***Geniostoma rupestre*(1)**	Forst.	
LORANTHACEAE	***Decaisnina forsteriana***	(J.&J.Schultz) Barlow	*tapuna*
LYTHRACEAE	*Cuphea carthagenensis*	(Jacq.) Macbr.	
MALVACEAE	***Hibiscus tiliaceus***	L.	*fau*
MELASTOMACEAE	***Astronidium samoense***	(S. Moore) Markgraf	
MELASTOMACEAE	***Astronidium subcordatum***	(A. Gray) Christoph.	
MELASTOMACEAE	*Clidemia hirta*	(L.) D. Don	*vao fulufulu*
MELASTOMACEAE	*Dissotis rotundifolia*	(Sm.) Triana	
MELASTOMACEAE	***Medinilla samoensis***	(Hochreut.) Christoph.	
MELASTOMACEAE	***Melastoma denticulatum***	Labill.	*fua lole*
MELIACEAE	***Dysoxylum huntii***	Merr.	*maota mea*
MELIACEAE	***Dysoxylum samoense***	A. Gray	*mamala*
MONIMIACEAE	***Hedycarya denticulata***	(A. Gray) Perk. & Gilg	*fatimatao?*
MORACEAE	*Castilla elastica*	Sessé	*pulu māmoe*
MORACEAE	***Ficus godeffroyi*(1)**	Warb.	
MORACEAE	***Ficus uniauriculata***	Warb.	
MYRISTICACEAE	***Myristica hypargyraea***	A. Gray	*'atone ulu*
MYRISTICACEAE	***Myristica inutilis***	Rich ex A. Gray	*'atone*
MYRSINACEAE	***Embelia vaupelii***	Mez	

FAMILY	*Species*	Authors	Samoan Name
MYRSINACEAE	***Maesa tabacifolia***	Mez	
MYRTACEAE	***Metrosideros collina***	A. Gray	
MYRTACEAE	*Psidium guajava*	L.	*ku'ava*
MYRTACEAE	***Syzygium carolinense***	(Koidz.) Hosokawa	*popona?*
MYRTACEAE	***Syzygium curvistylum***	(Gillespie) Merr. & Perry	
MYRTACEAE	***Syzygium hebephyllum*(1)**	Melville	
MYRTACEAE	***Syzygium inophylloides***	(A. Gray) C. Muell.	*asi vao?*
MYRTACEAE	*Syzygium samarangense*	(Bl.) Merr. & Perry	*nonu vao*
NYCTAGINACEAE	***Pisonia merytafolia***	Whistler	
ONAGRACEAE	*Ludwigia hyssopifolia*	(G. Don) Exell	
ONAGRACEAE	*Ludwigia octovalvis*	(Jacq.) Raven	
PASSIFLORACEAE	*Passiflora laurifolia*	L.	*pasio vao*
PIPERACEAE	***Macropiper timothianum***	A.C. Smith	*'ava'avaaitu*
PIPERACEAE	***Peperomia reineckei***	C. DC.	
PIPERACEAE	***Piper macropiper***	Pennant	*fue manogi*
PIPERACEAE	***Piper rechingeri***	C. DC.	
POLYGALACEAE	*Polygala paniculata*	L.	*pulunamulole*
RHAMNACEAE	***Alphitonia zizyphoides***	(Spreng.) A. Gray	*toi*
RUBIACEAE	***Calycosia sessilis***	A. Gray	
RUBIACEAE	***Geophila repens***	(L.) I. M. Johnston	*tono*
RUBIACEAE	***Morinda* cf. *tripetala***	Christoph.	
RUBIACEAE	***Neonauclea forsteri***	(Seem. ex Havil.) Merr.	*afa*
RUBIACEAE	***Psychotria closterocarpa***	A. Gray	
RUBIACEAE	***Psychotria geminodens***	K. Schum.	
RUBIACEAE	***Psychotria pacifica*(1)**	K. Schum.	
RUBIACEAE	***Psychotria samoana*(1)**	K. Schum.	
RUBIACEAE	***Psydrax merrillii*(1)**	(Setchell) Whistler	*olasina*
SAPINDACEAE	***Elattostachys apetala***	(Labill.) Radlk.	*taputo'i*
SAPINDACEAE	***Pometia pinnata***	Forst.	*tava*
SAPOTACEAE	***Palaquium stehlinii***	Christoph.	*gasu*
SCROPHULARIACEAE	***Limnophila fragrans*(1)**	(Forst. f.) Seem.	*teine ole pō*
SOLANACEAE	*Cestrum nocturnum*	L.	*vī vao*
THYMELAEACEAE	***Phaleria glabra*(1)**	(Turrill) Domke	
TILIACEAE	***Trichospermum richii***	(A. Gray) Seem.	*ma'osina*

FAMILY	*Species*	Authors	Samoan Name
URTICACEAE	***Elatostema grandifolium***	Reinecke	
VERBENACEAE	***Faradaya amicorum***	Seem.	*mamalupe*
VERBENACEAE	*Lantana camara*	L.	*latana*
VERBENACEAE	***MONOCOTS***		
AGAVACEAE	***Cordyline fruticosa***	(L.) Chev.	*tī vao*
ARACEAE	*Amorphophallus paeoniiformis*(1)	(Dennst.) Nicolson	*teve*
ARACEAE	***Rhaphidophora graeffei***	Engl.	*tuafaga?*
ARECACEAE	***Balaka taitensis***	(Wendl.) Becc.	*māniuniu*
ARECACEAE	***Clinostigma samoense***	Wendl.	*niu vao*
ARECACEAE	***Clinostigma onchorhyncha***	Becc.	*niu vao*
COMMELINACEAE	*Commelina diffusa*	Burm. f.	*mau'utoga*
CYPERACEAE	***Eleocharis dulcis***	(Burm. f.) Hens.	*'utu'utu*
CYPERACEAE	*Kyllinga polyphylla*	Willd. ex Kunth	
CYPERACEAE	***Rhynchospora corymbosa***	(L.) Britten	*selesele*
FLAGELLARIACEAE	***Flagellaria gigantea***	Hook. f.	*lafo*
HELICONIACEAE	***Heliconia laufao***	Kress	*laufao*
ORCHIDACEAE	***Bulbophyllum* cf. *atrorubens***	Schltr.	
ORCHIDACEAE	***Bulbophyllum betchei***	F. Muell.	
ORCHIDACEAE	***Bulbophyllum longiscapum***	Rolfe	
ORCHIDACEAE	***Bulbophyllum samoanum***	Schltr.	
ORCHIDACEAE	***Coelogyne lycastoides***	F. Müll. and Kraenzl.	
ORCHIDACEAE	***Dendrobium biflorum***	(Forst. f.) Sw.	
ORCHIDACEAE	***Dendrobium dactylodes***	Rchb. f.	
FAMILY	***Species***	**Authors**	***Samoan Name***
ORCHIDACEAE	***Dendrobium lepidochilum***	Kraenzl.	
ORCHIDACEAE	***Dendrobium reineckei***	Schltr.	
ORCHIDACEAE	***Diplocaulobium fililobum***	(F. Müll.) Kraenzl.	
ORCHIDACEAE	***Eria rostriflora***	Rchb. f.	
ORCHIDACEAE	***Habenaria samoensis* (1)**	F. Muell. & Kraenzl.	
ORCHIDACEAE	***Liparis condylobulbon***	Rchb. f.	
ORCHIDACEAE	***Microstylis resupinata***	(Forst. f.) Drake	
ORCHIDACEAE	***Microstylistetraloba*(1)**	Schltr.	
ORCHIDACEAE	***Microstylis taurina***	Rchb. f.	

FAMILY	*Species*	Authors	Samoan Name
ORCHIDACEAE	***Peristylis trandescantifolius* (1)**	(Rchb. f.) Kores	
ORCHIDACEAE	***Phaius terrestris***	(L.) Ormerod	
ORCHIDACEAE	***Phreatia micrantha***	(A. Rich.) Schltr.	
ORCHIDACEAE	***Phreatia minima***	Schltr.	
ORCHIDACEAE	***Phreatia myosurus***	(Forst. f.) Ames	
ORCHIDACEAE	***Pseuderia ramosa***	L. O. Williams	
ORCHIDACEAE	***Spathoglottis plicata***	Bl.	
ORCHIDACEAE	***Thalasis carinata* (1)**	Bl.	
ORCHIDACEAE	***Vrydagzynea samoana*(1)**	Schltr.	
ORCHIDACEAE	***Zeuxine plantaginea* (1)**	Schltr.	
PANDANACEAE	***Freycinetia reineckei***	Warb.	*'ie'ie*
PANDANACEAE	***Freycinetia storckii***	Seem.	*'ie'ie*
PANDANACEAE	***Pandanus turritus***	Mart.	*fasa*
POACEAE	*Axonopus fissifolius*	(Raddi) Kuhlm.	
POACEAE	***Centosteca lappacea***	(L.) Desv.	*sefa?*
POACEAE	***Cyrtococcum oxyphyllum***	Stapf	
POACEAE	*Paspalum conjugatum*	Bergius	*vao lima*
POACEAE	***Paspalum orbiculare***	Forst. f.	
POACEAE	*Schizostachyum glaucifolium*	(Rupr.) Munro	*ofe sāmoa*
POACEAE	*Setaria palmifolia*	(Koenig) Stapf	
	FERNS		
ANGIOPTERIDACEAE	***Angiopteris evecta***	(Forst. f.) Hoffman	*gase*
ASPIDIACEAE	***Lastreopsis davalloides***	(Brack.) Tindale	
ASPIDIACEAE	***Pleocnemia cumingiana***	Presl	
ASPIDIACEAE	***Pleocnemia irregularis***	(Presl) Holttum	
ASPIDIACEAE	***Tectaria crenata***	Cav.	
ASPIDIACEAE	***Tectaria decurrens***	(Presl) Copeland	
ASPIDIACEAE	**Species indet.**		
ASPLENIACEAE	***Asplenium feejeense***	Brack.	
ASPLENIACEAE	***Asplenium horridum***	Kaulf.	
ASPLENIACEAE	***Asplenium laserpitiifolium***	Lam.	
ASPLENIACEAE	***Asplenium nidus***	L.	*laugapāpā*
ATHYRIACEAE	***Diplazium bulbiferum***	Brack.	
ATHYRIACEAE	***Diplazium dilatatum***	Bl.	
BLECHNACEAE	***Blechnum orientale***	L.	
CULCITACEAE	***Culcita straminea***	(Labill.) Maxon	

FAMILY	*Species*	Authors	Samoan Name
CYATHEACEAE	***Cyathea alta***	Copeland	*oliolī*
CYATHEACEAE	***Cyathea lunulata***	(Hook.) Copeland	*oliolī*
CYATHEACEAE	***Cyathea medullaris***	(Forst. f.) Sw.	*oliolī*
CYATHEACEAE	***Cyathea vaupelii***	Copeland	*oliolī*
CYATHEACEAE	***Cyathea whitmeei***	Baker	*oliolī*
DAVALLIACEAE	***Davallia denticulata***	(Burm. f.) Mett. ex Kuhn	*laugasēsē*
DAVALLIACEAE	***Davallia graeffei***	Luerssen	
DAVALLIACEAE	***Davallia heterophylla***	J. Sm.	
DAVALLIACEAE	***Davallia solida***	(Forst. f.) Sw.	*laugasēsē*
DAVALLIACEAE	***Leucostegia pallida***	(Mett.) Copeland	
DENNSTAEDTIACEAE	***Dennstaedtia flaccida***	(Forst. f.) Bernh.	
DENNSTAEDTIACEAE	***Dennstaedtia samoensis***	(Brack.) Moore	
DENNSTAEDTIACEAE	***Microlepia speluncae***	(L.) Moore	
ELAPHOGLOSSACEAE	***Elaphoglossum reineckei***	Hier.	
GLEICHENIACEAE	***Dicranopteris linearis***	(Burm.) Underw.	*'asaua*
GRAMMITIDACEAE	***Ctenopteris seemannii***	(J. Smith) Copeland	
HYMENOPHYLLACEAE	***Hymenophyllum praetervisum***	Christ	
HYMENOPHYLLACEAE	***Trichomanes apiifolium***	Presl	
HYMENOPHYLLACEAE	***Trichomanes assimile***	Mett.	
HYMENOPHYLLACEAE	***Trichomanes bimarginatum***	Bosch	
HYMENOPHYLLACEAE	***Trichomanes boryanum***	Kuntze	
HYMENOPHYLLACEAE	***Trichomanes saxifragoides***	Presl	
HYPOLEPIDACEAE	***Histiopteris incisa***	(Thunb.) J. Sm.	
LOMARIOPSIDACEAE	***Bolbitis palustris***	(Brack.) Hennipman	
LOMARIOPSIDACEAE	***Lomagramma cordipinna***	Holttum	
LOXOGRAMMACEAE	***Loxogramme parksii***	Copeland	
NEPHROLEPIDACEAE	***Nephrolepis biserrata***	(Sw.) Schott	*vao tuaniu*
OLEANDRACEAE	***Oleandra neriiformis***	Cav.	
OPHIOGLOSSACEAE	***Ophioglossum pendulum***	L.	
POLYPODIACEAE	***Lemmaphyllum accedens***	(Bl.) Donk	
POLYPODIACEAE	***Phymatosorus grossus***	(Langs.&Fisch.) Brownlie	*lauautā*

FAMILY	*Species*	Authors	Samoan Name
POLYPODIACEAE	***Phymatosorus nigrescens***	(Bl.) P. Serm.	
POLYPODIACEAE	***Phymatosorus powellii***	(Baker) P. Serm.	
POLYPODIACEAE	***Polypodium subauriculatum***	Bl.	
POLYPODIACEAE	***Pyrrosia lanceolata***	(L.) Farwell	lau tasi
POLYPODIACEAE	***Selliguea feeoides***	Copeland	
THELYPTERIDACEAE	***Cyclosorus interruptus***	(Willd.) H. Ito	
THELYPTERIDACEAE	***Pneumatopteris glandulifera***	(Brack.) Holttum	
VITTARIACEAE	***Antrophyum subfalcatum***	Brack.	
VITTARIACEAE	***Vaginularia angustissima***	(Brack.) Mett.	
	FERN ALLIES		
LYCOPODIACEAE	***Lycopodium phlegmaria***	L.	
Names in bold are native species.			
(1) Found in the area during previous surveys, but not during the present one.			

Chapter 2: Report on the Land Reptiles Survey of the Falealupo Peninsula Coastal Rainforest, Central Savai'i Rainforest and Uafato-Ti'avea Coastal Rainforest

The Micronesian skink *Emoia adspersa.* Photo by Jonathan Richmond.

Team Leader/Author: Jonathan Richmond (USGS)
Team Members: Jordyn Mulder (USGS), Fialelei Enoka (DEC-MNRE), Maoluma Onesemo (SVS Aiga Folau), Agape Timoteo (MNRE), Kim Keleti (MNRE)

Summary

Accumulating baseline knowledge of Samoa's’ reptiles is clearing a pathway forward in conserving and managing this largely regionally endemic fauna. We conducted a rapid biodiversity assessment (BIORAP) for reptiles at four main survey sites in Samoa between 16 July and 2 August 2016. Sites were located within three key biodiversity areas (KBAs) formally recognized by the Samoan Ministry of Natural Resources and Environment (MNRE), two on Savai’i (Falealupo Peninsula Coastal Rain Forest and the Central Savai’i Rainforest) and one on Upolu (Uafato/Tiavea Coastal Rain Forests). Our objectives were to (1) determine presence/absence of reptile species in each of the three KBAs, (2) identify elevation limits for each species detected, (3) determine presence/absence of invasive species with known or presumed effects on reptiles, with emphasis on the yellow crazy ant *Anoplolepis gracilipes*; and (4) compare findings to previous work to provide a current assessment on the conservation status, diversity and distribution of Samoas’ reptiles. Sampling techniques included 13.2 km of trapping transects and visual encounter surveys (day and night), ranging in elevation from sea level to approximately 1500 m. We captured a total of 93 specimens using glue board transects, made 124 incidental field observations, and collected 99 voucher specimens and 110 tissue samples during this effort. Twelve of the 14 known native reptiles in Samoa were represented in this sample, including one new island record for the common dwarf gecko *Hemiphyllodactylus typus* on Savai’i. The upper elevation limit for reptiles is 1260 m in upland Savai'i. *Anoplolepis gracilipes* was present at all sites, but we found a sharp, elevation maximum for the species at 662 m above-sea-level on Savai’i. This work provides critical comparative data for future assessments on the status of Samoa’s herpetofauna, where the effects of climate change, anthropogenic habitat loss and disturbance, and continuing spread of non-native species pose threats to this largely endemic fauna.

1.Introduction

The Samoa archipelago is a chain of high volcanic islands with a hotspot origin, formed within the past ~5.0 Ma in the southwest Pacific Ocean (Keating 1992; Koppers et al. 2008). The westernmost islands, Upolu and Savai'i, represent the beginnings of a linear, age-progressive trail of islands formed by plate tectonic movement over a static, deep-seated mantle plume (Koppers *et al*. 2008). Because of this 'conveyor belt-like' process, Savai'i and Upolu represent the oldest, largest, and most mountainous of the islands forming the chain, respectively. Savai'i has a land area of approximately 1700 km^2 and an extensive, interior region of unique upland habitat that extends up to 1858 m at Mount Silisili. Upolu has an area of approximately 1100 km^2 and a high point of 1100 m at Mount Fito, but few (and mostly steep) forested regions above 600 m. Both islands support a rich biota of plants and animals (Conservation International 2010), but limited field efforts in their interiors have prevented a comprehensive understanding about the diversity and distributions of certain taxonomic groups.

The Samoa reptile fauna consists of a number of regionally endemic species that share close historical biogeographic relationships with conspecifics in the Tonga and Fiji, in addition to several more widespread species that extend throughout the western Pacific Region (Brown 1991; Schwaner 1979). Information about this fauna has been accruing piecemeal since the early 1980s (e.g. Schwaner 1979; Amerson 1982a, 1982b), but these studies were focused on the younger, easternmost islands of American Samoa. Gill (1993) summarized the limited knowledge about Samoas' reptiles but did not include information from Zug and Ineich's (1992) unpublished work. The next formal surveys in Samoa did not take place for another two decades, until Stringer et al. (2003a, b) and Parrish et al. (2004) surveyed Nu'utele and Nu'ulua Islands. These efforts were followed by Fisher et al. (2012a) and included Nu'utele, Nu'ulua, Namua and Fanuatapu islands. A reptile focused survey near Mt. Silisili then took place in 2012 (Fisher & Uili 2012b) as part of a rapid biodiversity assessment (BIORAP) of upland Savai'i (Atherton & Jeffries 2012), and two years later Hathaway (2014) reported on surveys conducted during a second BIORAP (Kerslake & Pouli 2014) covering low and mid-elevation sites on Upolu and Savai'i. Each study has contributed to a growing database about reptile diversity, distributions, and abundance in Samoa, but most are unpublished and substantial knowledge gaps still exist for each of these subjects.

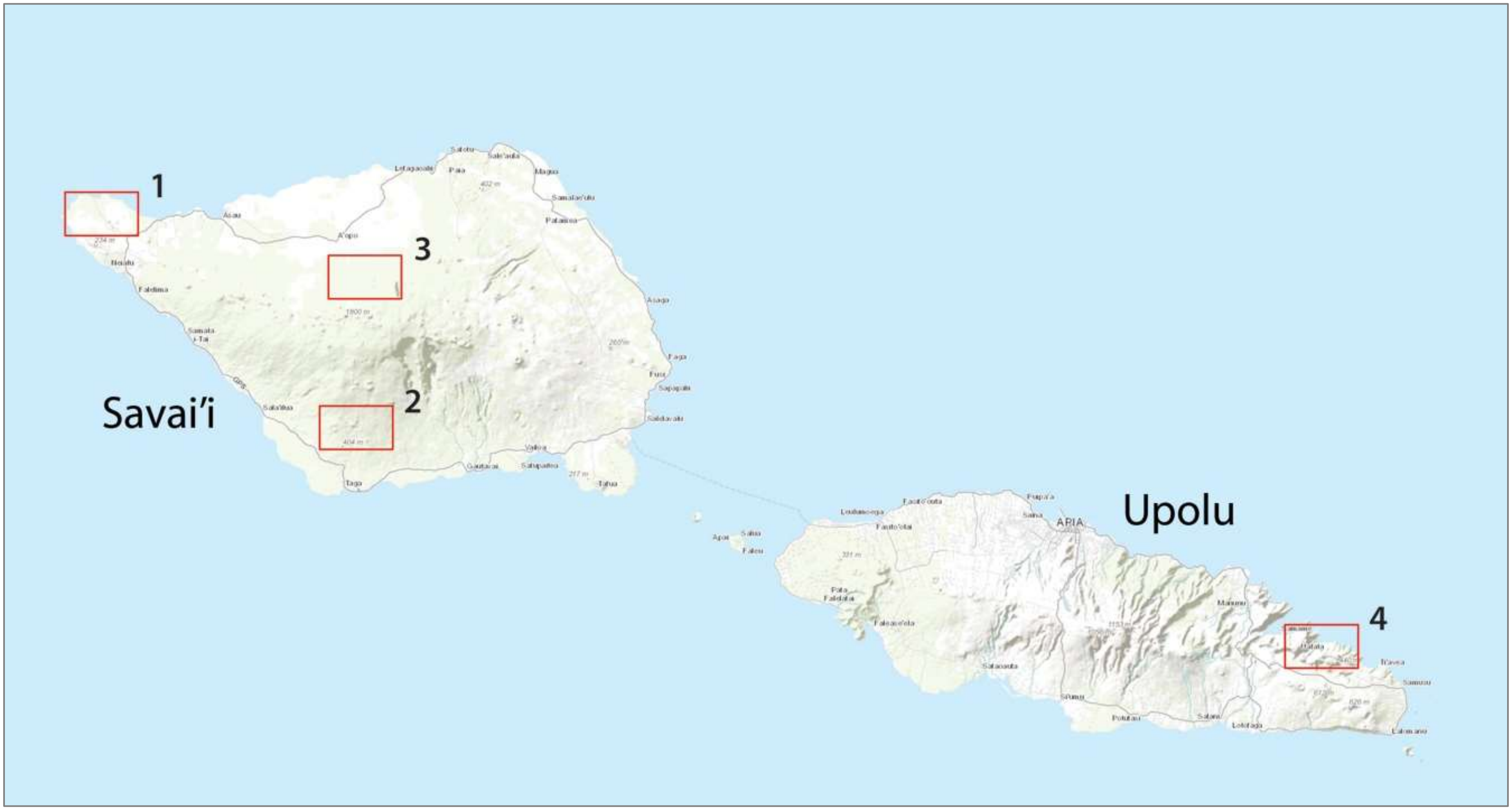
Identifying the distributional limits and habitat preferences, particularly the elevation thresholds, for reptile species in Samoa is important for assessing effects of habitat degradation, predation or competition from non-native species, and climate change. For example, if resource competition between native and non-native species is high in coastal areas, native species might be forced into higher elevations where habitat may be unsuitable and/or temperatures approach critical physiological limits. Similarly, climate change and land use practices may be decreasing the amount of available habitat, which in turn could translate to population declines. These issues may be especially acute for small terrestrial vertebrate populations because the total land area on islands is often small and the probability of successful dispersal to other islands is low.

We recently completed BIORAP at four survey sites in three 'key biodiversity areas' (KBAs) on Upolu and Savai'i (Central Savai'i Rainforest; Falealupo Peninsula Coastal Rain Forest, Savai'i; Uafato/Tiavea Coastal Rain Forests, Upolu), ranging from sea level to approximately 1500 m in the interior of Savai'i (Fig. 2.1). We also conducted a literature review of data on reptiles in the Apia Cathments KBA.

Developed by Conservation International, the BIORAP concept focuses on rapid assessment of the biodiversity in targeted areas, while emphasizing the training of local scientists in field survey techniques and promoting conservation education. Criteria considered during BIORAP surveys typically include: species richness, species endemism, rare and/or threatened species, and habitat condition (Morrison & Nawadra 2009; Atherton & Jefferies 2012).

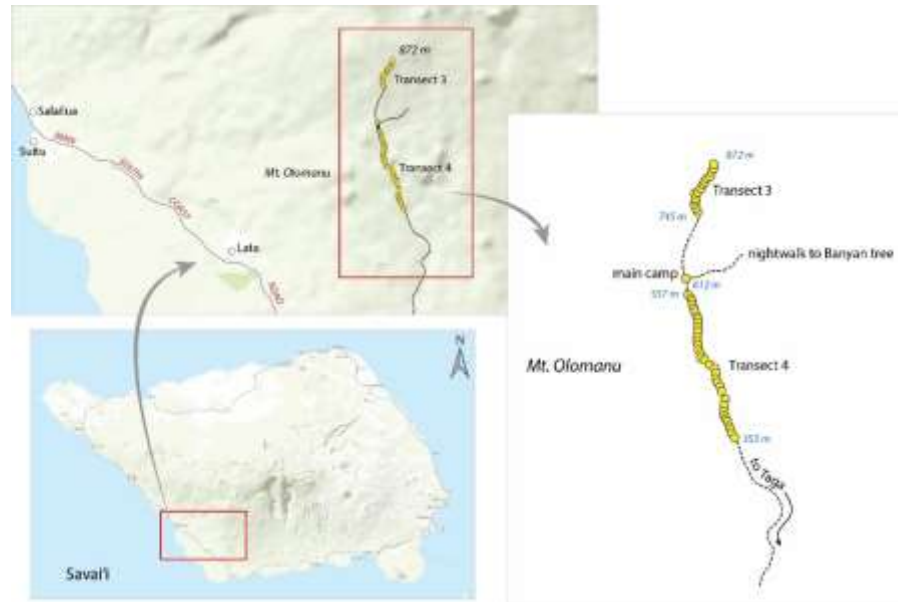
The main objectives of this BIORAP were as follows: (1) Determine presence/absence of reptile species in each of the three KBAs on Upolu and Savai'i (Fig. 2.1); (2) identify elevation limits for each species detected; (3) determine presence/absence of invasive species with known or presumed effects on reptiles, with emphasis on the yellow crazy ant *Anoplolepis gracilipes*; (4) compared findings to previous work, including two BIORAPs conducted in Samoa in 2012 and 2014, to provide a comprehensive, up-to-date assessment on the conservation status, species richness and distribution of Samoas' reptiles. A main goal of this work was to strengthen local capacity and incentives to reduce habitat loss, and to promote a conservation practices that are consistent with sustainable local livelihoods. Results of this work will contribute to developing management plans and actions for each KBA and establish baseline information to allow future comparative assessments on the status of Samoa's herpetofauna. Such data are particularly important with respect to documenting the effects of global climate change and the spread of invasive, non-native species, both of which constitute major threats to this largely endemic fauna.

Figure 2.1 Sampling areas for the Samoa 2016 BIORAP. 1.) Falealupo Peninsula Coastal Rainforest; 2.) Central Savai'i Rainforest, Taga access site; 3.) Central Savai'i Rainforest, A'opo access site; 4.) Uafato-Ti'avea Coastal Rain Forest.

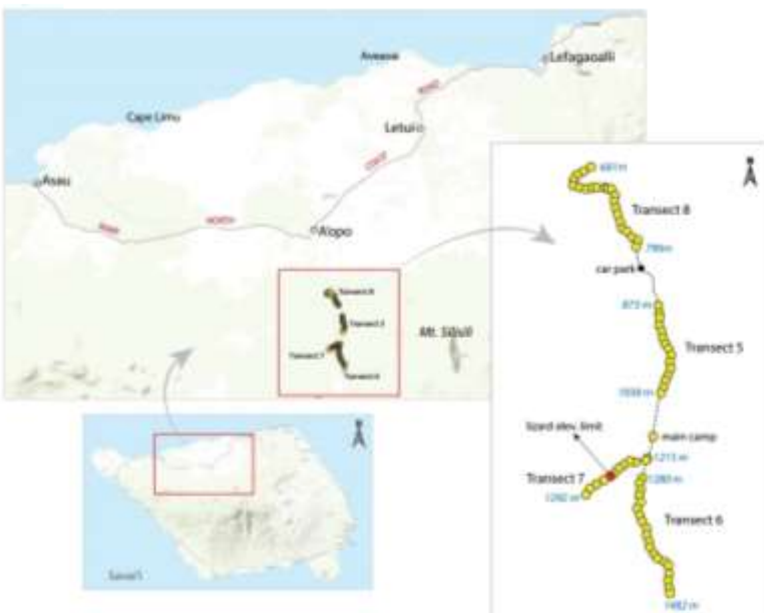


Map 1. Falealupo Peninsula Coastal Forest

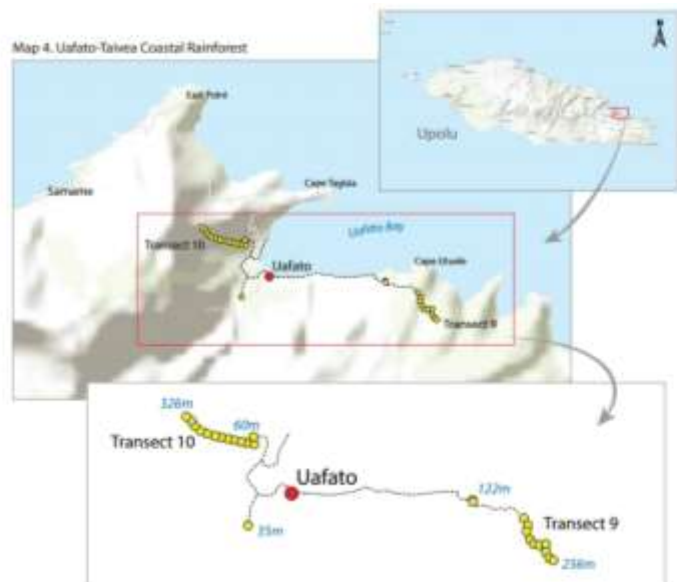
Map 2. Central Savaii Rainforest- Taga access site



Map 3. Central Savaii Rainforest- Aopo access site



Map 4. Uafato-Ti'avea Coastal Rain Forest



2.Methodology

2.1 Sampling techniques

We used 'glue board' trapping transects and visual encounter surveys to document the reptiles at each site. Individual glue boards (~22 cm L x ~13 cm W; Fig. 2.2) are the type used to ensnare rats or mice and can passively capture lizards as they walk over the adhesive surface (e.g. Victor® Mouse Glue Boards). Live specimens were removed by applying cooking oil (e.g. palm or olive) to the parts of the body in contact with the board, which degrades the adhesive. Each transect spanned a range of elevation and habitat types, and consisted of 10–25 stations spaced 30 m apart. Stations consisted of three glue boards positioned (1) on the ground, (2) on a fallen log (~1.0 m of the ground), and (3) on a tree trunk (>1.5m above ground). This configuration was intended to capture different lizard species with different behavioral tendencies – we recorded captures based on the transect number, trap station, and trap location. We also recorded latitude/longitude coordinates for each station.

Figure 2.2. Example of a glue board trap.

Visual encounter surveys consisted of slowly walking through different habitat types while disarticulating fallen logs, peeling bark off of trees, looking underneath prop roots that often grew up the base of tree trunks, raking through leaf debris, and turning over rocks. Visual surveys took place during the day and at night in all weather conditions, although heavy down pours impeded our efforts on several occasions (see *Summary for each survey site* in the Results section below). We recorded GPS coordinates for capture points and incidental sightings.

We preserved a proportion of individuals from each survey site as voucher specimens following the general protocol of McDiarmid (1994). Specimens were euthanized using an intracardial injection of dilute chloretone (trichloro-2-methyl-2-propanol; 1 teaspoon/1L water). We recorded length (snout-to-vent) and mass measurements prior to removing liver tissue for DNA, and photographed representatives of all species. We stored the tissue samples in 95% ethanol and pickled all specimens in a 10% buffered formalin (900 ml water, 100 ml formaldehyde, 1.5 teaspoon/L Magnesium Carbonate [buffer]; Fig. 2.3). Specimens and tissues have been accessioned at the California Academy of Sciences in San Francisco, California (accession no. CAS 260774-870: www.calacademy.org/scientists/herpetology) and are publicly available for further scientific research in accordance with the Nagoya Protocol (https://www.cbd.int/abs/about/).

Use of glue boards also provided a convenient method for detecting insects. In particular, we focused on documenting the distribution of the invasive *A. gracilipes* due to its adverse ecological impacts on other Pacific Islands. This species has been introduced into numerous tropical and subtropical islands including those in the Caribbean, the Indian Ocean (Seychelles, Madagascar, Mauritius, Réunion, the Cocos Islands and the Christmas Islands) and in the Pacific (New Caledonia, Hawaii, French Polynesia, Okinawa, Vanuatu, Micronesia and the Galapagos archipelago: McGlynn & Terrence 1999; Wetterer 2005; Holway et al. 2002).

Figure 2.3. Trays of museum voucher specimens preserved in 10% formalin.

2.2 Site information

There are currently eight terrestrial KBAs in Samoa covering 940 km^2 or approximately 33% of the total land area. Six of these have been completely or partially established as conservation areas by the government of Samoa or by local communities. The highest priority for terrestrial conservation in Samoa is the Central Savai'i Rainforest KBA, the largest contiguous area of rainforest in Polynesia. Official safeguard status is currently limited to the lower portions this KBA, although the upper portion is now considered a priority for protection given the potential for high species endemism. Information about surveys dates, numbers of transects surveyed, and whether night surveys were conducted are provided in Table 2.1.

Table 2.1. Survey site (and corresponding KBA) summary data for the Samoa 2016 BIORAP.

Survey site	Date range	No. of transects	No. night surveys
Falealupo (Falealupo Coastal Forest)	18-19 July	3	1
Taga (Central Savai'i Rainforest)	21-24 July	2	2
A'opo (Central Savai'i Rainforest)	26-29 July	4	4
Uafato-Ti'avea (Uafato-Ti'avea Coastal Forest)	1-2 August	2	2

<u>Falealupo Peninsula Coastal Rain Forest</u> (Fig 2.1 Map 1)

We placed glue board transects along two main trails that followed a general north-south trajectory. Transect 1 was split into two sections, one at higher elevation near the upper village (total length = 859 m; referred to as the 'canopy walk') and another closer to the coast (total length = 1105 m, extending to approximately sea level). We left a gap between sections due to the rugged terrain (loose, sharp basalt), the relatively homogeneity of the habitat in the central part of the transect, and the limited time for the survey; however, we visually surveyed the full transect. Transect 2 was continuous and had little elevation change between the start and end points, and much of the habitat was similar to the central gap in Transect 1. We conducted a night survey for both sections of Transect 1 and left glue boards overnight only in the lower section due to time constraints.

<u>Central Savai'i Rainforest</u> (Fig 2.1 Maps 2 and 3)

We surveyed the Central Savai'i Rainforest KBA from two access sites, one on the south side of the island at Taga and another on the north side at A'opo. At Taga, we placed two glue board transects in opposite directions from a 600 m base camp. One extended up to ~900 m in relatively pristine forest (i.e. Transect 3) and the other down to ~360 m, ending in an open-canopy plantation (Transect 4). We conducted a night survey on a third transect at 600 m (fixed elevation) but did not use glue boards due to persistent rain (no number assigned).

At A'opo, we placed two glue board transects in opposite directions from a 1200 m base camp, one down to ~800 m (Transect 5) and another extending up to ~1550 m (Transect 6). We set a third transect at 1200 m (fixed elevation; Transect 7), and a fourth transect between the lower camp at 800 m down to ~700 m (Transect 8). Below 800 m, the habitat was considerably more open and heavily disturbed (mainly open plantation) compared to areas above 800 m.

<u>Uafato/Tiavea Coastal Rain Forest</u> (Fig 2.1 Map 4)

We set two glue board transects on the east and west sides of the main village of Uafato. Transect 9 was placed in steep, rugged terrain but with little elevation change between the endpoints. The transect started in an open kava plantation and continued southeast, ending in closed canopy forest. We were only able to place 10 trapping stations along this transect due to heavy downpours but had intermittent opportunities to conduct visual searches when the rain subsided. We were unable to do night surveys along Transect 9 due to treacherous terrain (steep, slippery, with sharp rocks), so we instead searched a lower reach of the same trail along the coastline.

Transect 10 extended to the west of the village along a narrow ridge, beginning in a plantation and ending in mostly closed canopy forest. The number of stations was limited by the terrain, and overcast conditions with occasional rain persisted throughout much of the day. Late afternoon clearing allowed us to search in disturbed forest along the beach, and at night we surveyed a heavily disturbed patch of mostly closed canopy forest to the south of the village.

3.Results

3.1 General findings

We captured a total of 93 lizards using glue board transects (567 individual traps), made 124 incidental observations, and collected 99 voucher specimens during the survey effort. Table 2.2 provides capture data for each survey site. We detected 12 of the 14 native reptiles known from Samoa, including seven skink species, four gecko species and one snake species. We also had one new island record for the common dwarf gecko *Hemiphyllodactylus typus* on Savai'i, a species only known from eggs collected near Lake Lanoto'o on Upolu. We recorded an upper elevation threshold for lizards at 1260 m in the Central Savai'i Rainforest, although lizard activity and abundance notably tapered above ~900 m. We recorded the presence of *A. gracilipes* in portions of all survey areas, and ant densities varied depending on location. The highest recorded elevation for *A. gracilipes* was 662 m in the Central Savai'i Rainforest, approximately 100m higher than a record obtained two years earlier from the northern slope of Mt. Silisili. Other non-native species detections are discussed below.

Table 2.2. Presence/absence and no. of individuals per species at each survey site in the Samoa 2016 BIORAP ('*' denotes native reptile species not detected in this BIORAP but known from Samoa). The corresponding KBA is listed in parentheses below the survey sites.

Species	Falealupo	Taga	A'opo	Uafato	Totals
Lizards (family Scincidae)					
Emoia cyanura	50+	16	5	–	71+
Emoia impar	3	10	7	4	24
Emoia nigra	8	3	–	5	16
Emoia samoensis	–	2	5	2	9
Emoia tongana	2	1	2	3	8
Lipinia noctua	1	1	2	3	7
Emoia adspersa	3	–	–	–	3
Cryptoblepharus poecileopluris*	–	–	–	–	–
Lizards (family Gekkonidae)					
Nactus pelagicus	5	10	11	11	37
Gehyra oceanica	15	3	3	30	51
Lepidodactylus lugubris	2	–	–	4	6
Hemiphyllodactylus typhus	–	3	–	–	3
Gehyra mutilata*	–	–	–	–	–
Snakes					
Candoia bibroni	2	1	1	–	4

3.2 Summary for each survey site

Table 2.1 provides information about the number of trapping days, number of transects, and number of night surveys for each survey site. Sampling maps are provided in a separate document.

Falealupo Peninsula Coastal Rain Forest (Fig 2.1 Map 1)

We surveyed Transect 1 under mostly sunny skies but with some intermittent cloud cover. The sky was mostly overcast but with a high ceiling and no precipitation during surveys for Transect 2.

We captured 7 skink species, 2 gecko species, and a member of the bird team made one snake observation. We also found a shed skin from a second snake near the coastline on Transect 1. The most common skink species was Azure-tailed skink *Emoia cyanura.* During the 2 night surveys, the Pelagic gecko *Nactus pelagicus* and Oceanic gecko *Gehyra oceanica* were the most common gecko species*. Anoplolepis gracilipes* was abundant throughout this area, often catching 200+ on a single glue board (but see caveats '*Comments on invasive species*' in the Discussion).

Central Savai'i Rainforest (Fig 2.1 Maps 2 and 3)

At Taga, there was patchy sunlight during sampling for the lower part of Transect 3 until the late morning on Day 1, but intermittent heavy rain prevailed for the remainder of the day and most of the night. There was patchy sunlight for Transect 4 until late in the afternoon, again followed by rain for the remainder of the day and into the evening. At the A'opo access site, intermittent, heavy rain and overcast skies were a persistent issue for the upper- and fixed-elevation transects (Transects 6 and 7), but conditions were mostly sunny for the two lower transects.

We captured 6 skink species, 3 gecko species, and 1 snake species. *Emoia cyanura* and *E. impar* were the most common skink species, and abundances for both were notably higher on the 'wet' side of the island at Taga. *Nactus pelagicus* was the most common gecko species on south facing slope (Taga), whereas *G. oceanica* and *N. pelagicus* were roughly equally common on the north facing slope (A'opo). *Anoplolepis gracilipes* was present throughout Transect 4 at lower elevations, but absent above 662m along Transect 3.

Uafato/Tiavea Coastal Rain Forests (Fig 2.1 Map 4)

Rain began falling soon after we started setting traps for Transect 9. Once the transect was set, we had intermittent opportunities to conduct visual surveys when the rain let up near the last trapping station. Skies were completely overcast for the Transect 10 survey (but no rainfall), giving way to patchy sunlight late in the afternoon. We recorded 6 skink species and 2 gecko species. *Anoplolepis gracilipes* was present along both transects. One peculiar finding at this site was the absence of *E. cyanura*, which was the most abundant skink at all other survey areas.

3.3 Summary of reptile species

Table 2.3 summarizes body size data for each species, partitioned by sex given that most of the lizards are sexually dimorphic in size (and in some cases shape). We also include three appendices: 2.1. summary data for voucher specimens (location, size, age class, sex); 2.2 capture data from glue board transects (transect no., station no. within each transect, ecological data, etc and 2.3. a short literature review of reptile records from the Apia catchments KBA.

Table 2.3. Body size data (snout-to-vent length [SVL] in mm) partitioned by sex. Juveniles and/or specimens in which the sex could not be positively determined were excluded. Note that *Nactus pelagicus*, *Lepidodactylus lugubris*, and *Hemiphyllodacylus typus* are all unisexual species (parthenogenic) and consist of females only.

Species	*n*	sex	min.	max.	mean
Lizards (family Scincidae)					
Emoia cyanura	12	F	41.0	47.5	44.4
	8	M	39.3	49.2	45.1
Emoia impar	3	F	39.4	47.4	43.0
	2	M	44.4	47.6	46.0
Emoia nigra	3	F	70.5	99.3	89.6
	5	M	95.8	111.4	102.3
Emoia samoensis	2	F	91.5	100.9	96.2
	1	M	—	107.9	—
Emoia tongana	1	F	—	63.3	—
	4	M	68.6	78.0	73.4
Emoia adspersa	1	F	—	77.7	—
Lipinia noctua	2	F	37.7	47.8	42.7
	2	M	39.4	41.1	40.3
Lizards (geckos)					
Nactus pelagicus	9	F	56.5	71.3	63.1
Gehyra oceanica	17	F	50.5	88.3	66.2
	3	M	71.1	96.3	69.4
Lepidodactylus lugubris	5	F	34.1	43.6	39.5
Hemiphyllodacylus typus	3	F	35.3	41.3	38.8
Snakes					
Candoia bibroni	2	M	431.0	605.0	518.0

Skinks

Figure 2.4. Top left – *Emoia impar*; top right – *Emoia cyanura*; bottom left – *Emoia adspersa*; bottom right – *Lipinia noctua*.

Azure-tailed skink *Emoia cyanura* (Fig. 2.4 top right): This was the most abundant skink species detected, occurring from sea level to 785 m. It was common in sun-exposed, disturbed habitat and was always captured on the ground or on low-lying logs. At some sites it co-occurred with *E. impar*, although it appears to be more tolerant of extreme disturbance than *E. impar.* It also seems to have little difficulty co-existing with *A. gracilipes*, as the species was common even in areas with high ant abundance (Fig 2.4.

Dark-bellied copper-striped skink *Emoia impar* (Fig. 2.4 top left): This was the second most abundant skink species, occurring in open disturbed areas to shaded forest understory (although in the forest it seeks out patches of sunlight) on the ground or low-lying logs/branches. It tended to occur at higher levation and further away from extreme forms of disturbance compared to *E. cyanura*. For example, we never observed *E. impar* in or immediately around the villages. Like *E. cyanura*, it co-occurs with *A. gracilipes*

Steindachner's Emo skink, or Micronesian skink *Emoia adspersa* (Fig. 2.4 bottom left): We detected *E. adspersa* only in one area near the beach in the Falealupo Peninsula Coastal Rain Forest, although more extensive searches parallel to and immediately along the coastline would have almost certainly produced more (given the extensive span of the same habitat across this area). We observed this species on the ground and underneath felled logs on sandy substrate. *Anoplolepis gracilipes* were also at high density throughout this same area.

Figure 2.5. The climbing skinks. Top – *Emoia tongana*; middle – *Emoia samoensis*; bottom – *Emoia nigra.*

Moth skink *Lipinia noctua* (Fig. 2.4 bottom right): We observed this small, secretive skink almost always at the base of trees, where they were either crawling on the trunks (typically at night) or seeking refuge underneath loose bark (during the day). In one night survey, we found a male/female pair together ~0.5 m off the ground at the base of a tree. We regularly found this species in areas that were heavily infested with *A. gracilipes.*

Polynesian slender tree skink *Emoia tongana* (Fig. 2.5 top): We always captured this species in trees or on high log perches. Two adult individuals were seemingly active and captured at night but it is unclear whether our activity caused disturbed prior to observing them with a head torch. This is perhaps the most agile climber of all *Emoia* species in Samoa.

Samoan skink *Emoia samoensis* (Fig. 2.5 middle): This large skink has long been considered an endemic to Samoa, but more recent field surveys and molecular data have shown that it also occurs on islands in eastern Fiji (e.g. Cikobia, Qamea, and Taveuni; Richmond, unpub. data). It is an agile climber, most often observed on tree limbs or trunks in closed canopy forest with areas of patchy sunlight. This species had the highest elevation record (1260 m, Central Savai'i Rainforest, A'opo) of all reptiles surveyed.

Black skink *Emoia nigra* (Fig. 2.5 bottom): This is the largest lizard in Samoa. We frequently observed this skink in disturbed, open habitat (i.e. plantation) on the ground, underneath logs, perched on logs, and on tree trunks or branches. They would often climb upward in the trees to evade capture, rather than moving to the ground. We captured it in many of the same areas as *E. cyanura* and it is seemingly tolerant to the presence of *A. gracilipes*, at least to some degree.

Geckos

Figure 2.6. The geckos. Top panel – *Nactus pelagicus*; middle – *Gehyra oceanica*; bottom – *Lepidodactylus lugubris.*

Pelagic gecko *Nactus pelagicus* (Fig. 2.6 top): This is another common gecko species that was active during night searches at all study sites. Like *G. oceanica* we were also able to find them by peeling loose bark from felled or standing trees, or by rolling logs. We encountered this species climbing on tree trunks as well as on the ground. Unlike *G. oceanica*, there were no striking differences in abundance between the Taga (wetter) and A'opo sites (drier) in the Central Savai'i Rainforest.

Oceanic gecko *Gehyra oceanica* (Fig. 2.6 middle): This is one of the two gecko species that was abundant and easily detected during night searches, most often climbing on tree trunks. We also found them during the day, usually underneath bark at the base of tree trunks or rotting logs. This species was present in all study sites. However, of the two sites surveyed in the Central Savai'i Rainforest highlands, *G. oceanica* was noticeably less abundant on the south-facing Taga site (wetter) versus the north-facing A'opo site (drier

Mourning gecko *Lepidodactylus lugubris* (Fig. 2.6 bottom)*:* This species was only found in the two Coastal Rain Forest KBA's (Falealupo Peninsula on Savai'i and Uafato on Upolu) and was absent from the central and upland cloud forests of Savai'i. We observed most individuals in the leaf axils of *Pandanas* trees near the coastline.

Indo-Pacific slender gecko *Hemiphyllodactylus typus* (Fig. 2.7): This species was found only at the Taga survey site in central Savai'i. We captured several individuals in a root mat at the base of a large fern tree that was left standing in the middle of an open canopy plantation (Transect 4). This was a new island record for this species.

Snake

Pacific boa *Candoia bibroni* (Fig. 2.8): The three snakes collected in this survey were all found during the day in heavily disturbed habitat (i.e. plantations). We found them by peeling bark off of old logs (where the bark had lifted, forming a crawl space for hiding), underneath root mats at the base of trees, and in the leaf axes of ferns. One was seen basking on a small tree ~1.5 m off the ground in the early morning at Falealupo (M. O'Brien, pers. obs.).

3.4 Invasive species detection

Samoa has two non-native species of reptiles, the house gecko *Hemidactylus frenatus* and the Brahminy blind snake *Indotyphlops braminus.* We observed *H. frenatus* at lodging accommodations and in village infrastructure on Savai'i and Upolu, but never in any of the core survey areas. We performed targeted searches for *I. braminus* by sifting through leaf litter, coconut husk piles, and woody debris near villages (where they are often found) but did not encounter them.

For invasive arthropods, we focused mainly on the detection of *A. gracilipes* because of its capacity for invading Pacific Islands and its suspected impacts on native reptiles in Samoa. We detected *A. gracilipes* at all sampling sites, although ant density differed within and across these sites. Densities appeared to be highest in the Falealupo Peninsula, although it is unclear whether this is a true result versus an artifact of disturbance as we set our trapping transects (for more details see '*Comments on invasive species*' in the Discussion below). In the Central Savai'i Rainforest KBA, the upper elevation maxima for *A. gracilipes* differed between the south-facing, 'wet' side of the island at Taga compared to the north-facing, drier side of the island at A'opo. At Taga, the maximum elevation for *A. gracilipes* was ~353 m ASL, whereas at A'opo the ants extended up to but did not exceed 662 m. *Anoplolepis gracilipes* was common in all sampling areas at Uafato-Tiavea on Upolu.

We made numerous observations of the Asian Forest Centipede *Scolopendra subspinipes* along the lower transect at A'opo during a night survey. The only other site where we detected them was at Taga, but the density was markedly lower (n = 3; two along the banyan tree transect and one in a fern leaf axis in the plantation near the car park).

Samoa has several non-native mammal species that are of concern for reptiles, namely rats, cats, dogs and pigs. We detected rats (species unknown) in two areas on Savai'i (along Transect 4 at Taga and Transect 8 in A'opo; Maps 2 & 3) and one on Upolu (Transect 9 at Uafato; Map 4). Sightings ranged from 247–832 m in elevation. We did not directly observe cats at any survey sites, but we found numerous cat scats extending across the large lava field between the campsites at 1550 and 1600 m ASL in upland Savai'i. We also found scat near the 1600 m campsite, including one with a nearly full wing and feathers of a wattled honeyeater *Foulehaio carunculatus* (photographed and verified by F. Enoka and M. O'Brien). We did not observe stray dogs at any of the survey sites, and dogs that we did see were always with their owners. Pigs were common near villages and along the roads, but we found only limited evidence of pig activity within the main survey areas. The 1200 m campsite in upland Savai'i had clear evidence of pig rooting when we first arrived, and the area searched during our final night survey in Uafato (immediately south of the village leading to the bird observatory) was heavily damaged by pigs.

Last, we recovered numerous individuals of the Giant African snail *Achatina fulica* in Falealupo in an old plantation area along Transect 1 (stations 9 and 10). This was the only survey site where we observed them.

4. Discussion

This work provides substantial new information about the distributions and abundances of reptile species in high priority conservation areas in Samoa. This includes one new island record on Savai'i for a lizard species only known from two egg specimens (Zug and Ineich, unpub. data; Fisher et al. 2013) – the Indo-Pacific slender gecko *H. typus* (Fig. 2.7). Until now, no adult specimens of *H. typus* were ever collected from Samoa, and the eggs attributed to this species were last collected on Upolu in 1992.

The only native reptile species that we did not observe were the Oceania snake-eyed skink, *Cryptoblepharus poecilopleurus* and the Pacific stump-toed gecko *Gehyra mutilata*. Museum records document *C. poecilopleurus* from localised coastal areas near Apia (Palolo Deep/Vaiala Beach and Mulinu'u) and Manono Island, and Fisher and Uili (2012b) recorded it on Savai'i from the coast at Asau to ~8.0 km inland (240 m elevation). *Gehyra mutilata* has been documented only from coastal Savai'i on bare lava flows below 30 m (Fisher & Uili 2012b). The only site that approached bare lava flows during this study was at Falealupo, but there the basalt is heavily infiltrated by secondary disturbed forest. The fact that we were unable to detect either species adds to the evidence that both are rare and have very restricted distributions in Samoa.

Figure 2.7. *Hemiphyllodactylus typus*

We also increased knowledge about the threats that Samoas' reptiles face from a number of invasive species, and we discuss these species in some detail below (see *Comments on invasive species* below). Perhaps as equally important as documenting the presence of certain invasive species was confirming the absence of others. For example, we confirmed the absence of the cane toad *Rhinella marina* and the brown treesnake *Boiga irregularis*, both of which are responsible for reptile declines and extinctions on other Pacific islands (Fritts and Rodda 1998; Lever 2001, 2003). *Rhinella marina* is highly toxic to most animals if ingested and is a voracious predator that consumes a wide variety of prey (e.g. small rodents, reptiles, birds, a range of invertebrates [Lever 2001]). The toad is already well-established in nearby American Samoa and is therefore a critical concern for Samoa. In addition, the ease at which *B. irregularis* can be incidentally transported in air and ship cargo, combined with favorable climate and abundant suitable prey in Samoa, makes this snake particularly dangerous to Samoa's indigenous birds, reptiles, and mammals (Rodda and Savidge 2007).

4.1 General findings

The greatest opportunity for new reptile species discoveries in Samoa lies in the upland forest of Central Savai'i, but mounting evidence suggests that reptiles are unable to persist above ~1300 m. This is presumably due to physiological limitations (i.e. average temperatures are too low for reptiles to become active, avoid predation, digest food, etc.). Although we are reasonably confident that this threshold is real, additional surveys at higher elevation sites are warranted because of the uniqueness of the habitat and the limited amount work in this area. Reptiles have been recorded at higher elevations on other western Pacific islands (e.g. Solomon Island and Papua New Guinea), although these faunas are substantially older compared to Samoa's and have therefore had longer time spans to adapt to high-elevation environments (McCoy 2006, Allison 2007).

If new species discoveries are most likely to occur in the central Savai'i highlands, a logical question centers on why we did not target sites above 1300 m. The main reason is because the BIORAP approach demands that researchers prioritize where the most important information can be gained in a relatively small amount of field time. Here, our strategy was to overlap and extend the elevation sampling of the only previous survey ever conducted in this area (e.g. Fisher & Uili 2012b), with the intent of confirming or broadening the known elevation range for reptile occurrence. A focused, thorough effort at high elevation was beyond the scope of this survey given that it was quite possible that no reptiles would have been detected above 1300 m, and considerable knowledge gaps still existed at the lower elevations.

One lower elevation species with limited available information was the Pacific boa *C. bibroni*. The snake is considered rare in Samoa, but repeated occurrence records in all Samoa BIORAPs to date, combined with other factors, suggests that it may be more common than is currently recognized. Searches for *C. bibroni* have been largely limited to night surveys when the snake is expected to be most active – in this BIORAP, we observed all snakes during the day as they sought refuge in the leaf axes of tree ferns and cavities created by rotting bark of felled trees. One was also seen basking on a tree branch in the early morning. It is possible that the emphasis on visual night searches has resulted in low detection rates, and that when combined with the snake's secretive nature and the low frequency at which it is encountered by locals (with the exception of regular plantation workers), these factors have led to the perception that they are rare. We are not suggesting that night searches should be avoided, or that the snakes are common, or that they should not be protected. In fact, *C. bibroni* is often viewed with contempt, considered dangerous, the subject of folklore, and killed on sight. However, we advocate for increased daytime searching, with emphasis on disarticulating the leaf axes of tree ferns, exploring under root mats and vines that accumulate at the base of trees, removing bark from felled trees, and that plantation and forested areas be given equal attention.

Figure 2.8. The Pacific boa *Candoia bibroni.*

Other general findings include some noteworthy contrasts with previous field studies. For example, based on the presence of *E. cyanura* in certain areas where *E. nigra* is absent, Fisher and Uili (2012b) suggested that the larger *E. nigra* imposes limits on the distribution of the smaller *E. cyanura* due to predation; however, we found the two species co-occurring in at least three different sites (Taga access site to upland Savai'i, at Falealupo, and at Uafato). While the larger *E. nigra* may limit the densities of *E. cyanura* through competition or predation, results from this work show that the two can and do coexist at the same sites. Thus, while BIORAPs have added substantial baseline knowledge about reptile species' richness and distributions, much remains to be understood about the ecological determinants of those distributions.

4.2 Comments on invasive species

Non-native invasive species presumed to have adverse effects on the native reptiles of Samoa include both invertebrate and vertebrate taxa. One invasive species not detected at any survey sites was the House gecko *Hemidactylus frenatus*; however, the species was common at lodging accommodations and in villages near the coast. This gecko competes with or predates on native reptiles on other western Pacific islands (Bolger & Case 1992, Case et al. 1994, Petren & Case 1996, Cole et al. 2005; Cole and Harris 2011) and is known to invade natural areas (Cole 2005; Smith et al. 2012); thus, we advocate for continued monitoring of this species in Samoa and suggest that cautionary measures be taken to prevent its further spread.

For invertebrates, we emphasized detection of *A. gracilipes* because of its invasion success and adverse ecological effects on Pacific islands, including Samoa (Holway et al. 2002; O'Dowd et al. 2003; Boland et al. 2011; Smith et al. 2012; Hoffman *et al.* 2014). A major concern is its potential to infiltrate the central Savai'i upland rainforest, where native-species endemism could be high due to the uniqueness of the habitat. If these same native endemics are negatively impacted by *A. gracilipes*, successful ant invasion could potentially lead to their extinction because they simply have nowhere else to retreat to. For reptiles, *A. gracilipes* may have direct impacts through predation (i.e. ambushing lizards or attacking eggs), or indirect effects through displacement of native arthropods that the reptiles feed on (Holway *et al.*

2002; Hoffman *et al.* 2014). Distribution records for *A. gracilipes* on Hawaii also show that this ant has spread to as high as 900 m (Wilson and Taylor 1967; Gillespie & Reimer 1993; Reimer 1994). Our surveys revealed a slightly higher elevation maximum for *A. gracilipes* at A'opo (662 m) compared to the two previous Samoa BIORAPs. The highest record in the 2014 BIORAP was at 550 m on the slopes of the Falealila River (Edwards 2014), and Fisher and Uili (2012) documented *A. gracilipes* up to 519 m on the northern slope of Mt. Silisili. Both records are from Savai'i.

Based on these data alone we cannot conclude that *A. gracilipes* has expanded it elevation range within the KBA, as the same sites were not surveyed in the 2012 or 2014 BIORAPs (although both included survey areas within the same central Savai'i KBA). What we can say is that during our 2016 survey, we detected a well-defined elevation threshold at 662 m for *A. gracilipes* on the main road leading up to the lower camp and carpark. Beyond this point, we found no *A. gracilipes* on glue boards or during extensive visual surveys along the road and in the adjacent forest. Notably, we did not detect them at the carpark at 800 m, where substantial human traffic during the survey would have undoubtedly exposed them. Below the 662 m threshold and along the main jeep trail, *A. gracilipes* were easily seen under cover objects (logs, leaf litter, etc.) and at the base of tree trunks.

Our observational and glue board data suggest that *A. gracilipes* density differs depending on location (but see caveats below), and we suspect that their spread is multi-directional rather than purely being from coastal to more inland areas at higher elevation. The concern about spreading to higher elevation is legitimate given the sensitivity of Savai'i's upland habitat and the species within it, but other important ecological impacts related to *A. gracilipes* invasion dynamics could be missed if future studies remain too focused on the subject of elevational increase.

Fisher and Uili (2012) suggest that the absence of *E. adspersa* and other lizard species from the main area of *A. gracilipes* infestation along their elevational transect indicated sensitivity to the ants' presence; however, in this study we detected at least four *E. adspersa* in a small stretch of sandy habitat only at Falealupo, a site that was heavily infested with *A. gracilipes*. Other skinks (*E. nigra*, *E. cyanura*, and *E. impar*) and geckos (*G. oceanica* and *N. pelagicus*) were also abundant at Falealupo despite the ant's presence, and two *C. bibroni* were detected in this same KBA. While there is good reason to believe that *A. gracilipes* is adversely impacting Samoa's reptiles (Reimer 1994; O'Dowd et al. 2003; Boland et al. 2011; Smith et al. 2012), our findings combined with a lack of direct evidence supporting this conclusion argues for more studies that quantify the ants' true impacts. To attribute reptile declines to *A. gracilipes* without a firm knowledge of how they are directly or indirectly affecting these populations could be diverting attention from other aspects of the environmental degradation that are perhaps more damaging.

Figure 2.9. A log infested with *A. gracilipes*.

Previous work also attempted to quantify *A. gracilipes* abundance based on counts if individual ants from glue boards (e.g. Fisher and Uili 2012); however, we emphasize caution in this approach given that (1) the ants can be easily agitated if the area near a trapping station becomes too disturbed (i.e. the more foot traffic, the more likely we were to detect them at higher density if they were present), and (2) we had a number of instances where we observed *A. gracilipes* during visual surveys but did not detect them on traps in the same general areas. To remedy the first issue, (1) trapping stations be placed 3-5 m off the main trail; (2) a maximum of three people be used to set traps at a given station (one person setting traps, one recording data, and one flagging the station – only the person setting traps should go off-trail); (3) additional surveyors should move ~5 m beyond the trapping station during trap set-up; (4) avoid habitat disturbance off-trail. If trails need to be cut at sites known to have *A. gracilipes*, it is best if they are cut well in advance of surveys (i.e. 1-2 weeks). To remedy the second issue, we recommend that visual surveys always be conducted near the glue trap transects. This can be as simple as flipping logs, rocks, digging through leaf litter, or peeling bark off of felled or standing trees, but limited to when the traps are removed during the final check (to avoid agitating the ants).

We made numerous observations of the Asian Forest Centipede (*Scolopendra subspinipes*) along the lower transect at A'opo during a night survey. The only other site where we detected *S. subspinipes* was at Taga, but the density was markedly lower (*n* = 3; two along the banyan tree transect and one in a fern leaf axis in the plantation). Fisher and Uili (2012) report only one *S. subspinipes* from the ferry dock on Upolu. The high abundance of centipedes at A'opo was striking, although we observed most of them on the main jeep trail below 800 m. It is unclear whether the jeep trail, which was a well-worn two-track with compacted dirt, may have made them easier to detect, or whether they truly occur at higher density here compared to other sites (where walking tracks were laden with tree roots, rocks, and leaf litter). We suspect some combination of the two but are reasonably confident that *S. subspinipes* occurs at higher density at this particular site. This is because their large size and tendency to 'perch' in conspicuous areas make them difficult to miss in places where they are present. Effects of *S. subspinipes* on reptiles in Samoa are unknown, but the species is a voracious predator with toxic venom and feeds mostly on vertebrates, including reptiles, rats, bats and insects (Undheim and King 2011).

While it probably has limited or no effects on reptiles, we note the presence of the Giant African snail *Achatina fulica* in the Falealupo Peninsula KBA. Most of the snails appeared to be aggregated in an old plantation area, where we observed or captured numerous *E. cyanura*. In the 2014 RAP, *A. fulica* was reported only at the start of the Punaseesee-Mt Ve'a track (Savai'i) at 380 m (Edwards 2014).

4.3 Distributional limits for reptiles and implications of climate change

Islands are vulnerable to the effects of climate change because of their typically small size, low elevation, remote locations, and the tendency for human populations to cluster along the coastlines (Leong *et al.* 2014). With rising sea level and increasing air temperatures predicted by climate change models, the human population may be forced to move upslope into the more interior and currently less disturbed parts of Upolu and Savai'i, further reducing the remaining amounts of habitat that wildlife is able to occupy (Benning *et al.* 2002). Coincident with this transition could be the increased spread of non-native, invasive species, as the invasives tend to be more concentrated in disturbed areas (Leong *et al.* 2014).

While our surveys suggest that certain species are more tolerant of disturbance than others (e.g. *E. cyanura* vs. *E. impar*, respectively) and may therefore be less effected by climate change, others that are less tolerant of disturbance, have restricted distributions, and/or have specific habitat requirements may be more susceptible to extinction. This is particularly true for species that occur at higher densities near the coastline, where sea level rise could eliminate preferred habitat. These species include *G. mutilata*, *C. poecilopleurus*, and possibly *E. adspersa*, although Fisher and Uili (2012b) recorded one *E. adspersa* ~12.0 km inland at 688 m ASL. *Gehyra mutilata* and *C. poecilopleurus* are both rare species known from only a few areas, at least on Savai'I (see Gill 1993 for other records on Upolu), with *G. mutilata* seemingly having the highest degree of habitat specialization.

In contrast, more generalist species with broad elevation ranges may have room to expand upslope. The highest elevation record for reptiles in our survey was 1260 m, close to the 1320 m record from the 2012 BIORAP (surveys in the 2014 BIORAP did not reach these elevations). Both records were for *E. samoensis* at sites that were relatively close to each other on Savai'i (2318 m apart, straight-line distance from Google Earth). The fact that our glue board transects near and above 1200 m failed to detect lizards, combined with only one capture above 990 m in the BIORAP 2012, suggests that ~1300 m represents a thermal tolerance limit for reptiles in Samoa. Cooler night time temperatures and increased rainfall could mean that longer sunny periods during the day are needed to instigate lizard activity near this elevation, and that the absence of cloud cover may be even more critical for survey efforts compared to the lowlands (i.e. below 900 m). It is interesting that the highest record is for a large skink species, rather than one of the nocturnal geckos, which tend to be more tolerant of cooler conditions; however, lower nighttime temperature and increased rainfall at these elevations may simply be too extreme even for nocturnal geckos.

We note that weather conditions during surveys that approached or went beyond 1300 m ASL consisted of intermittent cloud cover, were overcast, and or it was raining. Similar conditions were reported in the 2012 BIORAP for transects near the same elevation (Fisher and Uili 2012), and Hathaway (2014) reports being rained out completely from one of their survey sites. Due to the dependency of reptile activity on weather and the short BIORAP time frame, additional surveys at sites where weather impeded previous efforts would be useful, particularly at ~900 m and higher. Inclement weather was a factor in our surveys at Transects 3 and 4 at Taga, Transect 6 in upland Savai'i, and Transects 9 and 10 at Uafato, which happen to be some of our highest transects.

In the Savai'i upland rainforest, one finding that adds support to the ~1300 m threshold hypothesis for reptiles was the near absence of orthopterans (i.e. crickets) on glue boards below 1000 m, where lizards were present, and the near 100% presence of crickets on all glue boards above 1200 m, where lizards were absent. In fact, our 1200 m campsite in upland Savai'i was notably more infested with crickets than all other campsites combined. As top predators of insects, these crickets almost certainly constitute a large portion of the lizard diet (although gut content data are needed to confirm this idea). The striking increase in the presence/abundance of crickets across the same elevation range where lizard presence/abundance markedly drops off suggests that the absence of a major cricket predator near the ~1300 m threshold may explain (among other things) the shift in cricket densities.

5. Recommendations

8. Sites where at least one trapping session was prevented by rain should be revisited to gain baseline information about reptile species occurrence and abundance at those sites. We also advocate for additional survey work above ~1300 m in the Central Savai'i uplands to confirm the absence of reptiles above this threshold, given that the potential for new species discoveries are highest in this area.
9. Manage and limit access to the upland rainforest in Central Savai'i – this is the best way to minimize disturbance to the habitat and prevent the further spread of non-native species.
10. Educate locals about the damage of human foot and vehicle traffic on the upland habitat, as well as accidental transport of non-native and potentially invasive species that could lead to the extinction of certain native species found nowhere else in the world outside of Samoa. Education should coincide with management so that locals have an understanding of the impacts of this activity and are directly involved with the safeguarding of this habitat. This would limit the perception of being 'policed' government regulatory agencies.
11. Provide training for local communities to develop strategies to aid in the protection of Samoa's biodiversity (non-exclusive of #3). Key to this endeavor is helping people understand why this is important and not simply an exercise. This starts with education about the historical biogeography of Samoa, and how that history has led to the evolution of a unique fauna and flora. Emphasis on endemism and extinction adds context to the importance of conserving biodiversity.
12. Conduct studies that investigate the impacts of *A. gracilipes* on the distribution and abundance of Samoa's land reptiles. To date, evidence supporting *A. gracilipes* as a leading cause of reptile declines in Samoa is speculative (although it is almost certainly true). Assuming rather than having definitive evidence in support of this hypothesis could be directing attention away from other important factors causing population declines. If certain reptile species are differentially effected by the ant's presence, it may be possible to focus ant eradication efforts (or prevent introductions) in areas known to support the more sensitive species. Investigations on *A. gracilipes* eradication on Nu'utele are ongoing (Hoffman *et al.* 2014) and baseline reptile data already exist for that island (Fisher *et al.*

2012a); thus, opportunities to examine reptile responses to *A. gracilipes* eradication are already in place in Samoa and merit serious attention. As climate change is predicted to increase the spread of *A. gracilipes* and other invasive species, it is important to understand the degree to which these species influence the current distributions and survival of native reptiles.

13. Conduct studies on the viability of cat eradication in the Central Savai'i upland rain forest. Cats have a clear presence in this high elevation habitat, and we observed direct predation of at least one native bird species. Removal of cats from this area would increase resilience and potentially decrease the risk of extinction in native species in this unique habitat. Certain techniques have already been used to success on islands and should be considered here (Nogales *et al.* 2004; Campbell *et al.* 2011)

14. Continue to monitor previously surveyed areas with the same protocols to assess stability in species composition and abundance at the different survey sites. The best way to test for effects of climate change, spread of invasive species, land conversion, and other factors potentially leading to species' declines is to detect 'early warning signals' that indicate disruptions in the status quo.

Acknowledgements

I am indebted to the Ministry of Natural Resources and Environment of the Government of Samoa, Conservation International Pacific Islands Program, and the local communities of Falealupo, Taga, A'opo and Uafato for the opportunity to participate in this research. Field and specimen prep efforts from all reptile team members – Fialelei Enoka, Jordyn Mulder, Maoluma Onesemo, Kim Keleti, Agape Timoteo, and numerous local villagers – were vital to the success of this project and the atmosphere of comradery that came along with it. In particular, I thank Fialelei Enoka for his relentless work ethic and for sharing his extensive local field knowledge. I thank Jordyn Mulder for efforts in assembling this report, guaranteeing the safe transport of our specimens, and general assistance with everything on the front and back ends of the trip. The 2016 BIORAP would have not been possible without the logistical support provided by Schannel van Dijken, Afele Faiilagi, Danita Strictland and Pualele Pene, all of whom went to great lengths to ensure that the major aims of this BIORAP were accomplished. I appreciated the numerous discussions and support from each science team, including Eric Edwards, Vilikesa Masibalavu, Mark O'Brien, Isaac Rounds, Arthur Whistler, the 'intern crew', and my Samoan friends/colleagues that provided key support for each team. I thank the skipper Fealofani Bruun and the crew of the Va'atele Gaualofa for the amazing sailing experience and close-out celebration at the end of the trip. Greg Shirley provided helpful comments on a draft of this report. Above all, I am grateful for the new friendships and shared life experiences that were provided to me during the course of this project.

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The reptiles field crew at the Falealupo Peninsula Coastal Rainforest KBA. Note the extreme level of happiness among all participants.

Appendix 2.1. Summary data for all preserved specimens from the Samoa 2016 BIORAP vouchered at the California Academy of Sciences (accession #'s CAS 260774-870). Datum for latitude/longitude coordinates are WGS84. JQR#'s are Richmond field tag numbers. All specimens have accompanying tissue samples for ongoing or future DNA studies.

Island	Site	Date	JQR#	Species	Age	Sex	Weight (g)	Length (mm)	Lat	Long
Savai'i	Falealupo	18-Jul	2219	*Emoia adspersa*	A	U	9.0	77.73	-13.49718	-172.70256
Savai'i	Falealupo	18-Jul	2175	*Emoia cyanura*	A	F	1.5	41.02	-13.52392	-172.74488
Savai'i	Falealupo	18-Jul	2188	*Emoia cyanura*	A	F	1.3	41.02	-13.52021	-172.74653
Savai'i	Falealupo	18-Jul	2173	*Emoia cyanura*	A	F	1.5	42.73	-13.52392	-172.74488
Savai'i	Falealupo	18-Jul	2180	*Emoia cyanura*	A	F	1.1	43.31	-13.51946	-172.74485
Savai'i	Falealupo	18-Jul	2178	*Emoia cyanura*	A	F	1.5	44.32	-13.51946	-172.74485
Savai'i	Falealupo	18-Jul	2184	*Emoia cyanura*	A	F	2.1	45.03	-13.52021	-172.74653
Savai'i	Falealupo	18-Jul	2179	*Emoia cyanura*	A	F	1.3	45.32	-13.51946	-172.74485
Savai'i	Falealupo	18-Jul	2183	*Emoia cyanura*	A	F	1.3	46.09	-13.51945	-172.74533
Savai'i	Falealupo	18-Jul	2186	*Emoia cyanura*	A	F	2.0	46.19	-13.52021	-172.74653
Savai'i	Falealupo	18-Jul	2189	*Emoia cyanura*	A	F	2.1	47.51	-13.52341	-172.75136
Savai'i	Falealupo	18-Jul	2191	*Emoia cyanura*	A	M	1.2	43.61	-13.52341	-172.75136
Savai'i	Falealupo	18-Jul	2182	*Emoia cyanura*	A	M	1.3	44.71	-13.51945	-172.74533
Savai'i	Falealupo	18-Jul	2181	*Emoia cyanura*	A	M	1.4	45.09	-13.51946	-172.74485
Savai'i	Falealupo	18-Jul	2185	*Emoia cyanura*	A	M	2.2	45.34	-13.52021	-172.74653
Savai'i	Falealupo	18-Jul	2176	*Emoia cyanura*	A	M	1.6	46.00	-13.52270	-172.74384
Savai'i	Falealupo	18-Jul	2171	*Emoia cyanura*	A	M	2.0	47.28	-13.52403	-172.74628
Savai'i	Falealupo	18-Jul	2190	*Emoia cyanura*	A	M	2.3	49.19	-13.52341	-172.75136
Savai'i	Falealupo	18-Jul	2177	*Emoia cyanura*	J	U	1.3	25.32	-13.51946	-172.74485
Savai'i	Falealupo	18-Jul	2174	*Emoia cyanura*	J	U	1.3	31.13	-13.52392	-172.74488
Savai'i	Falealupo	18-Jul	2187	*Emoia cyanura*	J	U	1.2	35.01	-13.52021	-172.74653
Savai'i	Falealupo	18-Jul	2172	*Emoia cyanura*	A	U	1.5	43.26	-13.52400	-172.74581
Savai'i	Falealupo	18-Jul	2216	*Emoia nigra*	A	M	24.9	101.67	-13.52341	-172.75136
Savai'i	Falealupo	18-Jul	2170	*Emoia tongana*	A	M	5.0	72.50	-13.49915	-172.76564
Savai'i	Falealupo	18-Jul	2192	*Gehyra oceanica*	A	U	6.3	38.28	-13.49789	-172.76381
Savai'i	Falealupo	18-Jul	2194	*Gehyra oceanica*	J	F	6.0	50.49	-13.49794	-172.76399
Savai'i	Falealupo	18-Jul	2198	*Gehyra oceanica*	J	U	1.0	34.70	-13.49699	-172.76226
Savai'i	Falealupo	18-Jul	2197	*Lepidodactylus lugubris*	A	F	2.3	39.84	-13.51837	-172.74791
Savai'i	Falealupo	18-Jul	2214	*Lepidodactylus lugubris*	A	F	2.0	43.00	-13.49764	-172.76317
Savai'i	Falealupo	18-Jul	2195	*Nactus pelagicus*	A	F	4.3	58.35	-13.52385	-172.74513
Savai'i	Falealupo	18-Jul	2217	*Nactus pelagicus*	A	F	4.1	60.22	-13.49914	-172.76593
Savai'i	Falealupo	18-Jul	2196	*Nactus pelagicus*	A	F	5.1	63.59	-13.52401	-172.74634
Savai'i	Falealupo	18-Jul	2193	*Nactus pelagicus*	A	F	6.1	71.27	-13.49837	-172.76479
Savai'i	Falealupo	18-Jul	2169	*Nactus pelagicus*	A	U	4.5	65.04	-13.52400	-172.74581

Island	Site	Date	JQR#	Species	Age	Sex	Weight (g)	Length (mm)	Lat	Long
Savai'i	Falealupo	19-Jul	2212	*Emoia cyanura*	A	F	1.7	44.47	-13.50657	-172.77146
Savai'i	Falealupo	19-Jul	2205	*Emoia cyanura*	A	M	1.1	39.29	-13.51958	-172.74582
Savai'i	Falealupo	19-Jul	2206	*Emoia cyanura*	J	U	0.3	31.72	-13.51958	-172.74582
Savai'i	Falealupo	19-Jul	2200	*Emoia nigra*	J	F	9.3	70.48	-13.50360	-172.77335
Savai'i	Falealupo	19-Jul	2199	*Emoia nigra*	A	F	27.5	98.99	-13.50360	-172.77335
Savai'i	Falealupo	19-Jul	2213	*Emoia nigra*	A	M	22.1	95.97	-13.50443	-172.77219
Savai'i	Falealupo	19-Jul	2207	*Emoia nigra*	A	M	33.0	105.83	-13.50046	-172.77623
Savai'i	Falealupo	19-Jul	2218	*Emoia tongana*	A	M	7.1	68.58	-13.49736	-172.76270
Savai'i	Falealupo	19-Jul	2202	*Gehyra oceanica*	J	F	3.2	52.30	-13.49732	-172.76260
Savai'i	Falealupo	19-Jul	2208	*Gehyra oceanica*	J	F	3.2	53.34	-13.49770	-172.76294
Savai'i	Falealupo	19-Jul	2210	*Gehyra oceanica*	J	F	4.3	54.53	-13.49770	-172.76294
Savai'i	Falealupo	19-Jul	2201	*Gehyra oceanica*	J	F	3.3	56.77	-13.49740	-172.76279
Savai'i	Falealupo	19-Jul	2211	*Gehyra oceanica*	J	F	5.2	57.04	-13.49736	-172.76270
Savai'i	Falealupo	19-Jul	2209	*Gehyra oceanica*	A	F	7.2	67.25	-13.49770	-172.76294
Savai'i	Falealupo	19-Jul	2203	*Gehyra oceanica*	A	M	7.2	71.06	-13.49732	-172.76260
Savai'i	Falealupo	19-Jul	2204	*Gehyra oceanica*	A	M	11.2	75.68	-13.49732	-172.76260
Savai'i	Falealupo	19-Jul	2215	*Lipinia noctua*	J	U	0.4	26.47	-13.49699	-172.76226
Savai'i	Taga	23-Jul	2231	*Candoia bibroni*	A	M	26.6	431.00	-13.73750	-172.50835
Savai'i	Taga	23-Jul	2228	*Emoia cyanura*	J	U	1.0	35.86	-13.73666	-172.50888
Savai'i	Taga	23-Jul	2225	*Emoia impar*	A	F	1.3	42.34	-13.72896	-172.51086
Savai'i	Taga	23-Jul	2226	*Emoia impar*	A	M	1.4	44.35	-13.73536	-172.50951
Savai'i	Taga	23-Jul	2227	*Emoia impar*	J	U	0.3	33.21	-13.73536	-172.50951
Savai'i	Taga	23-Jul	2222	*Gehyra oceanica*	A	F	5.1	60.22	-13.73750	-172.50867
Savai'i	Taga	23-Jul	2223	*Gehyra oceanica*	A	F	4.2	60.40	-13.73750	-172.50867
Savai'i	Taga	23-Jul	2221	*Hemiphyllodacylus typus*	A	F	0.3	35.31	-13.73750	-172.50871
Savai'i	Taga	23-Jul	2220	*Hemiphyllodacylus typus*	A	F	1.0	39.66	-13.73750	-172.50871
Savai'i	Taga	23-Jul	2224	*Hemiphyllodacylus typus*	A	F	1.0	41.29	-13.73750	-172.50867
Savai'i	Taga	23-Jul	2230	*Nactus pelagicus*	A	F	5.4	63.08	-13.71746	-172.51407
Savai'i	Taga	23-Jul	2229	*Nactus pelagicus*	A	F	7.6	70.00	-13.71746	-172.51407
Savai'i	A'opo	26-Jul	2233	*Emoia samoensis*	A	F	27.2	100.89	-13.58092	-172.50565
Savai'i	A'opo	26-Jul	2232	*Emoia samoensis*	A	M	27.1	107.90	-13.57469	-172.50592
Savai'i	A'opo	29-Jul	2240	*Candoia bibroni*	A	M	66.0	605.00	-13.65540	-172.51045
Savai'i	A'opo	29-Jul	2235	*Emoia cyanura*	A	F	2.0	45.15	-13.56963	-172.50751
Savai'i	A'opo	29-Jul	2236	*Emoia samoensis*	J	U	4.1	62.96	-13.56485	-172.51257
Savai'i	A'opo	29-Jul	2234	*Gehyra oceanica*	A	F	13.2	83.89	-13.56554	-172.51045
Savai'i	A'opo	29-Jul	2239	*Gehyra oceanica*	A	M	20.0	96.29	-13.56343	-172.51047
Savai'i	A'opo	29-Jul	2237	*Lipinia noctua*	A	F	1.2	47.79	-13.56343	-172.51053
Savai'i	A'opo	29-Jul	2238	*Lipinia noctua*	A	M	1.3	41.12	-13.56343	-172.51053
Upolu	Uafato	1-Aug	2261	*Emoia impar*	A	F	2.0	39.37	-13.95260	-171.50192

Island	Site	Date	JQR#	Species	Age	Sex	Weight (g)	Length (mm)	Lat	Long
Upolu	Uafato	1-Aug	2260	*Emoia impar*	A	F	5.1	47.41	-13.95697	-171.49510
Upolu	Uafato	1-Aug	2254	*Emoia impar*	A	M	3.2	47.64	-13.95253	-171.50127
Upolu	Uafato	1-Aug	2253	*Emoia nigra*	A	F	20.9	99.29	-13.95253	-171.50127
Upolu	Uafato	1-Aug	2255	*Emoia nigra*	A	M	21.1	96.40	-13.95242	-171.50125
Upolu	Uafato	1-Aug	2252	*Emoia samoensis*	A	F	15.3	91.47	-13.95255	-171.50128
Upolu	Uafato	1-Aug	2257	*Gehyra oceanica*	A	F	9.2	7.91	-13.95258	-171.50122
Upolu	Uafato	1-Aug	2258	*Gehyra oceanica*	A	F	12.0	88.33	-13.95258	-171.50122
Upolu	Uafato	1-Aug	2259	*Lipinia noctua*	A	F	1.3	37.66	-13.95258	-171.50122
Upolu	Uafato	1-Aug	2262	*Lipinia noctua*	A	M	0.4	39.37	-13.95260	-171.50192
Upolu	Uafato	1-Aug	2241	*Nactus pelagicus*	A	F	4.0	56.50	-13.95317	-172.49722
Upolu	Uafato	1-Aug	2256	*Nactus pelagicus*	J	U	0.3	30.88	-13.95706	-171.49561
Upolu	Uafato	2-Aug	2251	*Emoia nigra*	A	M	30.5	111.44	-13.94746	-171.51840
Upolu	Uafato	2-Aug	2249	*Emoia tongana*	A	F	4.1	63.34	-13.94883	-171.51752
Upolu	Uafato	2-Aug	2266	*Emoia tongana*	A	M	7.1	74.61	-13.95278	-171.50101
Upolu	Uafato	2-Aug	2263	*Gehyra oceanica*	A	F	8.0	70.08	-13.95278	-171.50101
Upolu	Uafato	2-Aug	2265	*Gehyra oceanica*	A	F	7.2	70.87	-13.95764	-171.52148
Upolu	Uafato	2-Aug	2242	*Gehyra oceanica*	A	F	10.0	74.50	-13.94767	-171.51614
Upolu	Uafato	2-Aug	2250	*Gehyra oceanica*	A	F	10.5	76.18	-13.94883	-171.51752
Upolu	Uafato	2-Aug	2245	*Gehyra oceanica*	A	F	10.5	82.34	-13.94795	-171.51900
Upolu	Uafato	2-Aug	2264	*Gehyra oceanica*	A	U	11.2	82.30	-13.95764	-171.52148
Upolu	Uafato	2-Aug	2248	*Lepidodactylus lugubris*	A	F	1.0	34.11	-13.94767	-111.51614
Upolu	Uafato	2-Aug	2247	*Lepidodactylus lugubris*	A	F	1.1	36.82	-13.94767	-141.51614
Upolu	Uafato	2-Aug	2246	*Lepidodactylus lugubris*	A	F	2.0	43.62	-13.94767	-171.51614
Upolu	Uafato	2-Aug	2243	*Lipinia noctua*	J	U	1.1	35.50	-13.94790	-171.51930
Upolu	Uafato	2-Aug	2267	*Nactus pelagicus*	A	F	5.6	62.11	-13.95448	-171.51833
Upolu	Uafato	2-Aug	2244	*Nactus pelagicus*	A	F	5.0	62.52	-13.95417	-171.51834

Appendix 2.2. Capture data from glue board transects during the Samoa 2016 BIORAP. JQR#'s are Richmond field tag numbers. Location refers to ground (G), log (L), or tree (T).

Island	Site	Date	JQR#	Species	Age	Sex	Weight (g)	Length (mm)	Transect	Station	Loc. (G, L, T)
Savai'i	Falealupo	18-Jul	2169	*Nactus pelagicus*	A	U	4.5	65.04	1	2	L
Savai'i	Falealupo	18-Jul	2171	*Emoia cyanura*	A	M	2.0	47.28	1	1	L
Savai'i	Falealupo	18-Jul	2172	*Emoia cyanura*	A	U	1.5	43.26	1	2	G
Savai'i	Falealupo	18-Jul	2173	*Emoia cyanura*	A	F	1.5	42.73	1	4	L
Savai'i	Falealupo	18-Jul	2174	*Emoia cyanura*	J	U	1.3	31.13	1	4	G
Savai'i	Falealupo	18-Jul	2175	*Emoia cyanura*	A	F	1.5	41.02	1	4	G
Savai'i	Falealupo	18-Jul	2177	*Emoia cyanura*	J	U	1.3	25.32	1	6	L
Savai'i	Falealupo	18-Jul	2178	*Emoia cyanura*	A	F	1.5	44.32	1	6	L
Savai'i	Falealupo	18-Jul	2179	*Emoia cyanura*	A	F	1.3	45.32	1	6	G
Savai'i	Falealupo	18-Jul	2180	*Emoia cyanura*	A	F	1.1	43.31	1	6	G
Savai'i	Falealupo	18-Jul	2181	*Emoia cyanura*	A	M	1.4	45.09	1	6	G
Savai'i	Falealupo	18-Jul	2182	*Emoia cyanura*	A	M	1.3	44.71	1	7	G
Savai'i	Falealupo	18-Jul	2183	*Emoia cyanura*	A	F	1.3	46.09	1	7	G
Savai'i	Falealupo	18-Jul	2184	*Emoia cyanura*	A	F	2.1	45.03	1	10	G
Savai'i	Falealupo	18-Jul	2185	*Emoia cyanura*	A	M	2.2	45.34	1	10	L
Savai'i	Falealupo	18-Jul	2186	*Emoia cyanura*	A	F	2.0	46.19	1	10	L
Savai'i	Falealupo	18-Jul	2187	*Emoia cyanura*	J	U	1.2	35.01	1	10	L
Savai'i	Falealupo	18-Jul	2188	*Emoia cyanura*	A	F	1.3	41.02	1	10	L
Savai'i	Falealupo	18-Jul	2189	*Emoia cyanura*	A	F	2.1	47.51	1	26	G
Savai'i	Falealupo	18-Jul	2190	*Emoia cyanura*	A	M	2.3	49.19	1	26	G
Savai'i	Falealupo	18-Jul	2191	*Emoia cyanura*	A	M	1.2	43.61	1	26	G
Savai'i	Falealupo	18-Jul	2198	*Gehyra oceanica*	J	U	1.0	34.70	1	21	T
Savai'i	Falealupo	18-Jul	2216	*Emoia nigra*	A	M	24.9	101.67	1	26	G
Savai'i	Falealupo	19-Jul	2199	*Emoia nigra*	A	F	27.5	98.99	2	40	L
Savai'i	Falealupo	19-Jul	2200	*Emoia nigra*	J	F	9.3	70.48	2	40	L
Savai'i	Falealupo	19-Jul	2205	*Emoia cyanura*	A	M	1.1	39.29	1	8	G
Savai'i	Falealupo	19-Jul	2206	*Emoia cyanura*	J	U	0.3	31.72	1	8	L
Savai'i	Falealupo	19-Jul	2207	*Emoia nigra*	A	M	33.0	105.83	2	49	G
Savai'i	Falealupo	19-Jul	2212	*Emoia cyanura*	A	F	1.7	44.47	2	32	G
Savai'i	Falealupo	19-Jul	2213	*Emoia nigra*	A	M	22.1	95.97	2	37	L
Savai'i	Falealupo	19-Jul	2215	*Lipinia noctua*	J	U	0.4	26.47	2	21	T
Savai'i	Taga	23-Jul	2225	*Emoia impar*	A	F	1.3	42.34	4	85	G
Savai'i	Taga	23-Jul	2226	*Emoia impar*	A	M	1.4	44.35	4	96	G
Savai'i	Taga	23-Jul	2227	*Emoia impar*	J	U	0.3	33.21	4	96	G
Savai'i	Taga	23-Jul	2228	*Emoia cyanura*	J	M	1.0	35.86	4	99	L
Savai'i	A'opo	26-Jul	2232	*Emoia samoensis*	A	M	27.1	107.90	5	101	L

Island	Site	Date	JQR#	Species	Age	Sex	Weight (g)	Length (mm)	Transect	Station	Loc. (G, L, T)
Savai'i	A'opo	26-Jul	2233	*Emoia samoensis*	A	F	27.2	100.89	5	114	T
Savai'i	A'opo	29-Jul	2235	*Emoia cyanura*	A	F	2.0	45.15	8	147	G
Savai'i	A'opo	29-Jul	2236	*Emoia samoensis*	J	U	4.1	62.96	8	162	T
Savai'i	A'opo	29-Jul	NA	*Emoia tongana*	A	M	10.5	78.00	8	168	L
Upolu	Uafato	1-Aug	2253	*Emoia nigra*	A	F	20.9	99.29	9	177	G
Upolu	Uafato	1-Aug	2254	*Emoia impar*	A	M	3.2	47.64	9	177	G
Upolu	Uafato	1-Aug	2255	*Emoia nigra*	A	M	21.1	96.40	9	176	G
Upolu	Uafato	2-Aug	2251	*Emoia nigra*	A	M	30.5	111.44	10	178	G

Appendix 2.3. Literature review of reptiles in the Apia catchment

Very little is known about reptiles occurring in the Apia catchments. Only three studies provide records from this general area: Zug and Ineich (1992), Gill (1993), and Hathaway (2014), with Gill (1993) representing the only published study. I have never been able to obtain a copy of the Zug and Ineich 1992 report and have only seen it referenced in other unpublished studies. The boundary of the study area in Hathaway (2014) potentially includes some of the Apia catchment's periphery, but was not specific to it.

Gill (1993) offers the most comprehensive assessment of the area for reptiles, including records from Tiavi (cross-island) Road and Afiamalu. From the catchment area, Gill 1993 reports two species of geckos (*Gehyra mutilata* and *Gehyra oceanica*) and one skink (Emoia cyanura). In summary, there has never been any comprehensive data collection on reptiles within the Apia catchment, and the limited existing data was summarized in a brief report nearly 24 years ago.

Gill B.J. 1993. The land reptiles of Western Samoa. *Journal of the Royal Society of New Zealand* 23:79-89.

Hathaway S. A. 2014. Reptile Survey. Pp 101-122 in Kerslake, F.Y and T. Pouli, editors. Baseline Ecological Survey - (July 2014) Lake Lanoto'o National Park & Laulii to Falevao Upolu Mauga o Salafai National Park – Savaii. Integration of climate change to forest management in Samoa - *ICCRIFS Technical Report Series No. 09*. Forestry Division, Ministry of Natural Resources and Environment (MNRE), Apia, Samoa.

Chapter 3: Report on the Survey of moths & butterflies (Lepidoptera) of the Falealupo Peninsula Coastal Rainforest, Central Savai'i Rainforest and Uafato-Ti'avea Coastal Rainforest

A *Thalassodes* species emerald moth in the Central Savai'i Rainforests KBA

Team Leader/Author: Eric Edwards
Survey Team: Taito Vaitoelau, Clive Fala from MNRE Water Resources Division & Forestry Division. Kiran Liversage, Conservation International Samoa volunteer staff. Claudia Bruschini National University of Samoa. Aishwarya Bhattacharjee (City University of New York), Michelle Gan, Ruifeng Zhong and Benjamin Liau (University of Singapore). Capacity building included A'opo, Falealopo and Uafato Villagers. Wider support from the other survey teams and CI staff from Samoa and Fiji was also provided.
Photo credits, © Eric Edwards

Summary

- Butterfly and moth information for the three recommended KBAs was able to be analysed in the context of other Samoan and Pacific wide information about Lepidoptera, vegetation pattern and the state and trend of ecosystems. The survey documents 329 taxa and over 180 species in detail.
- A five million year history of the current Samoan islands together with an older regional persistence of islands has supported the evolution of a unique biological identity. Many unique butterflies and moths (including unique genera) have populations within these three KBAs.
- The scale and integrity of the Central Savai'i Rainforest KBA should not be as assumed because other large oceanic island uplands are more impacted by pest invasions, human induced fragmentation processes and in some cases vulcanism. Both its irreplaceability and vulnerability to a range of threats have been identified (eg. see Atherton 2012). The entire central rainforest can be viewed as a single entity and would benefit considerably were this to occur.
- Uafato-Tiavea steeplands, Uafato-Tiavea Coastal Forest KBA is of Pacific wide significance. An ancient lowland biota is retained because of steepland resilience and because of the past and presentstewardship which has allowed native fauna to survive. Throughout many countries, the gradual trend is for lower altitude sites of indigenous natural character to be overcome and irreplaceably lost.
- Falealupo Peninsula KBA is also coastal lowland but has landforms, climate and ecosystems in contrast with Uafato-Tiavea and therefore complements the range of ecosystems or biodiversity still present. It has a depleted natural character with reduction of land-crab, bat and birdlife and invasion of lopa red bead tree Adenanthera parvonina in some parts. However, it retains important indigenous plant and invertebrate elements, is >700 ha in size and is a compact shape including coastal linkage. Its ecosystems could be described as vulnerable or endangered but not collapsed (see Rodriguez et. al. 2015). These ecosystems are also poorly protected for natural values among inhabited islands of the Pacific and therefore of much more than of national significance. Enhancing these values would also be an inspiring example of best practice for many others around the Pacific to follow.
- Key recommendations include:
  - Build on existing knowledge of butterflies and moths by further survey in the sites and in the region but most significantly at Malololelei –Upolu where most of the known moth fauna of Samoa was first collected. The purpose would be to identify changes at that site and to be able to better assess the significance of other areas such as the uplands of Savai'i and the steeplands of Uafato where many of the endemic species were rediscovered. This also builds a better picture of threatened butterflies and moths.
  - Investigate the impacts of introduced black rat and pacific rat in montane and cloud forests. These are likely to be severe as found among other Pacific islands.
  - Conduct a dialogue between all stakeholders and traditional owners of the KBA and other natural areas to formalise their aspirations for future management and protection of indigenous ecosystems and for ecosystem services from them.

1. Introduction

The United Nations Development Program (UNDP) funded the Conservation International Pacific Islands Regional Office to use a Biorap approach to investigate and report indigenous biodiversity values and threats to those values for three regions known to be of significance for biodiversity in Samoa. These were Uafato-Tiavea (eastern Upolu), Falealupo (western Savai'i) and Central upland Savai'i. The Biorap approach includes a rapid survey and reporting of plant and animal resources. This approach also includes working closely with local experts and building capacity and awareness among local communities. All parties, including village communities have engaged in similar such activity in other surveys (See Schuster *et. al.* 1996, Atherton and Jeffries 2012). The three regions are unique in biological character and complementary in representing examples of Samoa's pattern of terrestrial biodiversity.

1.1 Savai'i interior

The area of Savai'i uplands retaining important biological heritage value, is in excess of 40,000 ha spanning ~800 -1800 m altitude (Figure 3.1, Figure 3.10) across the interior of Savai'i. Surface water is rare and ephemeral in this area. Biodiversity is dominated by mainly forest ecosystems which change across subtly changing landforms and soils (Whistler 1978; Whistler 1992; DLSE 2000). All forests are non-merchantable (Whistler 1978; Lovegrove *et. al.* 1992; Brown 1997) and being upslope with little other utility, the place has no road or track access and no other infrastructure (Bier 1990; DLSE 2000). All Savaiian villages own land in this core region of Savai'i. There is no local, national or international status recognising either biological or cultural heritage value.

1.2 Falealupo forest (Savai'i)

Falealupo - Falealupo Rainforest Reserve, is a loosely defined area (~700 ha; Figure 3.1) of disturbed forest and coastal tall shrubland on gently dipping old basalt flow. It spans a coastal margin to around 120 m altitude. The tall shrubland component is a distinctive ecosystem type of slightly drier coastal margins (see Whistler 1992) and is uncommon and threatened in Samoa. The area has a village covenant limited to restricting commercial logging (Cox and Elmquvist 1991) and has no national legislative status recognising either biological or cultural heritage.

1.3 Uafato-Tiavea steeplands (Upolu)

Uafato-Tiavea has dramatic steep landforms derived from relatively old eroded basalts (Fepuleai 1999). The place includes over 1300 ha of steeplands dropping sharply to the coast from high points over 600 m altitude (730 m high point) with narrow short gully systems. Relict original vegetation communities occur in inaccessible areas. Plantation together with harvested and some disturbed vegetation occurs where access is difficult. Heritage conservation status has included an informal and loosely defined status on behalf of Uafato community -Uafato Conservation Area (New Zealand Department of Conservation *et. al.* 2007). This included recognition of living cultural use associations as well as biological heritage (UNESCO 2006). More recently in 2006, MNRE submitted to IUCN a World Heritage

Area proposal -the Fagaloa Bay -Uafato Tiavea Conservation Zone. This has not advanced to formal listing but remains on a tentative list (UNESCO 2006). Again, this is on the basis of cultural associations within the area having a link to the Lapita period (UNESCO 2006). Boundaries were also loosely defined. There is no national legislative status recognising Uafato-Tiavea biological heritage.

However, all three of these survey areas have been assessed as Key Biodiversity Areas (Atherton *et. al.* 2010) and in combination represent much of the range of Samoa's terrestrial heritage. But it is also important to recognise the difference in scale among these KBAs:

- The Savai'i uplands KBA is more than 20 times larger than Uafato-Tiavea KBA or Falealopo Rainforest Preserve KBA.
- The other aspect of scale is that these uplands (central Savai'i rainforest) receive community stewardship from all Savai'i communities whereas Uafato-Tiavea has at least two governing communities and Falealupo is governed by one community.

While the focus of this survey is to evaluate bio-heritage and make recommendations to facilitate conservation among responsible communities and agencies, the scale and community context will affect those recommendations.

Figure 3.1. 2010 map of proposed Key Biodiversity Areas (KBAs) for Samoa (CI 2010).

The Biorap is a contribution to the Strengthening Multi-Sectoral Management of Critical Landscapes (SMSMCL) project managed by MNRE. The SMSMCL is the first upscaling initiative by the Government of Samoa to:

- mitigate land degradation /increase soil carbon sequestration,

- contribute to poverty alleviation,
- adapt to climate change impacts,
- contribute to [local &] global environmental benefits.

1.4 Objectives of this project

1) To conduct field work/surveys for an Environmental Baseline Study (EBS) on the above key biodiversity areas.
2) To establish baseline biodiversity information –including invertebrate moth and butterfly information, needed for the revision and establishment of effective multi-sectoral conservation and management plans at each of these sites, and their surrounding areas, and
3) To establish planning, monitoring and reporting baseline information and indicators (species & habitats) for the SMSMCL project.

1.5 Invertebrate context

Insects, spiders and snails have key roles in their respective habitats recycling dead plant material and nutrients, plant dispersal, flower pollination and as prey for birds and bats. These are all examples of roles that caterpillars and adults of butterflies and moths perform in ecosystems.

The Samoan islands in their oceanic setting are east of the archipelagos of Tonga and Fiji. These islands are also geologically young with Savai'i the oldest island at 5.21 million years (Neall and Trewick 2008). Many moth and butterfly species have evolved to become unique to Samoa (Hopkins 1927; Meyrick 1927; Prout 1928; Tams 1935).

As well there are many species of moths and butterflies present that typically disperse widely across oceans. These commonly occur in the Papua New Guinea region and across island chains to Vanuatu, Fiji and Samoa (Tams 1935; Robinson 1975; Holloway 1979; Edwards 2012). Further links to Australia and to Asian islands and beyond are also known for many species that occur in Samoa. However, land masses east of Samoa are small and distant and hence many butterflies and moths have not colonized those islands and Samoa is therefore the eastern limit of distribution for some species (Robinson 1975, Holloway 1983).

The third element of the moth and butterfly fauna includes human assisted dispersal including invasive exotic pests of coconuts, thatching and crops for example (Swezey 1942; Edwards 2012).

2. Site descriptions and methods

Figure 3.2 is a map of the Lepidoptera survey sites for the three target KBAs. Two methods were used for butterfly and moth sampling. These included insect light trapping (Figure 3.3a, Figure 3.4). Otherwise butterflies and moths were collected by hand often with a sweep net in all three sites and in general survey (Figure 3.3b). A literature review of lepidoptera records from the Apia Catchments KBA was also conducted and is shown in Appendix 3.5.

Figure 3.2. Lepidoptera survey sites

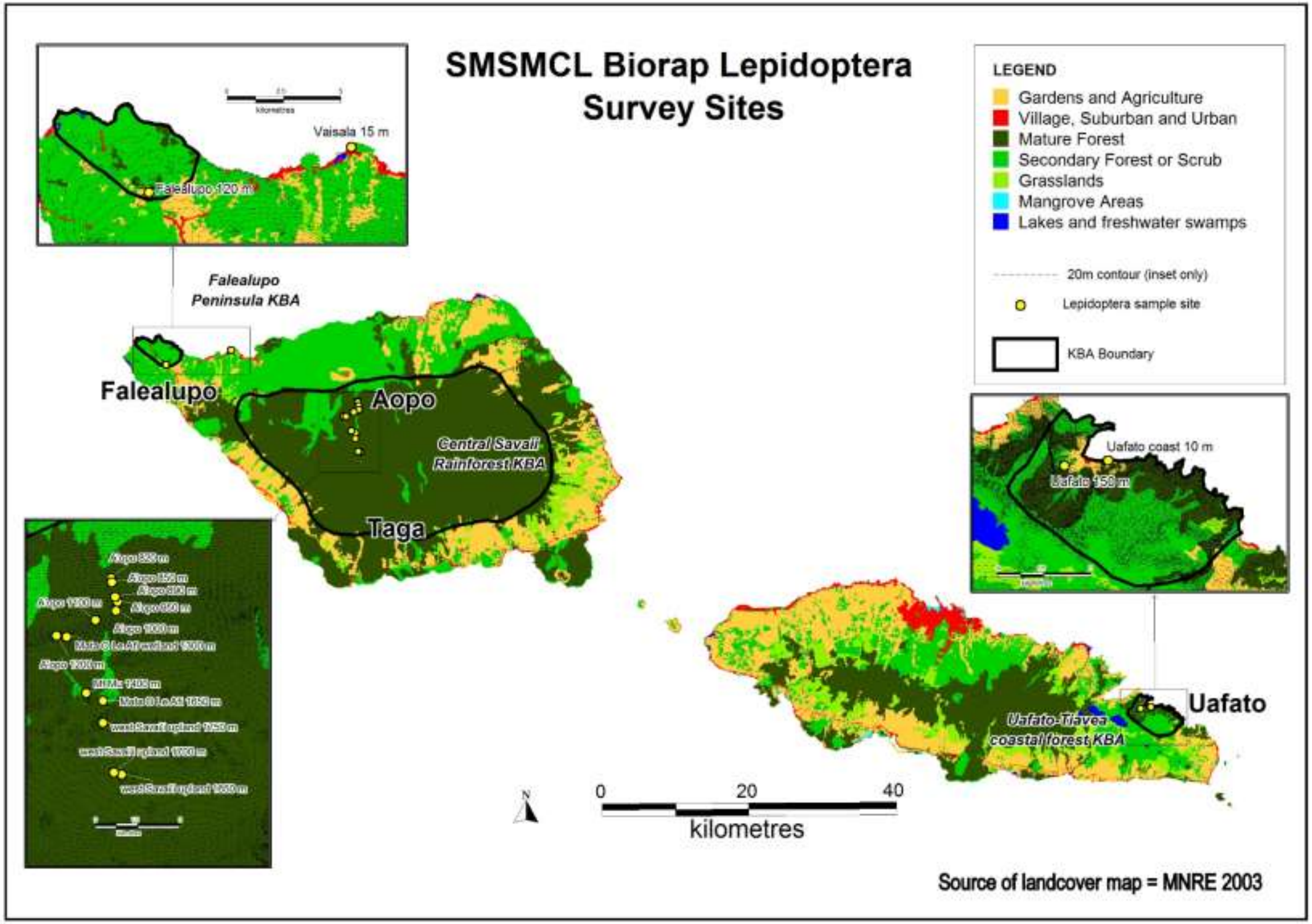

Figure 3.3 a,b. Invertebrate team preparing to light trap after dark on the side of a gully at Uafato-Tiavea site. Invertebrate team at Uafato Bay.

Insect light trapping begins at dusk and continues for about three hours. A 240 volt AC, 120 watt mercury vapour ballasted ultraviolet light powered by a portable generator was used to attract moths and other winged insects. A large white sheet is placed on the ground and the light placed in the middle (Figure 3.4). Expedition team members captured specimens of as many species as possible individually in small plastic jars to be later preserved and identified.

Simple hand collecting techniques were based on observing moths in a range of habitats and capturing samples in small plastic jars for later curation. A sweep net was also used aerially or through vegetation to capture moths and butterflies. Observations were made during the night as well as in daylight.

Figure 3.4. Light trapping team working at cloud forest camp -Mata O Le Afi 1650 m, Central Savai'i Rainforest.

3. Collections

Figure 3.5. A typical setting board being used during the survey at the cloud forest camp site Mata O Le Afi, Central Savai'i Rainforest.

While moths and butterflies were the key target, a general collection of invertebrates was made including beetles, flies, wasps, bugs, spiders, and smaller invertebrate orders (see Figure 3.5) for later analysis and reporting elsewhere. Collections will eventually be housed in the New Zealand Arthropod Collection (NZAC) in Auckland with most material presently held by the author for analysis and determination of new species. NZAC is an institutional insect collection with a strong representation of historic collections from many Pacific Islands – particularly Lepidoptera (i.e. moths and butterflies). Some of the material can potentially be studied in association with other institutions with Pacific collections such as the Bishop Museum in Honolulu.

3.1 Process of identifying taxonomic richness

Identification of taxa curated from the expedition was carried out by comparison with other collections and by use of published works for Fiji, Samoa, French Polynesia, Hawai'i and Australia. Many species may only be determined by detailed dissections of genitalia (in entomology these characteristics are often the only morphological features that distinguish species) and comparison with original type specimens and, in some cases, may be new to science. Where a taxon is tentatively assigned to a species then that species is assumed when interpreting and summarising information. If this is the situation in referring to a species in the text then it will appear as "cf." followed by a species name with which the author is confident is the same albeit not positively confirmed. Many caterpillar host plant associations were drawn from literature for moths.

Moths were assessed as introduced/exotic (and often but not always a pest) where they are reported to have spread or had human assistance to invade many Pacific islands or many other countries globally. A species can also be assessed as introduced if their caterpillars are only able to eat exotic plants.

4. Results

4.1 Moths and butterflies –Lepidoptera

The team found ~329 kinds of moth and butterfly, of which 192 larger species from 18 Families were identified to genus and mostly species level (Table 3.1, Appendix 3.1). Most were large bodied moths including butterflies (Families Hesperidae, Peridae, Lycanidae and Nymphalidae) and moths (Families: Pyralidae, Crambidae, Geometridae, Sphingidae, Uraniidae, Erebidae, Nolidae and Noctuidae) (Table 3.1, Appendix 3.1). Moths not identified were small and often tiny micro-moths. Micro-moths for Samoa include many species new to science that have either no formal published name or require dissection and comparison with Type specimens (usually in British and European collections).

Most of the moths were sampled at night time using a light trap while all of the butterflies and a few of the moth species were sampled during the day and mostly in mornings. Vaisala (NW Savai'i) had the lowest number of species records (Table 3.1) but this was probably due to the urban environment and the presence of night time street lights that compete with the light trap. Falealupo (west Savai'i) is a modified forest edge with low plant diversity and exotic species present. Forty two of 78 species were larger bodied species (Table 3.1.) recorded here in relatively dry calm conditions under a sparse canopy with little understory. A few moths and butterflies were recorded during the day but as for the other sites the majority of the species were recorded by using a lighttrap after dark. Uafato was the richest of the lowland sites during the survey (Table 3.1) although similar to the high cloud forest site sampled at Mata O Le Afi. The species composition between lowland and montane sites often had little in common (see Appendix 3.1). Overall, the richest site was natural slope forest in the upper montane zone of Savai'i above A'opo (Table 3.1).

Appendix 3.1 also shows exotic moths and pest species that have caterpillars on pumpkins, cucumbers, serials dried vegetables, palm thatching, coconut plantations, 'ulu breadfruit, 'umala sweet potato, beans, talo (taro) and other crops.

Table 3.1. Observed species richness among butterflies and larger bodied moth Families. The number of species sampled in each site is listed by Family. **(1) Families analysed in this report;** includes all the butterfly families and the larger bodied moths. 13 Families and 182 species in total. Most could be identified as published species and interpreted in detail. **(2) Remaining reported families;** includes many families and species of small-bodied moths. Most of these were not associated with published names and could not be discussed in detail.

(1) Families analysed in this report	Total all sites	Vaisala	Falealupo	Uafato	Montane A'opo	Upland Mata O Le Afi
Hesperidae	1	1	-	-	-	-
Peridae	2	1	2	1	-	-
Lycaenidae	5	1	3	2	-	-
Nymphalidae	8	1	1	5	2	-
Pyralidae	9	-	1	6	3	2
Crambidae	61	4	17	22	34	20
Uraniidae	4	-	1	2	1	-
Thyrididae	2	-	2	1	1	-
Sphingidae	2	-	-	2	-	1
Geometridae	27	4	7	10	20	10
Erebidae	31	2	3	6	22	15
Nolidae	14	2	2	7	5	-
Noctuidae	16	3	3	8	4	11
Totals of analysed families	**182**	**19**	**42**	**72**	**92**	**59**
(2) Remaining Families[1]						
Tortricidae	40	2	3	12	16	22
Alucitidae	1				1	
Immidae	2	1	1	2	1	
Lacturidae	1			1		
Pterophoridae	1	1				
Undetermined taxa among >12 families	102	8	32	22	48	19
Grand total	**329** recognised taxa (see Appendix 3.1.)					

[1] Micro-Lepidoptera identified as Recognisable Taxonomic Units (RTU's) but not able to be identified using formal published taxonomy to species level

Table 3.2. Ten species of moth recorded in the survey for the first time since they were originally collected and named.

Moth species	Sites	Year previously recorded	Moth family
Adoxophyes libralis	Uafato	1924	Tortricidae
Latagognoma dacryodes	above A'opo 1200m; Mata O Le Afi	1923	Pyralidae
Odontopaschia stephanuchra	Uafato	1925	Pyralidae
Thylacoptila gonylasia	Uafato	1924	Pyralidae
Exeristis pollosta	Falealupo; Mata O Le Afi	1924	Crambidae
Glaucocharis amydra	Uafato	1925	Crambidae
Cyclophora hypocris	above A'opo 1200m	1924	Geometridae
Epiplema lypera	above A'opo 1200m	1924	Uraniidae
Cymodegma buxtoni	above A'opo 1200m	1924	Erebidae
Mormecia lachnogyia	above A'opo 1200m	1924	Erebidae

Ten species of moth collected in the 1920's (Table 3.2) are reported from this survey for the first time since they were originally described. All were described by Tams (1935) with the exception of the Geometrid moth *Cyclophora hypocris* which was described by Prout (1927). Five species of moth described from Samoa are endemic at the Genus level (Tams 1935) and all five are montane and upland species and were recorded in this survey (Table 3.3.).

Table 3.3. All five species of moth known for Samoa to be endemic at the Genus level were recorded in the survey. The sites recorded in the survey as well as other recent surveys by Edwards (2012 & 2015) also shown.

Species	Sites	Moth family
Latagognoma dacryodes	above A'opo 1200m; Mata O Le Afi	Pyralidae
Cymodegma buxtoni	above A'opo 1200m	Erebidae
Machaeropalpus fasciatus	above A'opo 1200m	Erebidae
Mormecia lachnogyia	above A'opo 1200m	Erebidae
Anomocala hopkinsi	Mata O Le Afi; Mt. Te'elagi south crater 1360m; Mt Vea cone 830m	Noctuidae

4.2 Butterfly and moth records of note

The Samoan eggfly butterfly *Hypolimnas errabunda* is endemic to Upolu and Savai'i. Adults were not confirmed in the survey at any of the sites. However, its caterpillar (Figure 3.6a) was found in rough grazing land above Aopo (Savai'i) at 520 m elevation. When this unique butterfly was described by Hopkins in 1927 its caterpillar host plant was confused being described as *Cudrania* (a doubtful genus in Moraceae) and also the Urticaceae Family (Hopkins 1927). Swezey (1942) discovered caterpillars on *Cypholophus macrocephalus*

(Family Urticaceae; Afiamalu upper Cross Island Road Upolu). These were reared to adult butterflies. Our survey record now confirms Swezey's (1942) finding.

Figure 3.6 a. A caterpillar of the Samoan endemic butterfly *Hypolimnas errabunda*. Found at 520 m altitude above A'opo. And **Figure 3.6 b.,** endemic Samoan ranger butterfly *Phalanta exulans* from slope forest ~900 m Central Savai'i Rainforest.

The Samoan ranger butterfly *Phalanta exulans* (Figure 3.6b.) is endemic to Upolu and Savai'i and is Samoa's highest dwelling butterfly. We observed a number of individuals in the forests above A'opo up to 1000 m elevation. Its caterpillars are hosted on a common tree of disturbed forest, *Melicytus samoensis*. The Samoan ranger or its caterpillar host tree were not seen at any of the other sites during the survey (see Whistler this report for information about *M. samoensis*). However, it is possible the butterfly and *M. samoensis* might be present in remote parts of the Uafato -Tiavea area.

Figure 3.7 shows an undescribed species from the Carposinidae Family (listed in Appendix 3.1 as "Micro sp. 47"). This is one example from the survey which recorded ~150 species from micro-moth families and most of these are unidentified (Appendix 3.1). Many of these were from montane and cloud forest sites (Appendix 3.1). Meyrick (1927), Swezey (1942) and Comstock (1966) collectively recorded around 150 micro-moths in various Families from Samoa. Meyrick (1927) notes very many more species need to be described and perhaps 60% of these are likely to be endemic to Samoa (Meyrick 1927). Some examples from the survey of undescribed moths that are likely upland Samoan endemics include the following species recorded in Appendix 3.1: *Glaucocharis* sp. A., *Schrankia* sp. A. and *Scotocyma* sp. 'long palpi'.

Figure 3.7. An undescribed cloud forest moth in the family Carposinidae (fruit-worm moths) from Mata o Le Afi 1650 m Central Savai'i Rainforest. Scale, wing is 10 mm across.

The large moth *Tiracola rufimargo samoensis* (wingspan 55 mm) was found during the survey to be very abundant during night time light trapping and were discovered in hundreds of thousands in flower panicles of the upland tree *Reynoldsia pleiosperma* (Figure 3.8). This is a common tree across several thousand hectares of Savai'i. A sister tree *Reynoldsia lanutoensis* is endemic to the uplands of Upolu where *T. r. samoensis* is also recorded.

Figure 3.8. Flowering panicles of the upland Savaiian endemic tree *Reynoldsia pleiosperma*. Note the many moths of *Tiracola rufimargo samoensis* attracted.

During the 2012 survey at Mata O Le Afi 1650 m (Atherton and Jefferies 2012), we observed a fruit-bat roost in a *Reynoldsia* tree. A cat was also seen in the same tree and cat scats were common. In the July 2016 survey of the same site, no bat roost was evident but cat scats and one cat was again seen. Seasonal abundance of *T. r. samoensis* is likely to be an important food source for cats and also two species of rat that are present.

Phassodes vitiensis (Figure 3.9) is the sole ghost moth species recorded from Samoa. It has a wing span of 100 -125 mm and has been recorded from June to November (Tams 1935; Comstock 1966 –Bishop Museum specimen). It is native to both Samoa and Fiji with Robinson (1975) describing it as a dry season species in Fiji. No recent records have been made in Samoa (Edwards 2012, Edwards 2015; and this survey 2016) and Fijian records have also been few (see Clayton 2012). This moth appears at least rare and its status should be assessed (e.g. *sensu* IUCN Red List) for threat of extinction.

Figure 3.9. Large ghost moth *Phassodes vitiensis*. Specimen and image from Bishop Museum, Hawai'i, Jim Boone by permission.

Table 3.4. The number of endemic species and exotic species identified in the three most speciose moth Families (Crambidae - 48 species out of 61 were categorised; Geometridae - 23 out of 27; Erebidae - 28 out of 31). The same calculation is totalled for the combined 13 Families of larger butterflies and moths noted in Table 3.1 above.

Category	Crambidae		Geometridae		Erebidae		All larger moths & butterflies	
Samoan endemic	19	40%	5	22%	14	50%	54	35%
Introduced	16	33%	1	4%	3	11%	34	22%
Native & found elsewhere	13	27%	17	74%	11	39%	65	42%
Total	48		23		28		153	
Unknown (uncategorised)	13		4		3		29	

Categories: "Samoan endemic category" includes moths only found in the Samoa's including American Samoa; "Introduced category" includes moths putatively brought to Samoa often by accident; "Category of Native & found elsewhere" denotes species indigenous to the Samoan islands as well as other countries such as Fiji and Australia.

While the Lepidoptera diversity signals indigenous dominance, there is a high proportion of exotic establishment. Table 3.4 shows that in the richest family of moths (the Crambidae where 48 species were categorised), one third are assessed as exotic introduced species. Without this level of invasion, the proportion of endemic Crambid moths unique to Samoa would otherwise be well over 50%. Geometrid moth diversity is lower and a high proportion of Geometrids are naturally widely dispersed in the Pacific and elsewhere. Across all the Families of larger moths sampled, the proportion of endemics is around 35% and exotic species are over 20% of the fauna.

Table 3.5. below, compares the number of species of moths recorded from light trapping at three sites. Uafato is at low elevation in a semi-natural steepland that has been occupied for many centuries. A second site included forested slopes at 1200 metres elevation above A'opo. This is a slope with a complex natural forest that has never had a road or dwelling. The third site Mata O Le Afi is at high elevation and has a complex habitat pattern of *Reynoldsia* dominated forest, tall shrubland, open heath shrubland and lichen/grass/herb cinderfield.

The greatest species richness was recorded at mid altitude above A'opo. The overall number of moth species was much the same between low altitude Uafato and high altitude Mata O Le Afi (Table 3.5). However, Appendix 3.1. shows that many moth species were different between these two sites. Table 3.5 also shows the number of introduced moths at low elevation was twice what was recorded at the high elevation Mata O Le Afi.

Table 3.5. Shows the number of species of larger bodied moths recorded at a light trap for three sites. Uafato Upolu is at low elevation. Slopes above A'opo Savai'i are at intermediate elevation (but well above merchantable timber harvest line) and Mata O Le Afi 1650 m is at high elevation.

Category	Uafato 150 m		A'opo 1200 m		Mata O Le Afi 1650 m	
Samoan endemic	13	27%	30	41%	20	39%
Introduced	15	31%	12	16%	7	14%
Native & found elsewhere	21	43%	32	43%	24	47%
Total categorised	49		74		51	
Unknown (uncategorised)	10		14		2	

Categories: as above in Table 3.4

Table 3.6. shows that half the species of moths categorised as restricted to Fiji and Samoa (11 out of 21 species) are also restricted to montane and cloud forests (550 metres elevation and above). This suggests that so long as upland habitats are available, dispersal to distant upland habitat might be as frequent as for other larger bodied species not restricted to uplands.

Ten species of moth previously only known from Fiji were recorded during the survey in Samoa (Table 3.6) and five of those are montane –cloud forest records. Three of the low altitude records are leafroller moths (Family Tortricidae) which are still largely undocumented for both countries (but see Razowski 2016a; Razowski 2016b and Appendix 3.1). Two other new Samoan records were moths also known from Tonga and one from Rotuma –a northern Fijian island whose fauna is often considered distinct from the rest of Fiji and with elements in common with Samoa (Holloway 1983). Two of the newly recorded upland Geometrid moths

Chloroclystis nina and *Cyclophora* cf. *harrietae* (Table 3.6.) are described as montane species and rare for Fiji (Robinson 1975). The Geometrid *Sauris priva* is described as exceptionally rare for Fiji (Robinson 1975) (Table 3.6.).

Table 3.6. List of moths identified in the survey, limited to Samoa and its neighbour countries.

Key to country associations:

S,F =Samoa + Fiji | S,T,F =Samoa + Tonga + Fiji
S,T =Samoa + Tonga | S,R =Samoa + Rotuma (north Fiji)
S, Nuie =Samoa + Nuie | (prob.) =A tentative but likely species has been interpreted
M+ =montane & upland or elevations above 550 m
new record =newly recorded in Samoa this survey

Family	Taxon	Countries	Notes
Crambidae	*Calamotropha dielota*	S,F	new record
Crambidae	*Leucophotis pulchra*	S,F	
Crambidae	*Piletocera albescens*	S,F	
Geometridae	*Cleora fowlesi*	S,F	
Geometridae	*Casbia cf. alphitoniae*	S,F (prob.)	new record
Nolidae	*Etanna vailima*	S,F	
Immidae	*Imma philonoma*	S,F	
Tortricidae	*Daedaluncus fijiensis*	S,F	new record
Tortricidae	*Icelita cf. grossoperas*	S,F (prob.)	new record
Tortricidae	*Trymalitis cf. macarista*	S,F (prob.)	new record
Crambidae	*Aphrophantis velifera*	S,F	M+
Crambidae	*Eudonia cf. orthioplecta*	S,F (prob.)	M+
Crambidae	*Phostria oconnori*	S,F	M+
Geometridae	*Asthena eurychora*	S,F	M+
Geometridae	*Chloroclystis nina*	S,F	M+, new record
Geometridae	*Cyclophora cf. harrietae*	S,F (prob.)	M+, new record
Geometridae	*Gymnoscelis cf. sara*	S,F (prob.)	M+, new record
Geometridae	*Sauris priva*	S,F	M+, new record
Erebidae	*Leptotroga armstrongi*	S,F	M+
Noctuidae	*Aegilia vitiscribens*	S,F	M+, new record
Tortricidae	*Strepsicrates glaucothoe*	S,F	M+
Crambidae	*Agrioglypta cf. enneactis*	S,T,F (prob.)	new record
Geometridae	*Comostola rhodoselas*	S,T,F	
Geometridae	*Cleora samoana*	S,T,F	
Geometridae	*Idaea rhipistis*	S,T,F	new record
Peridae	*Appias athama manaia*	S,T	(subspecies)
Erebidae	*Schrankia cf. furoroa*	S,R (prob.)	new record
Lycaenidae	*Jamides argentina*	S, Nuie	

4.3 Additional observation

First record of a frost event for Samoa

Location: Mata O Le Afi cinderfields 1650 meters above sea level, 13.61091°S 172.51791° W (Appendix 3.4.). See pictures in Appendix 3.2.

During July 2016, A trail cutting team from A'opo and Conservation International –Apia visited Mata O Le Afi camp area and left on 30th June. A member of that party, Schannel van Dijken observed no browning or withering of vegetation in the sites before the track marking team left. The Survey Teams then arrived 26th July 2016 26 days later. We saw extensive and recent uniform vegetation withering within two basin areas (Appendix 3.2.). There was a sudden transition to unaffected vegetation near the upper margin of these basins and on tree canopies emergent from one of the basins (Appendix 3.2). This is evidence of a cold air ponding event and leaf frost damage that has occurred during night time –early morning with little wind. Cold air being denser than warm air has drained into these basins and the temperature has dropped below zero degrees Celcius for perhaps more than an hour causing leaf tissue damage right across the basin on ferns, grasses and shrubs.

Vegetation in these basins appears to be structured by such events which we suggest occur during infrequent episodes every few years. The ground is free draining and cinder in the area is a poor soil for forest development. But the additional stress from forest episodes reducing plant establishment appears to have restricted forest and shrubland development and favoured a stable cover of grasses and *Blechnum* spp. ferns (see Appendix 3.2). This creates a small but unique natural class of ecosystem for a tropical Pacific island.

5. Discussion

By focusing on butterfly and moth (Lepidoptera) fauna, this survey has achieved a detailed analysis of four Sampling sites in three tentative KBAs (excluding Vaisala –an urban site of low natural character). Insights are many and show for example:

- Falealupo Rainforest site has distinctive vegetation but of low complexity (Whistler this report). The Lepidoptera fauna was rich in micro-moths but otherwise not well sampled- apart from day active butterflies and moths. Most of these were native including *Exeristis pollosta* which has not been seen since the 1920's. Future survey near forest plot sites would more accurately characterize the fauna matching this area's distinctive classes of vegetation. Examples include coastal rock platform *Capris cordifolia* shrubs which support good populations of caper white butterfly (*Belenois java schmeltzi*) and Eastern Pacific Albatross butterfly (*Appias athama manaia*).
- Uafato-Ti'avea lowland steeplands retain a rich Samoa fauna of moths including four species from the survey that have remained undocumented since they were first discovered in the 1920's (Table 3.2). The nationwide assessment of remaining lowland areas retaining natural character done in 1992 (Lovegrove *et. al.* 1992) identified Uafato-Ti'avea as the most significant lowland rainforest site for Upolu. This fauna survey done 24 years later still supports their finding. However, these lowlands are

also invaded (~30% of the moths are assessed as exotic Table 3.5) including many pest species (Appendix 3.1). This is most likely characteristic of lowlands elsewhere in Samoa.

- Slope forest at 1200 m elevation on the flank of the Savai'i central uplands appears outstanding in its faunal associations. It lacks butterflies probably because of the cool and wet conditions found at this height. But stands out with a diversity well above that recorded for lowlands. The number of exotic moths recorded was only a little less than the lowland sites but the number and proportion of endemics including four out of the five known endemic genera is significant (Table 3.5). We recorded five species here not noted since the 1920's. The site is well upslope from the maximum elevation for merchantable timber and therefore much less invaded by exotic plants and insects (Whistler 2012, Edwards 2012, Brook 2012, Whistler this report, Table 3.5 above).
- Most of the original records of moths described in the 1920's and 1930's were from Malololelei which is near the top of Cross Island Road (Upolu) at about or above 600m elevation. This site is also montane (see Whistler 1992). It would add significant insight to re-survey a natural or semi-natural area close to the original Malololelei 'Type Locality' and then compare with the results of this survey.
- Higher upslope at 1650 m elevation we sampled a complex of vegetation types spanning forest, heathland and cinderfield with bare ground the dominant cover. Species richness was reduced and similar to that recorded in the lowlands (Table 3.1, Table 3.5.). However, the exotic species component was low and many interesting undescribed species of moth are noted including some large Geometrid and Crambid moths (see Appendix 3.1). A large emerald moth species of the Genus *Thalassodes* inhabiting hardwood shrub is widespread and common in the cloud forest. Similarly, the Geometrid *Scotocyma* 'long palpi', Crambid *Bradina* (sp. C.), and many others are also common (see Appendix 3.1).
- This survey extended our understanding of the faunal relationship with Fiji and montane Fijian moth fauna (see Table 3.6 which also notes many new records). The scale, integrity and significance of the Savai'i uplands as an eastern outpost of Melanesian fauna is shown by its clear association with Fiji's mountains as well as its own high level of endemism within the Samoan islands.

5.1 Applying the principles of KBAs (Key Biodiversity Areas)

KBAs are an essential tool for governments to honour their mandate to conserve natural heritage/indigenous birds, plants and other wildlife for future generations. It can focus the efforts of governments and environmental NGO's. The context is often global asking the question is a site's biodiversity of international significance? Context may also be national –is the site of national significance for its biodiversity?

Village stewardship or governance may have little relationship to an external analysis that identifies whether a site does or does not have significance globally for biodiversity value. Therefore, other village centered processes will be vital in determining environmental management including, how a sites' biodiversity is protected against irreversible loss and instead protected for the future.

For the purposes of this report “irreplaceability”, “vulnerability” and “conservation needs of target species” are defined as below (cited from definitions used for KBAs):

“The ***irreplaceability*** (or uniqueness) of a site is the degree to which geographic (or spatial) options for conservation will be lost if that particular site is lost (Pressey *et. al.* 1994)” (in Langhammer *et. al.* 2007).

“***Vulnerability*** (or threat) refers to the likelihood that a site’s biodiversity value will be lost in the future (Pressey and Taffs 2001).

- Thus, vulnerability can also be seen as a measure of irreplaceability, but over time, rather than space.
- Thus, highly vulnerable sites can either be protected now or never. Sites facing low threat will retain options for conservation in the future.
- Vulnerability may be measured on a site basis (likelihood that the species will be locally extirpated from a site) or a species-basis (likelihood that the species will go globally extinct).” (from Langhammer *et. al.* 2007)

“The best way to ensure that the conservation needs of target species [& ecosystems] are met is to define the boundaries of each spatial unit based on existing land management units. Because land management units are the scale at which site conservation actually takes place, they make the most relevant conservation planning units.” (also from Langhammer *et. al.* 2007).

6. Recommendations

1. Build on existing knowledge of butterflies and moths by further survey in the sites and in the region but most significantly at Malololelei –Upolu where most of the known moth fauna of Samoa was first collected. The purpose would be to identify changes at that site and to be able to better assess the significance of other areas such as the uplands of Savai’i and the steeplands of Uafato where many of the endemic species were rediscovered. This also builds a better picture of threatened butterflies and moths.
2. Identify populations and habitats of the spectacular ghost moth Phassodes vitiensis in both Samoa and Fiji since this moth has not been recorded from Samoa since 1924, American Samoa since early 1960s and is rarely recorded in Fiji. This moth is large and likely attracted to night time lights and so would not be mistaken. A taxonomic investigation of Samoan Phassodes may also identify an endemic new species.
3. Survey Falealupo Peninsula and Uafato-Tiavea proposed KBAs outside of the dry season for the potential presence of four cryptic endemic butterflies including Samoan dart Oriens augustula alexina, Samoan eggfly Hypolimnas errabunda, Samoan ranger Phalanta exulans (caterpillar host Melicytus samoensis not recorded yet in these two proposed KBA areas) and Samoan cornealian Deudorix doris. Samoan dart has not been seen for many years and lowland sites for the other endemic butterflies are not yet recognized and managed anywhere.
4. Enhance forest shrub Micromelum minutum talafalu. This tree was recorded in Falealupo Peninsula during the survey and is not yet reported for Uafato-Tiavea. Talafalu was the key caterpillar host plant for Samoan swallowtail butterfly prior to its extinction from Upolu

and Savai'i. A future programme to re-introduce this lost butterfly would need healthy populations of talafalu which now appears common at the A'opo Flow near Letui but rare and occasional elsewhere in Upolu and Savai'i.

5. Investigate the impacts of introduced black rat and pacific rat in montane and cloud forests. These are likely to be severe as found among other Pacific islands.
6. Conduct a dialogue between all stakeholders and traditional owners of the KBA and other natural areas to formalise their aspirations for future management and protection of indigenous ecosystems and for ecosystem services from them.

Figure 3.10. Satellite image of Savai'i showing the 550 m elevation boundary to montane zone, and 1200 m boundary to cloud forest zone. The 800 m elevation contour is also shown as indicative of upper elevation limit of merchantable timber which has all been harvested. About and above the 800m elevation line about 40,000 hectares of highly natural and fragile natural heritage remains.

Imagery: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Place names derived from: GEOINT New Zealand, New Zealand Defence Force, Creative Commons Attribution 3.0 New Zealand, https://geodata.nzdf.mil.nz/license/attribution-3-0-newzealand/
Contours derived from Jarvis A., H.I. Reuter, A. Nelson, E. Guevara, 2008, Hole-filled seamless SRTM data V4, International Centre for Tropical Agriculture (CIAT), available from http://srtm.csi.cgiar.org

Acknowledgements

Conservation International Apia led the programme assisted by government staff across several divisions of MNRE. Thanks to Danita Strickland, Schannel van Dijken and Pualele Pene from CI. A number of students provided support and social media interpretation including; Aishwarya Bhattacharjee (City University of New York), Michelle Gan, Ruifeng Zhong and Benjamin Liau (University of Singapore). A'opo, Falealopu and Uafato gave spirited field support. Kiran Liversage collected, sorted and curated insects and landsnails. Claudia Bruschini collected and curated butterflies. Greg Sherley cared for the collection. Czarina Stowers (MNRE) organised the insect permit. Sue Taei, Karin Mahlfeld, Mark O'Brien and Issac Rounds discussed interpretation. Geraldine Moore and James Atherton provided mapping. Greg Sherley edited and improved this chapter.

The Core Invertebrate Team, from Left: Taito Vaitoelau (MNRE) Kiran Liversage (Conservation International), Clive Fala (MNRE), Eric Edwards (NZ Department of Conservation) and Claudia Bruschini (National University of Samoa)

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Appendix 3.1. Lepidoptera taxa recorded in the SMSMCL Biorap

Family/species	Locality	Notes
Family Hesperidae -Skipper butterflies		
Badamia exclamationis	Vaisala 15 m	Talie skipper butterfly. Caterpillars eat *Terminalia* spp. (Combretaceae) Talie or native almond. Distributed widely in the tropics.
Eurema hecabe sulphurata	A'opo 400 m	Grass yellow butterfly. Caterpillars eat a wide range of herbaceous plants in Fabaceae, Euphorbiaceae and Cucurbitaceae. Worldwide species, subspecies regional.
Eurema hecabe sulphurata	Uafato 10 m	
Eurema hecabe sulphurata	Vaisala 15 m	
Appias athama manaia	Falealupo 120 m	Eastern Pacific albatross butterfly. Widespread Pacific species. Subspecies endemic Samoa and Tonga.
Family Lycaenidae -Blue butterflies		
Euchrysops cnejus samoa	Falealupo 120 m	Pea blue butterfly. Widespread tropical species. Regional subspecies including Samoan archipelago.
Jamides argentina	Uafato Coast 10 m	2x. Samoan Cerulean butterfly. Species endemic to Samoan archipelagos and Nuie.
Petrelaea tombugensis	Vaisala 15 m	Almond blue butterfly. Host Talie native almond *Terminalia* spp. Trees. Widespread Vanuatu and Pacific.
Zizina otis labradus	Falealupo 120 m	Grass blue butterfly. Widespread tropical and temperate species and subspecies.
Zizina otis labradus	Uafato 10 m	2x
Zizula hylax dampierensis	Falealupo 120 m	Dainty Blue butterfly. Widespread tropical species. Subspecies on many tropical islands.
Family Nymphalidae -Brushfooted butterflies		
Danaus plexippus	Falealupo 120 m	Monarch butterfly. Worldwide tropical and temperate species.
Danaus plexippus	Mata O Le Afi 1650 m	Observed flying past. Vagrant at this site since no caterpillar host plants are present.
Danaus plexippus	Uafato Coast 10 m	
Euploea algea schmeltzi	A'opo 400 m	Samoan crow butterfly. Widespread tropics. Subspecies endemic to Samoa.
Euploea algea schmeltzi	Uafato 10 m	
Hypolimnas bolina pallescens	Vaisala 15 m	Blue moon butterfly. Worldwide species, subspecies regional.
Hypolimnas errabunda	A'opo 520 m	Samoan eggfly butterfly. A Samoan endemic species. Caterpillars eat *Cypholophus macrocephalus* (Urticaceae). Hopkins (1927) illustrated the caterpillar (Plate IV figure 12.) and suggested this butterfly might

Family/species	Locality	Notes
		have its caterpillar hosted on a native plant of the Moraceae or Urticaceae. Swezey (1942) notes *C. macrocephalus* as the host plant and we are confident to confirm that as the host plant (see Figure 3.6a.) though our caterpillar was lost before pupating.
Junonia villida	A'opo 400 m	Meadow argus butterfly. Distributed widely in the tropical Pacific.
Junonia villida	Uafato Coast 10 m	
Phalanta exulans	A'opo 1000 m	Butterfly Samoan ranger. Endemic Upolu and Savai'i. Lavae feed on *Melicytus samoensis* a forest tree scattered throughout from remnant native forest at 350 m asl. to high elevations
Tirumala hamata melittula	A'opo 400 m	Blue tiger butterfly. Subspecies endemic to Samoa.
Tirumala hamata melittula	Uafato 10 m	
Vagrans egista bowdenia	A'opo 820 m	Common vagrant butterfly. Larvae eat Flacourtiaceae. Widespread tropical butterfly, Pacific subspecies.
Vagrans egista bowdenia	Uafato 10 m	
Family Pyralidae -Pyralid snout moths		
Endotricha mesenterialis	A'opo 1200 m	2x. Larvae feed on tropical trees including Calophyllaceae. Distributed South East Asia to Australia and Polynesia.
Endotricha mesenterialis	Mata O Le Afi 1650 m	4x
Endotricha mesenterialis	Uafato 150 m	
Hypsipyla swezeyi	Falealupo 120 m	A Samoan endemic species. Caterpillars recorded feeding on cacao (*Theobroma cacao*) Malvaceae (Dumbelton in Comstock 1966) and likely has a native plant host in Meliaceae as well. Worldwide *Hypsepyla* spp. are shoot-boring pests of Meliaceae.
Latagognoma dacryodes	A'opo 1200 m	2x. A Samoan endemic species. First record since 1924. Tams (1935) reports Tutuila : Pago Pago, 1 ♀, 14.ix.1923 (Steffany). However a number of records reported in Tams from Steffany 'Pago Pago' appear to be otherwise reported from montane forests.
Latagognoma dacryodes	Mata O Le Afi 1650 m	
Odontopaschia stephanuchra	Uafato 150 m	A Samoan endemic species. First record since 1925.
Pyralidae sp. A	A'opo 1200 m	
Pyralidae sp. B	Uafato 150 m	7x

Family/species	Locality	Notes
Pyralis pictalis	Uafato 150 m	2x. Painted Meal Moth or Poplar Pyralis. Larvae eat dried vegetable foods e.g., cereals. Global distribution but likely native to Asia-Indonesia-Melanesia.
Thylacoptila gonylasia	Uafato 150 m	A Samoan endemic species. First record since 1924.
Tirathaba complexa	Uafato 150 m	A coconut spike moth. Larvae eat flowers and early developing nuts of palms Arecaceae including *Cocos nucifera* coconut. Distributed south-east Asia, Australia and Pacific Islands. An exotic pest.
Family Crambidae -Crambid snout moths		
Agrioglypta cf. enneactis	Falealupo 120 m	Moths in this genus have larvae on Moraceae including *Ficus*. *A. enneactis* distributed Fiji, Tonga and Samoa.
Agrioglypta cf. enneactis	Uafato 150 m	3x
Agrioglypta eurytusalis	Uafato 150 m	3x. Moths in this genus have larvae on Moraceae including *Ficus*. Distributed Australia and Pacific.
Ambia ellipes	A'opo 1200 m	Larvae in this genus are often on wetland plants. Endemic to Samoa. First record of this moth since 1924 (see Tams 1935 -as genus *Baeoptila*).
Ambia tendicularis	A'opo 1100 m	Larvae in this genus are often on wetland plants. Endemic to Samoa.
Ambia tendicularis	Falealupo 120 m	3x
Ambia tendicularis	Uafato 150 m	
Aphrophantis velifera	A'opo 1200 m	An upland species. Recorded distribution Fiji and Samoa
Aphrophantis velifera	Mata O Le Afi 1650 m	4x
Bradina admixtalis	Mt Mu 1400 m	2x. Larvae in various grasses Poaceae and can be a pest on range of crops. An almost global distribution in tropical areas.
Bradina admixtalis	west Savai'i upland 1650 m	
Bradina leptolopha	A'opo 890 m	Endemic to Samoan uplands - noted in Tams (1935) '2000 feet' asl. and above.
Bradina leptolopha	Mt Mu 1400 m	
Bradina leptolopha	west Savai'i upland 1650 m	
Bradina leptolopha	west Savai'i upland 1700 m	2x
Bradina parbattoides	A'opo 1200 m	4x. Endemic to Samoan uplands
Bradina pycnolopha	A'opo 1000 m	A Samoan endemic species
Bradina pycnolopha	A'opo 1200 m	
Bradina pycnolopha	A'opo 1250 m	
Bradina pycnolopha	A'opo 1280 m	3x
Bradina pycnolopha	A'opo 850 m	
Bradina pycnolopha	A'opo 890 m	5x
Bradina pycnolopha	A'opo 950 m	
Bradina sp. A	A'opo 1200 m	5x. Likely a native species.
Bradina sp. B	Falealupo 120 m	2x. Likely a native species.

Family/species	Locality	Notes
Bradina sp. C	Mata O Le Afi wetland 1300 m	Likely a native species
Bradina sp. C	west Savai'i upland 1650 m	
Bradina sp. C	west Savai'i upland 1700 m	
Bradina sp. C	west Savai'i upland 1750 m	
Bradina sp. D	Mata O Le Afi wetland 1300 m	Likely a native species
Calamotropha dielota	Uafato 150 m	Distributed Fiji and now also Samoa.
cf. 'Hyalobathra' aequalis	Falealupo 120 m	3x. *Hyalobathra aequalis* distributed at least South east Asia, Australia and Samoa
Clepsimelia phryganeoides	Mata O Le Afi 1650 m	2x. Distributed Indonesia to Samoa and described in Robinson (1975) as "A rare species restricted to primary montane rainforest"
Cnaphalocrocis poeyalis	A'opo 1200 m	Lesser rice leafroller. Larvae feed on rice and a range of grasses Poaceae. Distributed Africa, Asia and Pacific
Cnaphalocrocis poeyalis	A'opo 880 m	4x
Cnaphalocrocis poeyalis	Falealupo 120 m	4x
Cnaphalocrocis poeyalis	Mata O Le Afi 1650 m	
Cnaphalocrocis poeyalis	Uafato 150 m	
Cnaphalocrocis poeyalis	Vaisala 15 m	
Crambidae sp. A	A'opo 1200 m	
Crambidae sp. B	A'opo 1200 m	
Crambidae sp. C	Vaisala 15 m	
Crambidae sp. D	A'opo 1200 m	2x
Cydalima laticostalis	A'opo 1200 m	3x. Caterpillars eat exotic and possibly native trees in the family Apocynaceae. Distributed at least Australia, Tonga and Samoa. Likely Fiji to New Guinea Region as well.
Cydalima laticostalis	Uafato 150 m	
Diaphania indica	Falealupo 120 m	Cucumber moth or cotton caterpillar. Larvae eat Cucurbitaceae and some other plants. Distributed south Asia and introduced around the Pacific and elsewhere.
Dracaenura adela	A'opo 1100 m	Endemic to Samoa
Dracaenura adela	A'opo 1200 m	
Dracaenura adela	Mata O Le Afi 1650 m	
Dracaenura adela	Mata O Le Afi 1650 m	

Family/species	Locality	Notes
Dracaenura adela	west Savai'i upland 1750 m	
Dracaenura agramma dolia	Falealupo 120 m	4x. A subspecies endemic to Samoan islands. Comstock (1966) records larvae on *Clerodendrum fragrans* - Lamiaceae.
Eudonia cf. orthioplecta	A'opo 1200 m	*E. orthioplecta* is known from Fiji
Eurrhyparodes tricoloralis	Uafato 150 m	Distributed old world tropics to Australia and Pacific.
Exeristis asynopta	west Savai'i upland 1700 m	A Samoan endemic species
Exeristis catharia	Mata O Le Afi 1650 m	4x. A Samoan endemic species
Exeristis catharia	Mata O Le Afi 1650 m	6x
Exeristis pollosta	Falealupo 120 m	4x. A Samoan endemic species
Exeristis pollosta	Mata O Le Afi 1650 m	
Exeristis pollosta	Mata O Le Afi 1650 m	
Glaucocharis amydra	Uafato 150 m	A Samoan endemic species. First record of this moth since 1925.
Glaucocharis dialitha	A'opo 1200 m	8x. A Samoan endemic species. Also recorded 2012 from wetlands below Silisili summit. Tams (1935) notes records from Upolu upland at Malololelei and Savai'i Fagamalo. Comstock (1966) records larvae (possibly a sister species) on *Macaranga* and *Hibiscus* on Tutuila.
Glaucocharis dialitha	Falealupo 120 m	
Glaucocharis sp. A	A'opo 1200 m	2x. Likely a native upland species.
Glyphodes caesalis	A'opo 1200 m	4x. Breadfruit borer. Larvae known to feed on *Artocarpus* spp. 'ulu breadfruit Moraceae. Distributed South East Asia to Australia and Polynesia
Glyphodes caesalis	Mata O Le Afi 1650 m	2x
Glyphodes caesalis	Mata O Le Afi 1650 m	10x
Haritalodes derogata	Falealupo 120 m	Larvae eat Hibiscus. Distributed old world tropics to Australia and Pacific.
Haritalodes derogata	Uafato 150 m	
Herpetogramma licarsisalis	A'opo 1200 m	2x. Tropical grass webworm. Caterpillars feed on grasses Poaceae, living in shelters at the base of grass clumps. Distributed Asia, Australia and New Zealand and introduced to many Pacific Islands.
Herpetogramma rudis	A'opo 1200 m	2x. Species in this genus often have larvae on grasses. Distributed South East Asia, Fiji and Samoa.
Herpetogramma rudis	Mata O Le Afi 1300 m	

Family/species	Locality	Notes
Herpetogramma rudis	Mata O Le Afi 1650 m	
Herpetogramma rudis	Uafato 150 m	6x
Herpetogramma stultalis	A'opo 1200 m	Caterpillars have been recorded feeding on Amaranthaceae and Lamiaceae which in Samoa are exotic weeds. Swezey in Comstock (1966) records caterpillars on *Coleus* at Malololelei. Noted in Tams (1935) as genus *Psara*. Widely distributed Asia to New Guinea and Australia.
Hoploscopa astrapias nauticorum	A'opo 1200 m	Subspecies endemic to Samoa
Hoploscopa astrapias nauticorum	Mata O Le Afi 1650 m	
Hoploscopa astrapias nauticorum	Mata O Le Afi 1650 m	7x
Hyalobathra sp.	Falealupo 120 m	
Hyalobathra sp.	Uafato 150 m	3x
Hyalobathra sp.	Vaisala 15 m	
Hyalobathra wilderi	A'opo 1200 m	3x. Endemic to the Samoa's
Hyalobathra wilderi	Mata O Le Afi 1650 m	2x
Hydriris ornatalis	Falealupo 120 m	3x. Caterpillars eat Convolvulaceae species, including *Ipomoea* and 'umala sweet potato *I. batatas.* Pan tropical distribution.
Hydriris ornatalis	Uafato 150 m	3x
Leucophotis pulchra	A'opo 1200 m	2x. Distributed at least Fiji and Samoa
Leucophotis pulchra	Mata O Le Afi 1650 m	
Leucophotis pulchra	Uafato 150 m	
Maruca vitrata	A'opo 1200 m	Bean pod borer. A pantropical insect pest of leguminous crops
Meroctena staintonii	A'opo 1200 m	Distributed New Guinea region (including highlands), Fiji and Samoa.
Omiodes diemenalis	Uafato 150 m	Bean leafroller. Caterpillers eat a range of climbing and herbaceous Fabaceae (beans). Distributed from Idia to the western Pacific and Australia.
Omiodes leucostrepta	Falealupo 120 m	Larvae in this genus are often on Fabaceae -beans. Distributed Samoa, Tonga and Fiji
Omiodes leucostrepta	Uafato 150 m	
Parotis suralis	Uafato 150 m	Distributed Southeast Asia to Australia and some Pacific Islands
Parthenodes eugethes	Uafato 150 m	2x. A Samoan endemic species. First record since 1961.
Phostria oconnori	A'opo 1200 m	6x. Larvae recorded feeding on *Strongylodon* Fabaceae. Distribution known from Fiji and Samoa.
Phostria oconnori	Mata O Le Afi 1650 m	4x

Family/species	Locality	Notes
Phostria oconnori	west Savai'i upland 1650 m	North draining channel and pool site
Piletocera albescens	A'opo 1200 m	4x. Larvae on forest floor herbs, Adults fly low in sun-flecked areas. Distribution Samoa and Fiji
Piletocera albescens	A'opo 890 m	
Piletocera albescens	Falealupo 120 m	
Piletocera albescens	Mata O Le Afi 1650 m	6x
Piletocera albescens	Uafato 150 m	
Piletocera cyclospila	A'opo 1200 m	Endemic to the Samoa's.
Piletocera cyclospila	A'opo 890 m	
Piletocera cyclospila	Falealupo 120 m	
Piletocera cyclospila	Uafato 150 m	2x
Piletocera ochrosema	A'opo 1200 m	2x. Caterpillar host unknown but probably on litter. Distributed Vanuatu, Fiji, Tonga and Samoa
Piletocera rechingeri	A'opo 1200 m	2x. Endemic to the Samoan archipelagos
Piletocera rechingeri	Uafato 150 m	2x
Piletocera signiferalis	A'opo 1200 m	Caterpillar foodplant unknown but probably leaf litter. Distributed widely among Pacific islands and also Australia. Adults common visiting shrubland flowers.
Piletocera signiferalis	Falealupo 120 m	2x
Piletocera signiferalis	Vaisala 15 m	2x
Piletocera steffanyi	Falealupo 120 m	3x. Endemic to the Samoan archipelagos
Rehimena cissophora	Uafato coast 10 m	Known also from Australia.
Stemorrhages oceanitis	A'opo 1200 m	2x. Distributed among Pacific islands and descibed as upland for Rarotonga.
Stemorrhages oceanitis	Mata O Le Afi 1650 m	2x
Sufetula hemiophthalma	Mata O Le Afi 1650 m	Larvae in this genus known on Monocots. Distributed among Pacific Islands, Australia and Malaysia
Sufetula hemiophthalma	west Savai'i upland 1700 m	
Syllepte sabinusalis	A'opo 1200 m	Larvae in this genus known on Urticaceae. Distributed Fiji to Papua New Guinea and Asia.
Syllepte sabinusalis	Uafato 150 m	5x
Trichophysetis neophyla	A'opo 1200 m	Distributed Australia and Samoa
Family Uraniidae -swallowtail moths		
Epiplema hapala	Uafato 150 m	3x. A Samoan endemic species.
Epiplema lypera	A'opo 1200 m	6x. A Samoan endemic species.
Epiplema sp. A	Uafato 150 m	
Phazaca sp. A	Falealupo 120 m	
Family Thyrididae -Window winged moths		
Banisia lithophora	Falealupo 120 m	Described from Samoa by Tams (1935). A Samoan endemic species.

Family/species	Locality	Notes
Striglina oecia	A'opo 1200 m	5x. Larvae eat a range of tree and shrub species leaves (polyphageous). A samoan endemic species. However, Tams (1935) and Whaley (1976) propose close relationship with *Striglina navigatorum* present in Fiji, Australia and elsewhere.
Striglina oecia	Falealupo 120 m	
Striglina oecia	Uafato 150 m	
Family Sphingidae -Hawk moths		
Agrius convolvuli	Mata O Le Afi 1650 m	2x. Convolvulus hawk moth. Larvae feed on Convolvulus and Ipomoea. Global distribution.
Agrius convolvuli	Uafato 150 m	
Theretra silhetensis intersecta	Uafato 150 m	brown-banded hunter hawkmoth. Caterpillars polyphagous on a viariety of fleshy aquatic plants and Convolvulaceae. Subspecies distributed Phillipines Pacific Islands, Vanuatu and Australia.
Family Geometridae -Loopers or geometrid moths		
Asthena eurychora	A'opo 1200 m	An upland species of Savai'i and Upolu. However, Robinson (1975) notes the genus needs revision. Likely a synonym of *Eoasthena stygna* whose caterpillars are known from *Glochidion* Euphorbiaceae in Fiji where it is "a moderately common forest species" (Robinson 1975).
Asthena eurychora	Mata O Le Afi 1650 m	5x
Asthena eurychora	Mata O Le Afi 1650 m	7x. Including the only male record.
Asthena eurychora	west Savai'i upland 1650 m	
Asthena eurychora	west Savai'i upland 1700 m	
Casbia cf. alphitoniae	A'opo 1200 m	*C. alphitoniae* caterpillars eat *Alphitonia zizyphoides* in Fiji (Robinson 1975). First record of *Casbia* genus moths for Samoa.
Casbia cf. alphitoniae	Falealupo 120 m	
Casbia cf. alphitoniae	Uafato 150 m	
Chloroclystis encteta	Uafato 150 m	Distributed Vanuatu, Fiji and Samoa.
Chloroclystis nina	Mata O Le Afi 1650 m	New record for Samoa. Described from Fiji "moss forest" Robinson (1975).
Chloroclystis rubicunda	A'opo 1200 m	3x. Species in this genus often have larvae in flowers. Described in Robinson (1975) as "an uncommon species of primary forest". Distributed Vanuatu to Samoa.
Chloroclystis rubicunda	Mata O Le Afi 1650 m	2x
Chloroclystis rubicunda	Mata O Le Afi 1650 m	5x
Chloroclystis sp. A	A'opo 1200 m	

Family/species	Locality	Notes
Cleora fowlesi	A'opo 1200 m	Species in this genus often have larvae in tall shrubland or trees. Known from Fiji and Samoa. Robinson (1975) notes for Fiji: "Rare, apparently restricted to lowland forest".
Cleora samoana	A'opo 1200 m	3x. Species in this genus often have caterpillars in tall shrubland or trees. Recorded from *Eugenia reinwardtiana* or *Syzygium* family Myrtaceae. Native to Samoa, Tonga and Fiji.
Cleora samoana	Falealupo 120 m	2x
Cleora samoana	Mata O Le Afi 1650 m	4x
Cleora samoana	Mata O Le Afi 1650 m	11x
Cleora samoana	Uafato 150 m	6x
Comostola rhodoselas	A'opo 1200 m	Distributed Samoa and probably Tonga plus Fiji archipelago. Holloway (1996) notes "The taxon in Fiji referred to *Pyrrhogona* by Robinson (1975) has male genitalia similar to those of *C. rhodoselas* Prout comb. n. from Samoa."
Comostola rhodoselas	Falealupo 120 m	
Comostola rhodoselas	Uafato 150 m	
Cyclophora cf. harrietae	A'opo 1200 m	*C. harrietae* would be new record for Samoa. Described from Fiji. Robinson (1975) remarks "A rare species apparently restricted to montane forest".
Cyclophora hypocris	A'opo 1200 m	2x. A Samoan endemic moth. Genus formerly *Anisodes*. A single female only, recorded Malololelei Upolu 1924 (Prout 1928). Plate VI Figure 6. Tams (1935).
Gymnoscelis cf. sara	Mata O Le Afi 1650 m	2x. If *G. sara*, newly recorded for Samoa. Distributed Fiji -montane forest (Robinson 1975).
Gymnoscelis concinna	A'opo 1200 m	4x. Distributed Samoa, Tonga, Fiji, Vanuatu, Society Islands and other French Polynesia islands. A few subspecies are recognised for the region.
Gymnoscelis concinna	Uafato 150 m	
Gymnoscelis sp. A	A'opo 1200 m	3x
Gymnoscelis sp. B	Uafato 150 m	
Idaea rhipistis	Falealupo 120 m	Distributed Fiji, Tonga and Samoa. Newly reported from Samoa in this survey.
Mnesiloba eupitheciata	A'opo 1200 m	Larvae feeding in grasses including *Ischaemum indicum*. Distributed India -Pacific
Nadagara hypomerops	A'opo 1200 m	A Samoan endemic species. Related species occur in Fiji, Solomon Is. and Australia.
Nadagara hypomerops	Uafato 150 m	2x
Perixera samoana	A'opo 1200 m	3x. Caterpillars eat *Syzygium cumini* (Myrtaceae) and *Cosmos sulphureus* (Asteraceae) and likely related plants. Distributed Samoa and a range of Pacific Islands to Vanuatu, Society Islands and New

Family/species	Locality	Notes
		Caledonia. Recorded as genus *Anisodes* by Prout (1928), Comstock (1966) and Robinson (1975).
Perixera samoana	Falealupo 120 m	
Sauris elaica	A'opo 1200 m	Distributed Vanuatu to Samoa. Robinson (1975) remarks "A moderately common species in primary montane rainforest, scarce elsewhere"
Sauris elaica	Uafato 150 m	
Sauris priva	A'opo 1200 m	New Samoan record of a moth species known from Fiji. Robinson (1975) remarks " known only from two specimens .. exceptionally rare."
Scotocyma miscix	Mata O Le Afi 1650 m	Distributed Australia, Melanesia -Samoa. Species known from Fiji. Newly recorded in 2012 in Savai'i uplands. Described in Robinson (1975) as "An uncommon species restricted to primary forest"
Scotocyma sp. 'long palpi'	A'opo 1200 m	Previously recorded Savai'i: Mt. Te'elagi south crater 1360 m and, under Mt Vaea Cone 830 m
Scotocyma sp. 'long palpi'	Mata O Le Afi 1650 m	
Thalassodes chloropis	A'opo 1200 m	3x. An emerald moth. In Fiji, caterpillars eat a range of small trees including *Rhus, Inocarpus, Syzygium, Barringtonia* and others. Robinson (1975) notes confusion between this and similar *T. pilaria* host associations. Distributed New Caledonia, Vanuatu, Fiji, Tonga and Samoa.
Thalassodes chloropis	Falealupo 120 m	
Thalassodes chloropis	Mata O Le Afi 1650 m	4x
Thalassodes chloropis	Uafato 150 m	4x
Thalassodes sp. A	A'opo 1200 m	An emerald moth. Likely a new endemic species associated with Samoan uplands
Thalassodes sp. A	Mata O Le Afi 1650 m	
Thalassodes sp. A	Mata O Le Afi 1650 m	5x
Thalassodes sp. A	west Savai'i upland 1650 m	channel pool site
Thalassodes sp. A	west Savai'i upland 1700 m	
Thalassodes pilaria	Falealupo 120 m	An emerald moth. Caterpillars known from a range of tree hosts including *Rhus Inocarpus, Syzygium, Barringtonia* and others. Robinson (1975) notes confusion between this and similar *T. chloropis* host associations. Distributed around the Pacific New Caledonia, Guam, Society Is. Pitcairn Is, Fiji, Tonga and Samoa. Described in Fiji as "a very uncommon and local species" Robinson (1975).
Thalassodes pilaria	Uafato 150 m	

Family/species	Locality	Notes
Thalassodes pilaria	Vaisala 15 m	
Ziridava dysorga	A'opo 1200 m	4x. An abundant Samoan endemic species including American Samoa (Comstock 1966). It does not belong in genus *Ziridava* and may prove to be an endemic genus (Jeremy Holloway personal communication).
Ziridava dysorga	Mata O Le Afi 1650 m	12x
Ziridava dysorga	Mata O Le Afi 1650 m	4x
Ziridava dysorga	Vaisala 15 m	
Ziridava dysorga	west Savai'i upland 1650 m	channel pool site
Family Erebidae subfamily Arctiinae -Tiger moths		
Lyclene cf. uniformeola	A'opo 1200 m	4x. *L. uniformeola* is distributed Southeast Asia and Samoa. Genus *Asura* in Tams (1935).
Lyclene hopkinsi	A'opo 1200 m	13x. A Samoan endemic species of mid altitudes
Lyclene pyropa	A'opo 1200 m	6x. Endemic to Savai'i and Upolu. Recorded 600 m asl. and above. May possibly have larvae feeding on montane forest ferns.
Lyclene pyropa	Mata O Le Afi 1650 m	
Lyclene sp. 'charcoal salmon'	A'opo 1200 m	Likely a native species
Monosyntaxis samoensis	A'opo 1200 m	4x. Endemic to Samoa. Related species noted (Subfamily Lithosiinae -see Common 1990) as feeding on rainforest lichens. Genus *Chrysaeglia* in Tams (1935).
Monosyntaxis samoensis	Mata O Le Afi 1650 m	
Nyctemera cf. (Luctuosana) luctuosa	Uafato coast 10 m	Wings are largely white with some dark venation and some specimens light fuscus at wing bases. If it is *N. luctuosa*, then distributed Phillipines, Papua New Guinea, Australia and Samoa. Larvae of *N. luctuosa* eat *Senecio* species.
Family Erebidae -Underwings and others		
Achaea fulminans	Mata O Le Afi 1650 m	5x. A Samoan endemic species
Anomis lyona	A'opo 1200 m	Distributed globally including Australia and Samoa.
Anomis lyona	Mata O Le Afi 1650 m	2x
Bocana manifestalis	A'opo 1200 m	2x. Larvae polyphagous -eat grasses and trees. Distributed India, Southeast Asia, Pacific and Australia.
Bocana manifestalis	Mata O Le Afi 1650 m	
Cymodegma buxtoni	A'opo 1200 m	6x. An upland species and genus endemic to Upolu and Savai'i. Only the female recorded in 1924 prior to this series.

Family/species	Locality	Notes
Dichromia cf. pullata	A'opo 1200 m	Distributed India, Asia & Pacific. Larvae eat Acanthaceae
Dichromia cf. pullata	Mata O Le Afi 1650 m	
Hydrillodes cf. crispipalpus	Uafato 150 m	*H. crispipalpus* is known from Society Islands -French Polynesia. Palpi and wings distinct from the other species of *Hydrillodes* recorded Samoa.
Hydrillodes sigma	A'opo 1200 m	12x. A Samoan endemic species.
Hydrillodes sigma	Mata O Le Afi 1650 m	
Hydrillodes sp. A.	Mata O Le Afi 1650 m	6x. Likely to be determined an endemic species.
Hydrillodes surata	Falealupo 120 m	4x. Larvae eat litter. Distributed central Pacific Islands.
Hypena iconicalis	Vaisala 15 m	Caterpillars eat *Desmodium* spp. Beggars tick and probably other semi-woody Fabaceae. Distributed India, Indonesia, New Guinea and Fiji.
Hypocala deflorata	Mata O Le Afi 1650 m	3x. Caterpillars eat *Diospyros* Ebinaceae and *Planchonella* Sapotaceae. Distributed Asia to Australia and Pacific Islands.
Hypospila similis similis	A'opo 1200 m	3x. A Samoan endemic subspecies. Caterpillar food plants unknown but sister species eat herbs in Fabaceae.
Hypospila similis similis	Mata O Le Afi 1650 m	4x
Hypospila similis similis	Uafato 150 m	
Leptotroga armstrongi	A'opo 1200 m	Distributed Fiji and Samoa. Robinson (1975) notes restricted to montane primary rainforest in Fiji and Samoa (Rotuma exception) and also a very rare species.
Machaeropalpus fasciatus	A'opo 1200 m	A Samoan endemic genus and species. Likely an upland species since the only other records are 2014 at Mt. Marfane; Tributary Seugagogo R. 784 m and in 1924 at Malololelei, Upolu.
Mormecia lachnogyia	A'opo 1200 m	An upland species and genus endemic to Upolu and Savai'i. Not recorded since 1924. New record Savai'i.
Ophiusa samoensis	A'opo 1200 m	A Samoan endemic species. Genus *Anua* in Tams (1935). Perhaps a montane variant of a close sister species *O. tongaensis* that has caterpillars on Myrtacecae and occurs widely among Pacific Islands.
Ophiusa samoensis	Mata O Le Afi 1650 m	3x
Oxyodes scrobiculata samoana	A'opo 1200 m	2x. Common name, Longan leaf-eating looper (*Oxyodes scrobiculata*). Subspecies samoana endemic to Samoan islands and Rotuma Island (Fiji Archipelago). Sister subspecies distributed India, Asia to Australia and Pacific.

Family/species	Locality	Notes
Oxyodes scrobiculata samoana	Falealupo 120 m	
Oxyodes scrobiculata samoana	Mata O Le Afi 1650 m	
Oxyodes scrobiculata samoana	Uafato 150 m	
Pindara prisca	A'opo 1200 m	Caterpillars eat shrubs in the Myrtaceae family including *Myrtus vitiensis* in Fiji. Distributed Vanuatiu, New Caledonia, Fiji, Samoa and Tonga.
Pindara prisca	Vaisala 15 m	
Rhesalides curvata	Uafato 150 m	2x. Distributed Australia, New Guinea, Fiji, Samoa and Cook Islands
Schrankia cf. furoroa	A'opo 1200 m	2x. *S. furoroa* is otherwise only known from Rotuma Island (Fiji Archapelago). Possibly a new record for Samoa or a new sister species to *S. furoroa*.
Schrankia cf. furoroa	Mata O Le Afi 1650 m	
Schrankia cf. furoroa	west Savai'i upland 1650 m	
Schrankia sp. A	A'opo 1200 m	Likely to be determined an endemic species
Schrankia taona	A'opo 1200 m	6x. A Samoan endemic species
Schrankia taona	Mata O Le Afi 1650 m	2x
Schrankia taona	Mata O Le Afi 1650 m	9x
Simplicia cornicalis	A'opo 1200 m	The larvae feed on dead leaves, and is a pest in roofs consisting of dried palm leaves. Southeast Asia, Australia and the Pacific
Simplicia cornicalis	Falealupo 120 m	
Simplicia sp. 'concave termin'	Uafato 150 m	
Thyas miniacea	A'opo 1200 m	Larvae eat Talie -*Terminalia catappa* and other Combretaceae. Vanuatu, New Caledonia, Fiji, Samoa.
Thyas miniacea	Mata O Le Afi 1650 m	2x
Family Nolidae -Tuft moths		
Etanna vailima	Uafato coast 10 m	Distributed Fiji and Samoa. Genus *Apothripa* from Tams (1935) and in Robinson (1975).
Giaura cf. punctata	A'opo 1200 m	2x. *G. punctata* is known from New Guinea and Australia and now tentatively Samoa.
Maceda mansueta	Uafato 150 m	Distributed India, South east Asia, New Guinea, Australia, Vanuatu, Fiji and Samoa. Described by Robinson (1975) in Fiji as: "An uncommon species encountered in primary forest and secondary bush".
Maceda sp. A	Uafato 150 m	2x
Maurilia iconica	Uafato 150 m	Caterpillars eat talie *Terminalia catappa* Combretaceae. Distributed India, South east Asia, New Guinea, Vanuatu, New Caledonia, Fiji and Samoa.

Family/species	Locality	Notes
Nanaguna breviuscula	Vaisala 15 m	Caterpillars known from flowers of beggars tick *Desmodium* and mango *Magnifera indica* in Fiji (Robinson 1975). Distributed India, Asia, Australia and Pacific. Described from Fiji as common in dry areas of secondary vegetation. Genus *Etanna* in Tams (1935).
Nola cf. insularum	Falealupo 120 m	2x. *Nola insularum* is distributed widely in the Pacific.
Nola cf. samoana	A'opo 1200 m	*N. samoana* is distributed Rotuma Island (Fiji Archapelago) Tonga, Samoa, New Caledonia and Vanuatu (see Holloway 1979). Genus *Celama* in Tams (1935)
Nola cf. tornotis	Uafato 150 m	4x. *N. tornotis* has been recorded Samoa (Tams 1935) Vanuatu, New Guinea and Australia
Nola sp. A	A'opo 1200 m	
Nola sp. B	A'opo 1200 m	
Nola sp. C	Falealupo 120 m	10x
Nola sp. C	Uafato coast 10 m	2x
Nola sp. D.	Uafato coast 10 m	
Nola sp. D.	Vaisala 15 m	2x
Nola sp. E	A'opo 1200 m	
Family Noctuidae -Owlets and others		
Aegilia vitiscribens	Mata O Le Afi 1650 m	2x. Described by Holloway (2005) from Fiji but Identified in Robinson (1975) as *Stictoptera describens* and noted as an uncommon species of primary forest. First record from Samoa.
Amyna axis	Uafato 150 m	Larvae eat range of herbs including climber *Cardiospermum halicacabum* Sapindaceae, *Parasponia andersonii* Canabaceae and spp. in Amaranthaceae Broadly distributed in tropical regions of the world. Noted in Robinson (1975) as *A. octo*.
Anomocala hopkinsi	Mata O Le Afi 1650 m	3x. A dark coloured owlet. Found in mid to higher altitudes of Upolu and Savai'i. Endemic at the genus level in Samoa.
Anomocala hopkinsi	Mata O Le Afi 1650 m	3x
Athetis thoracica	A'opo 1200 m	Larvae polyphagous and eat *Commelina, Ipomoea, Syzygium, Portulaca, Nicotiana, Camellia* as well as Gramineae and Leguminosae. Distributed Indonesia to Australia and tropical Pacific. Thought to be introduced from Fiji. in early 1900's (Zimmerman 1958).
Athetis thoracica	Mata O Le Afi 1650 m	2x
Athetis thoracica	Mata O Le Afi 1650 m	4x
Athetis thoracica	Vaisala 15 m	

Family/species	Locality	Notes
Callopistria maillardi	A'opo 1200 m	4x. Larvae eat ferns for example *Adiantum* and *Nephrolepis* species. Distributed at least India to Australia and many temperate and tropical Pacific islands.
Callopistria maillardi	Mata O Le Afi 1650 m	3x
Callopistria meridionalis nauticorum	Falealupo 120 m	3x. An endemic subspecies. Caterpillars recorded from Monarch fern *Phymatosorus scolopendria* (Comstock 1966).
Callopistria meridionalis nauticorum	Uafato 150 m	2x
Callopistria reticulata	Uafato 150 m	Caterpillars likely eat ferns. Distributed India, Asia, Vanuatu, Fiji and Samoa. New record for Samoa.
Chasmina tibialis	Uafato 150 m	Caterpillars recorded from *Hibiscus tiliaceus*. Distributed Asia to Australia and widely around the Pacific.
Chrysodeixis eriosoma	Falealupo 120 m	Green garden looper. Larvae eat a wide variety of plants -polyphagous. Distributed America, India, Asia, Australia and Pacific.
Chrysodeixis eriosoma	Mata O Le Afi 1650 m	3x
Chrysodeixis eriosoma	Mata O Le Afi 1650 m	10x
Chrysodeixis eriosoma	Mt Mu 1400 m	
Chrysodeixis eriosoma	Uafato 150 m	4x
Condica conducta	A'opo 1200 m	Caterpillars eat Asteraceae eg. *Senecio*. Widely distributed including Africa Hong Kong, Fiji, Society Islands and Chagos Archipelago.
Condica conducta	Mata O Le Afi 1650 m	3x
Condica conducta	Mata O Le Afi 1650 m	4x
Condica conducta	Vaisala 15 m	
Maliattha ritsemae	Uafato 150 m	Larvae eat signal grass *Brachiaria* spp. Poaceae. Distributed Indonesia, Australia, Vanuatu and the Pacific.
Penicillaria dinawa	Mata O Le Afi 1650 m	2x. Distributed New Guinea, Fiji and Samoa. Robinson (1975) notes for Fiji, an uncommon species associated with primary forest.
Spodoptera litura	Falealupo 120 m	Several common names: Oriental cutworm, Taro cutworm etc. Caterpillars polyphagous on grasses, herbs and trees. Global distribution.
Spodoptera litura	west Savai'i upland 1650 m	channel pool site
Targalla delatrix	Mata O Le Afi 1650 m	4x. Eugenia Caterpillar. Caterpillars eat *Eugenia uniflora* and *Syzigium* spp. Myrtaceae. Distributed Asia to Australia and Pacific Islands

Family/species	Locality	Notes
Targalla delatrix	Mata O Le Afi 1650 m	
Targalla delatrix	Uafato 150 m	
Tiracola plagiata	A'opo 1200 m	Cacao Armyworm. Larvae arboreal, polyphagous, e.g banana, yam, Citrus. Distributed Asia -Pacific and northern Australia
Tiracola plagiata	Mata O Le Afi 1650 m	5x
Tiracola plagiata	Mata O Le Afi 1650 m	3x
Tiracola plagiata	Uafato 150 m	2x
Tiracola plagiata	Vaisala 15 m	
Tiracola rufimargo samoensis	Mata O Le Afi 1650 m	11x. A Samoan endemic subspecies. Inhabits uplands. Very abundant during the survey with adults clustered at night in flowering panacles of the common upland tree *Reynoldsia pleiosperma*. *R. pleiosperma* is endemic to Savai'i island with a sister species on Upolu.
Tiracola rufimargo samoensis	Mata O Le Afi 1650 m	3x
Below: Micromoth families excluded from summary analysis in the report		
Family Alucitidae -Many plumed moths		
Alucita sp. A	A'opo 1200 m	Distinct in the 1/3 division of radial veins
Family Immidae -Immid moths		
Imma philonoma	A'opo 890 m	Noted from Fiji as having caterpillars on betel nut *Areca catechu* (Arecaceae). Distributed Fiji and Samoa.
Imma philonoma	Faleolupo 120 m	
Imma philonoma	Uafato 150 m	
Imma sp. A	Uafato 150 m	Likely a native species
Imma sp. A	Vaisala 15 m	
Family Lacturidae -Coloured micro-moths		
Anticrates diffluа	Uafato 150 m	An endemic micromoth not reported since Meyrick's original description in 1927. Only example from Family Lacturidae -tropical burnet moths reported from Samoa.
Family Pterophoridae -Plume moths		
Hepalastis pumilio	Vaisala 15 m	2x. A plume moth species distributed worldwide tropics. Caterpillars bore in *Desmodium* and other herbaceous Fabaceae
Family Tortricidae -Leafroller moths		
Acanthoclita sp. A	Mata O Le Afi 1650 m	5x. Many *Acanthoclita* species caterpillars eat plants in Fabaceae
Acanthoclita sp. B	Mata O Le Afi 1650 m	3x

Family/species	Locality	Notes
Adoxophyes libralis	Uafato 150 m	10x. A Samoan endemic species. First record since described in 1927 as collected by Armstrong [who collected in Samoa 1922 -1924] (Meyrick 1927).
Caenognosis incisa	Uafato 150 m	Distributed Phillipines to Australia and some Pacific Islands
Cryptophlebia sp. A	Mata O Le Afi 1650 m	
Daedaluncus fijiensis	Mata O Le Afi 1650 m	Newly described genus and species in 2016 (Razowski 2016). Only known from specimens collected 1974 Viti Levu and now recorded in Samoa.
Dudua aprobola	A'opo 1200 m	Caterpillars recorded feeding on tree canopy flowers. Type Locality Tonga but Distributed Asia, New Guinea and Australia and many Pacific islands including Fiji and Samoa.
Dudua aprobola	Uafato 150 m	
Dudua sp. A	Uafato 150 m	
Icelita cf. grossoperas	Uafato 150 m	12x. *I. grossoperas* is recently described from Fiji (Razowski 2016).
Strepsicrates glaucothoe	A'opo 1200 m	4x. Most *Strepsicrates* species have caterpillars on Myrtaceae. *S. glaucothoe* described from Samoa but also found in Fiji. Restricted to upland forests where it is common.
Strepsicrates glaucothoe	Mata O Le Afi 1650 m	3x
Strepsicrates glaucothoe	Mata O Le Afi 1650 m	3x
Trymalitis cf. macarista	Mata O Le Afi 1650 m	*T. macarista* is known from Fiji.
Trymalitis cf. macarista	Uafato 150 m	
Tortricidae sp. A	A'opo 1200 m	8x
Tortricidae sp. A	Mata O Le Afi 1650 m	4x
Tortricidae sp. A	Mata O Le Afi 1650 m	9x
Tortricidae sp. B	A'opo 1200 m	2x
Tortricidae sp. C	Faleolupo 120 m	Tortricini
Tortricidae sp. D	A'opo 1200 m	
Tortricidae sp. D	Uafato 150 m	
Tortricidae sp. E	Vaisala 15 m	3x
Tortricidae sp. F	A'opo 1200 m	2x
Tortricidae sp. F	Mata O Le Afi 1650 m	6x
Tortricidae sp. F	Mata O Le Afi 1650 m	11x
Tortricidae sp. G	Mata O Le Afi 1650 m	
Tortricidae sp. G	Uafato 150 m	4x

Family/species	Locality	Notes
Tortricidae sp. G	west Savai'i upland 1650 m	
Tortricidae sp. H	A'opo 1200 m	2x
Tortricidae sp. H	Mata O Le Afi 1650 m	
Tortricidae sp. H	Uafato 150 m	
Tortricidae sp. J	Mata O Le Afi 1650 m	
Tortricidae sp. K	Mata O Le Afi 1650 m	3x
Tortricidae sp. L	Faleolupo 120 m	
Tortricidae sp. M	Mata O Le Afi 1650 m	
Tortricidae sp. N	Mata O Le Afi 1650 m	
Tortricidae sp. O	Mata O Le Afi 1650 m	3x
Tortricidae sp. P	Mata O Le Afi 1650 m	
Tortricidae sp. P	Mata O Le Afi 1650 m	
Tortricidae sp. Q	A'opo 1200 m	
Tortricidae sp. Q	Uafato 150 m	
Tortricidae sp. R	A'opo 1200 m	4x
Tortricidae sp. R	Mata O Le Afi 1650 m	7x
Tortricidae sp. R	Mata O Le Afi 1650 m	8x
Tortricidae sp. R	west Savai'i upland 1650 m	channel pool site
Tortricidae sp. S	A'opo 1200 m	
Tortricidae sp. T	A'opo 1200 m	
Tortricidae sp. U	Mata O Le Afi 1650 m	
Tortricidae sp. U	Mata O Le Afi 1650 m	4x
Tortricidae sp. V	A'opo 1200 m	
Tortricidae sp. V	Mata O Le Afi 1650 m	
Tortricidae sp. W	Mata O Le Afi 1650 m	
Tortricidae sp. X	A'opo 1200 m	
Tortricidae sp. Y	Mata O Le Afi 1650 m	2x
Tortricidae sp. Z	A'opo 1200 m	
Tortricidae sp. Z	Faleolupo 120 m	
Tortricidae sp. ZA.	Uafato 150 m	
Tortricidae sp. ZB.	A'opo 1200 m	

Family/species	Locality	Notes
Tortricidae sp. ZC	Uafato 150 m	
Tortricidae sp. ZC.	A'opo 1200 m	
Tortricidae sp. ZD	Mata O Le Afi 1650 m	
Tortricidae sp. ZD	Vaisala 15 m	
Continued: Micromoth families not assigned and excluded from summary analysis in the report		
Micro sp. 1	A'opo 1200 m	8x. Oecophoridae
Micro sp. 1	A'opo 850 m	
Micro sp. 1	Mata O Le Afi 1650 m	
Micro sp. 2	Faleolupo 120 m	Oecophoridae
Micro sp. 2	Uafato 150 m	
Micro sp. 3	A'opo 1200 m	Oecophoridae
Micro sp. 4	A'opo 1200 m	
Micro sp. 5	A'opo 1200 m	3x
Micro sp. 5	Mata O Le Afi wetland 1300 m	
Micro sp. 5	west Savai'i upland 1700 m	
Micro sp. 6	A'opo 1200 m	
Micro sp. 7	A'opo 1200 m	3x
Micro sp. 8	A'opo 1200 m	2x. Oecophoridae
Micro sp. 8	Mata O Le Afi 1650 m	2x
Micro sp. 9	A'opo 1200 m	
Micro sp. 10	A'opo 1200 m	2x
Micro sp. 11	A'opo 1200 m	3x
Micro sp. 12	A'opo 1200 m	2x
Micro sp. 12	Uafato 150 m	5x
Micro sp. 13	A'opo 1200 m	3x
Micro sp. 14	A'opo 1200 m	
Micro sp. 15	A'opo 1200 m	5x
Micro sp. 16	Uafato 150 m	
Micro sp. 17	Uafato 150 m	
Micro sp. 18	A'opo 1200 m	
Micro sp. 18	Mata O Le Afi 1650 m	
Micro sp. 19	A'opo 1000 m	
Micro sp. 19	A'opo 1200 m	5x. Oecophoridae
Micro sp. 19	A'opo 1250 m	
Micro sp. 19	Mata O Le Afi wetland 1300 m	
Micro sp. 20	A'opo 1100 m	
Micro sp. 20	A'opo 1200 m	
Micro sp. 20	A'opo 950 m	

Family/species	Locality	Notes
Micro sp. 20	Mata O Le Afi 1650 m	
Micro sp. 20	Mata O Le Afi wetland 1300 m	
Micro sp. 21	A'opo 1200 m	2x. Oecophoridae.
Micro sp. 22	A'opo 890 m	
Micro sp. 22	Mata O Le Afi wetland 1300 m	
Micro sp. 23	Mata O Le Afi wetland 1300 m	
Micro sp. 23	Mata O Le Afi wetland 1550 m	
Micro sp. 24	A'opo 1200 m	2x
Micro sp. 25	A'opo 1200 m	2x. Stathmopodidae.
Micro sp. 25	Mata O Le Afi 1650 m	
Micro sp. 25	Uafato 150 m	
Micro sp. 26	A'opo 1200 m	
Micro sp. 27	Faleolupo 120 m	
Micro sp. 27	Vaisala 15 m	
Micro sp. 28	A'opo 1200 m	2x. Oecophoridae
Micro sp. 29	Uafato 150 m	3x
Micro sp. 30	A'opo 1200 m	3x
Micro sp. 30	Uafato 150 m	
Micro sp. 31	Faleolupo 120 m	
Micro sp. 32	Uafato 150 m	2x
Micro sp. 33	Faleolupo 120 m	
Micro sp. 34	Faleolupo 120 m	
Micro sp. 35	A'opo 1200 m	
Micro sp. 36	Faleolupo 120 m	
Micro sp. 37	Faleolupo 120 m	
Micro sp. 38	Uafato 150 m	
Micro sp. 39	A'opo 1200 m	
Micro sp. 40	A'opo 1200 m	
Micro sp. 41	A'opo 1200 m	
Micro sp. 42	Faleolupo 120 m	
Micro sp. 43	Vaisala 15 m	2x
Micro sp. 44	Faleolupo 120 m	
Micro sp. 44	Vaisala 15 m	
Micro sp. 45	Faleolupo 120 m	
Micro sp. 46	Mata O Le Afi 1650 m	
Micro sp. 47	Mata O Le Afi 1650 m	Carposinidae. A newly discovered species first recorded in the same locality in 2012.
Micro sp. 48	Vaisala 15 m	
Micro sp. 49	Vaisala 15 m	4x
Micro sp. 50	Faleolupo 120 m	2x
Micro sp. 50	Vaisala 15 m	14x
Micro sp. 51	Faleolupo 120 m	
Micro sp. 51	Mata O Le Afi 1650 m	

Family/species	Locality	Notes
Micro sp. 51	Mata O Le Afi 1650 m	
Micro sp. 52	Mata O Le Afi 1650 m	3x
Micro sp. 52	Mata O Le Afi 1650 m	
Micro sp. 53	A'opo 1200 m	
Micro sp. 53	Mata O Le Afi 1650 m	
Micro sp. 53	Mata O Le Afi 1650 m	11x
Micro sp. 54	A'opo 1200 m	
Micro sp. 54	Mata O Le Afi 1650 m	
Micro sp. 54	Uafato 150 m	2x
Micro sp. 55	A'opo 1200 m	
Micro sp. 55	Uafato 150 m	8x
Micro sp. 56	A'opo 1200 m	
Micro sp. 56	Uafato 150 m	5x
Micro sp. 58	Faleolupo 120 m	6x
Micro sp. 58	Uafato 150 m	3x
Micro sp. 59	Uafato 150 m	
Micro sp. 60	A'opo 1200 m	
Micro sp. 61	Faleolupo 120 m	
Micro sp. 62	A'opo 1200 m	
Micro sp. 62	A'opo 890 m	
Micro sp. 62	Faleolupo 120 m	
Micro sp. 62	Mata O Le Afi 1650 m	
Micro sp. 63	Mata O Le Afi 1650 m	
Micro sp. 64	Faleolupo 120 m	
Micro sp. 65	Faleolupo 120 m	2x
Micro sp. 66	Faleolupo 120 m	2x
Micro sp. 67	A'opo 1200 m	2x
Micro sp. 68	Uafato 150 m	4x
Micro sp. 69	Faleolupo 120 m	
Micro sp. 69	Vaisala 15 m	
Micro sp. 70	Faleolupo 120 m	
Micro sp. 71	Mata O Le Afi 1650 m	
Micro sp. 71	Mata O Le Afi 1650 m	
Micro sp. 72	Faleolupo 120 m	2x
Micro sp. 73	Faleolupo 120 m	2x
Micro sp. 74	Faleolupo 120 m	
Micro sp. 75	Faleolupo 120 m	

Family/species	Locality	Notes
Micro sp. 76	Uafato 150 m	
Micro sp. 77	Faleolupo 120 m	6x
Micro sp. 78	Faleolupo 120 m	2x
Micro sp. 79	A'opo 1200 m	
Micro sp. 80	A'opo 1200 m	
Micro sp. 81	Faleolupo 120 m	
Micro sp. 81	Uafato 150 m	
Micro sp. 82	Uafato 150 m	
Micro sp. 83	A'opo 1200 m	
Micro sp. 84	Faleolupo 120 m	3x
Micro sp. 85	Mata O Le Afi 1650 m	
Micro sp. 86	Faleolupo 120 m	
Micro sp. 87	Faleolupo 120 m	
Micro sp. 88	A'opo 1200 m	
Micro sp. 89	A'opo 1200 m	
Micro sp. 90	A'opo 1200 m	
Micro sp. 91	Vaisala 15 m	
Micro sp. 92	A'opo 1200 m	
Micro sp. 93	Uafato 150 m	
Micro sp. 94	A'opo 1200 m	2x
Micro sp. 95	A'opo 1200 m	
Micro sp. 96	Uafato 150 m	
Micro sp. 97	Faleolupo 120 m	
Micro sp. 98	Uafato 150 m	2x
Micro sp. 99	Uafato 150 m	2x
Micro sp. 100	A'opo 1200 m	
Micro sp. 101	A'opo 1200 m	
Micro sp. 102	Faleolupo 120 m	

Appendix 3.2. Pictures of frosted vegetation in two basin areas at Mata O Le Afi 1650 m above sea level, Central Savai'i Rainforest.
First record of a rare frost event for Samoa.

Appendix 3.3. Field diary of Invertebrate team activities

(author – Eric Edwards)

Day	Date	Activities	Participants
Sunday	24	Light trap Vaisala Hotel site. Light pollution from street lights reduced the catch.	Kristiane Davidson, Kiran Liversage, Claudia Bruschini
Monday	25	Vaisala. Collected *Petrelaea tombugensis* Talie Blue butterfly for molecular genetic evolution study - Claudia. Pinning insects from Vaisala. Plan, prep. equipment for four nights A'opo access to uplands. Light Trap Falialupo Rainforest Preserve with five core team plus Faleolupo assistants. A warm calm evening but moth catch was slow.	Core team: E Edwards, K. Liversage, C. Bruschini, Tito Vaitoelau, Clive Fala. And two Falealupo villagers
Tuesday	26	With all teams arrived road end 800 m asl. above A'opo. Much new land development and plantation. Formerly overgrown logging tracks cleared, groomed by digger to high standard. Exotic plantation trees cut out in favour of cropping. Some cattle. Met three A'opo villagers assigned to 'bug team'. Moved slowly up the well formed track. Partly cloudy but collected 6 *Phalanta exulans* Samoan Ranger butterflies at around 1000 m asl. for Claudia's study and expedition. All team plus Schannel involved. Went on up to Mata O Le Afi camp collecting along the way. Established camp and light trapped out of a light swirling southeast wind. Temperatures remained mild and did not drop as in the past.	Core team plus three A'opo villagers
Wednesday	27	Pinned insects on plastic lid. Team established two malaise traps and 11 pitfall traps and some camp furnishings. Light trapped in light drizzle under purpose built fly. Better catch than night before. Whole camp turned out to help even though a little cooler.	Core team plus three A'opo villagers
Thursday	28	Walked the cut track round Manga Mu and south to the head of south draining catchment at 1650 m asl. Stream poorly developed channel with temporal flood flow episodes. Some pools. Recorded dragonfly larvae, *Microvelia* and Gerrid pond skaters. Snail litter samples collected various places during the day. Walked out over crater high point ~1750 m asl. Light trapped at Mata o le Afi camp for third time. Still getting new records of moths. Very many *Tiracola p. samoensis*. Later spotlighted and found no rats but recorded one cat. Also discovered *T. p. samoensis* were in large numbers on flower pannicles of *Reynoldsia pleisperma.* This explains the abundance at light trap and signals an abundant	Core team plus three A'opo villagers and Zhong Ruifeng - Cameraman

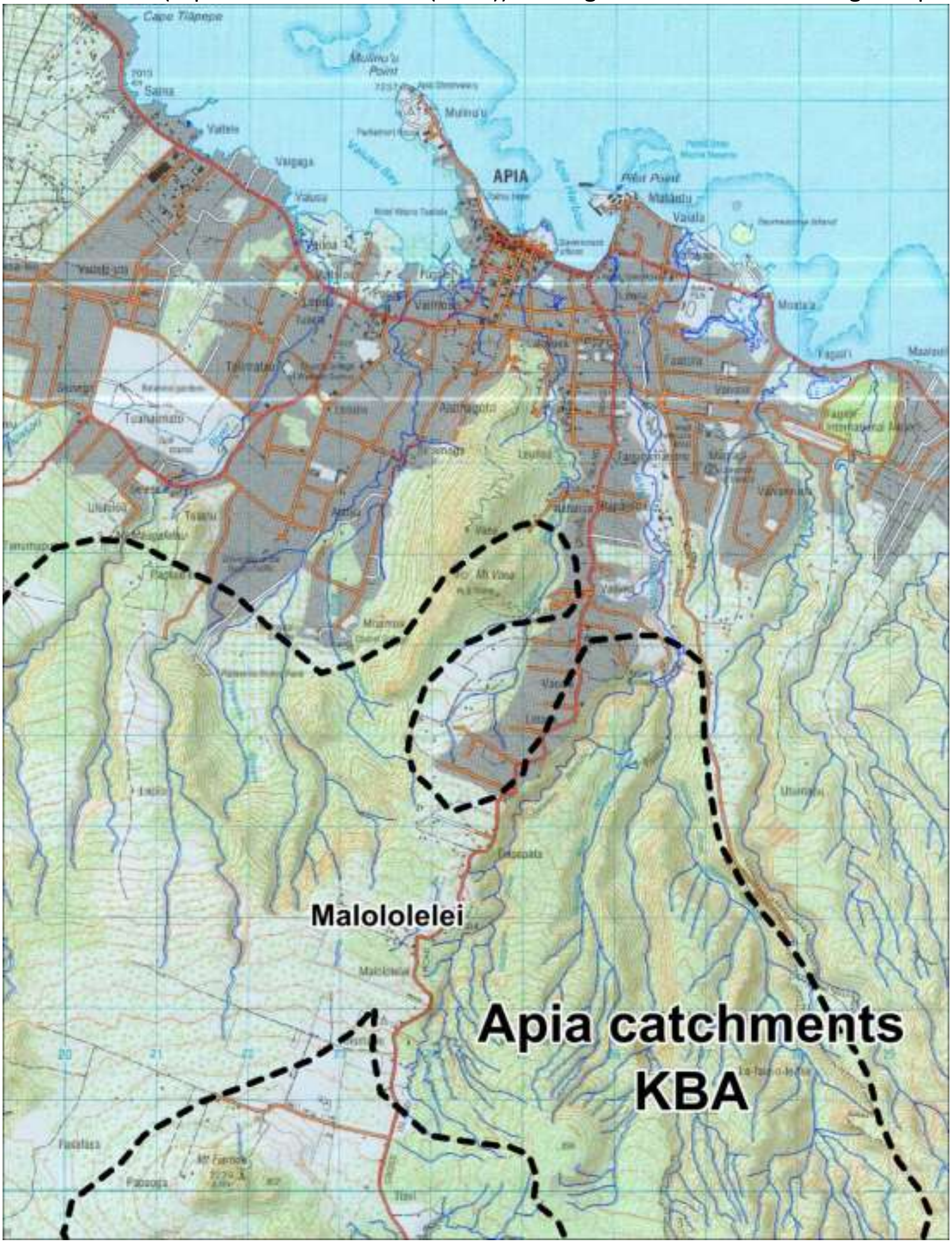
Day	Date	Activities	Participants
		seasonal food resource for insect feeding birds, pest cats and pest rat species *(Rattus rattus, Rattus exulans* and possibly (as yet unreported) *Rattus norvegicus).*	
Friday	29	Collected samples from Malaise traps and pitfalls. Packed up our camp and half team walked up Sili Sili summit. Kiran collected more snail litter samples. While I pinned insects. All walked down to 1200 m asl camp and met most other teams there. Set up light trap and cut moth fly paths in the bush. Light trapping very successful -very rich altitude -still above the merchantable timber line. May have gotten a record number of species for one night ever recorded in Samoa. Many helpers enjoyed the experience. Afterwards spotlighted till midnight and collected many micro-moths and other insects (beetles, crickets etc.). Some macro-pictures of insects.	Core team plus three A'opo villagers
Saturday	30	Packed up and walked out. Kiran, Clive & Claudia went early and netted butterflies at lower altitude and along the plantation road. Rest of us walked out in light rain. I attended a meeting of porters, villagers and MNRE staff. I was the only CI/CI consultant present and spoke on behalf of the 'experts'. Later drove down the track and found caterpillar of *Hypolimnas errabunda* (Samoan eggfly butterfly -entirely endemic to Samoa). Cleaned up at Vaisala and pinned some insects and pinned more after dinner.	Core team plus three A'opo villagers
Sunday	31	Returned Apia -CI office and motel. Pinned insects and attended planning meeting for Uafato-Tiavea.	Core team
Monday	1	Starting at Uafato, we met villagers assigned to our team. Surveyed coastal track and turned back in showery conditions. Pinned insects while team set up pitfalls and Malaise trap.	Core team plus three Uafato villagers
Tuesday	2	Team did coastal survey and went via steeplands to coastal cove and visited bird hide. Then all light trapped at Uafato bird hide site. Light trapping conditions were good with a warm calm night.	Core team plus three Uafato villagers
Wednesday	3	Pinned insects	
Thursday	4	Pinned insects and compiled powerpoint presentation.	
Friday	5	Joined team presentations at MNRE Apia office with senior officials and media present. Went to Vailima Gardens with Art Whistler and James Atherton to meet MNRE staff. Returned to CI Office.	
Saturday	6	Pinned insects	

Appendix 3.4. Grid references: Lepidoptera survey sample sites

Locality	Island	Grid reference	Notes
A'opo 820 m	Savai'i	-13.57081 -172.50723	Upslope road end. Modified exotic shrubland and scattered trees
A'opo 850 m	Savai'i	-13.57212 -172.50696	Fragmented weedy open forest remnant
A'opo 890 m	Savai'i	-13.57682 -172.50592	Logged forest
A'opo 950 m	Savai'i	-13.57841 -172.50504	Forest
A'opo 1000 m	Savai'i	-13.5812 -172.50565	Forest and tree fern understory
A'opo 1100 m	Savai'i	-13.5842 -172.5122	Above merchantable timber-line. Forest and tree fern understory
A'opo 1200 m	Savai'i	-13.58917 -172.5250	Complex forest
west Savai'i upland 1650 m	Savai'i	-13.63357 -172.50385	mixed complex upland forest
west Savai'i upland 1700 m	Savai'i	-13.63295 -172.50641	moss forest
west Savai'i upland 1750 m	Savai'i	-13.61705 -172.5010	Atop a cone moss forest
Mata O Le Afi 1650 m	Savai'i	-13.61005 -172.5010	Main team campsite open cinderfield, heath and Reynoldsia
Mata O Le Afi wetland 1300 m	Savai'i	-13.58951 -172.5218	Peaty wetland -fern, sedge and shrub
Mt Mu 1400 m	Savai'i	-13.60748 -172.5153	Airated larva and cinderfield open natural shrubland
Vaisala 15 m	Savai'i	-13.507 -172.6657	Urban by the sea -Talie
Falealupo 120 m	Savai'i	-13.52473 -172.7479	Fragmented weedy open coastal forest
Uafato 150 m	Upolu	-13.95315 -171.52249	Steepland modified forest and shrubland
Uafato coast 10 m	Upolu	-13.95153 -171.50947	Fragmented & invaded coastal tall shrubland & steepland cropping

Appendix 3.5. Literature Review of Lepidoptera Records from the Apia Catchments KBA

Appendix 3.5. Figure 1. Topographic map of Apia catchments, vegetation cover and location of Malololelei (reproduced from DLSE (2000)). Blue grids are one kilometre grid squares.



A high percentage of Samoa's moth fauna has been described from collections made at Malololelei in the Apia Catchments KBA at around 620 -670 metres, 13° 54' 20.3" (13.9056°) south 171° 46' 42.1" (171.7784°) west (see Appendix 3.5. Table 1). This is an important 'Type

Locality' for Samoan insects. Appendix 3.5. Table 1.shows 3 butterflies and 123 moths are described from specimens collected at Malololelei and that 234 species in total are known. This indicates sufficient data to provide a benchmark site for comparison almost 100 years later. While forest cover on the gentle slopes has been removed since the 1920's, River gorge systems immediately to the west of Malololelei retain indigenous dominated vegetation (Faiilagi 2015). Light trapping and hand collecting surveys associated with these river gorges are recommended to document the insect fauna and to compare with historical records. Vegetation and native invertebrate fauna values may prove worthy of protection here.

Appendix 3.5 –Table 1. Summary records of butterflies and moths recorded in the 1920s in the Apia Catchments at Malololelei. This is a montane site at about 620 m elevation Cross Island Road.

Author	Number of Type species	# additional records	Total number of species	Notes
Hopkins (1927)	3	3	6	All butterflies
Meyrick (1927)	63	21	84	Micro-moth species
Prout (1927)	9	9	18	Geometrid moths
Tams (1935)	51	75	126	Macro-moths including Pyraloidea
Total	**126**	**108**	**234**	

Lake Lanoto"o National Park and the upper Cross Island Road region

These areas straddle Upolu's dividing range and includes the origin of many stream headwaters of the Vaisigano and Fulu'asou Rivers draining to the north. Like the montane sites above a few hundred metres elsewhere in Upolu, these headwaters are very steep, gorged and difficult to access. Remnant native tall forest in tributaries can be seen in a context of typical afforestation activity and disturbed mixed forests adjacent. The steep, naturally protected gully systems are not easy to access but are likely the most important areas for native insects, snails and plants. And, these may be strategic to preventing local extinctions. Focussing on protecting, buffering and enhancing the wildlife in these more natural sites might be a challenge but further investigation could prove that such gorge areas provide the best protection for species in the Apia catchments.

Recommendations

- Hinterland remnant values are possibly undervalued in stream headwaters on Upolu. Natural gorge systems in Apia Catchments should be assessed to gauge vegetation, bird and invertebrate values. These may be found to be valuable, threatened and worthy of management.
- Surveys of butterflies and moths in indigenous dominated vegetation adjacent to Malololelei are recommended to assess catchment natural value and to compare with benchmark samples made over 90 years ago.

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Chapter 4: Report on the survey of birds of the Falealupo Peninsula Coastal Rainforest, Central Savai'i Rainforest and Uafato-Ti'avea Coastal Rainforest

Team Leaders/Authors: Mark O'Brien & Vilikesa Masibalavu
Team Members: Roini Tovia (DEC, MNRE), Va'a Anoifale (DEC, MNRE), Loto Tuitaalili (Forestry Division, MNRE), Michelle Gan Wan Jie (Intern)
Photo credits: All photos by Mark O'Brien unless otherwise stated

The Falealupo rainforest from the canopy walkway. Note the cyclone damage to the forest.

Summary

The avifauna team undertook rapid surveys at 4 sites in Samoa, 3 on Savaii and 1 on Upolu. A total of 157 standardised point counts were obtained, along with supplementary information on bird presence at each of the sites. This data-set, combined with the ICCRIFS survey in 2014 provides a comprehensive, standardised set of data for forest birds in Samoa.

The survey failed to find Samoan Moorhen (no confirmed observations for more than 100 years) but confirmed the presence of Tooth-billed Pigeon and 35 other species of native and introduced species in at least one of the sites surveyed.

The dataset provides the basis for assessing the global importance of each of the sites for bird species. The data confirms that the Central Savaii Rainforest is the most important of the KBA sites for Samoan bird populations, and indicates areas within that site that are of particular importance. The data also indicate the importance of the Apia Catchments KBA and Uafato-Tiavea Coastal Forest KBA.

The dataset agrees with previous information on altitudinal range of species – except that we recorded observations of Flat-billed Kingfisher at Mt Silisili at more than 1500m asl. The implications of this, the impact of increasing temperatures, and measures to minimise the effects of these changes are discussed.

First attempts at deriving population estimates for forest birds in Samoa are presented, although it is emphasised that a number of assumptions have been made in order to derive these estimates. Recommendations for further surveys and conservation actions are included.

1. Introduction

Ninety five bird species have been recorded in Samoa (Avibase 2017) of which 25 are breeding land-birds (BirdLife International 2017). Nine of these are endemic to Samoa, and 20 are classed as restricted-range species (species restricted to an area of less than 50,000km2) BirdLife International (2017), Stattersfield et. al. (1998), IUCN (2016a). Three bird species are currently classified as endangered or critically endangered (IUCN 2016b). These are Mao (Gymnomyza samoensis), Samoan Moorhen (Pareudiastes pacificus) (probably extinct) and Tooth-billed Pigeon (Didunculus strigirostris). Samoan names are respectively - ma'oma'o, puna'e and manumea.

Eight sites have been confirmed as Key Biodiversity Areas in Samoa (Conservation International et. al., 2010), six of which include birds as some, or all, of the species that trigger the sites as KBAs (Schuster 2011) (Table 4.1). One of the objectives of the current study is to provide information on bird populations for 3 of these Priority sites – Uafato-Tiavea Coastal Forest, Central Savaii Rainforest, Falealupo Peninsula – and to obtain any information on populations present at the 4th site – Apia Catchments.

Table 4.1. The land area of Priority Sites in Samoa (data from Conservation International (2010). Asterixed sites are part of the current study.

Site Name	KBA	IBA	Area (ha)	Percent of Samoa
Aleipata Marine Protected Area	Y	Y	156	0.06
Eastern Upolu Craters	Y	Y	4759	1.68
Uafato-Tiavea Coastal Forest *	Y	Y	2316	0.82
O le Pupu Pu'e National Park	Y	Y	4228	1.49
Apia Catchments *	Y	Y	8336	2.95
Safata Marine Protected Area	Y	N	101	0.04
Central Savaii Rainforest *	Y	Y	72699	25.69
Falealupo Peninsula *	Y	N	1537	0.54

The current survey assessed whether the sites contained at risk and common forest bird species. We estimated bird densities and each of the sites surveyed and indicated the extent to which these sites are ecologically important for the given species.
We assessed numbers of birds in relation to altitude because one of the likely impacts of Climate change is to move species, already restricted by altitude, to higher habitat. To identify those species most at threat we needed to understand which are already altitude-restricted.

1.1 Survey Team

Mark O'Brien (BirdLife International Pacific Partnership secretariat). Vilikesa Masibalavu (Conservation International Fiji Programme). Roini Tovia, Va'a Anoifale (DEC, MNRE), Loto Tuitaalili (Forestry Division, MNRE). Michelle Gan Wan Jie (Intern). The team surveyed in two groups. Each group was led by an experienced bird recorder – MOB and VM. Each team was supported by representatives of the relevant local community.

Figure 4.1. Bird survey field teams, together with local community representatives from Uafato. This photograph was taken after the last set of surveys in Uafato in August, 2016.

1.2 Taxonomy and the Species List used in this report

There are a number of alternative global taxonomies related to birds. All of these have extended our knowledge and understanding of species in the Pacific region in the last few years, with the result that many of the textbooks and Identification guides are currently out-of-date. Avibase (2017) provides a summary of the current status of each of the taxonomies that are currently in operation. This report follows the Handbook of Birds of the World format. The approach is based on 'the application of quantitative criteria for species delimitation, evaluating differences in morphology, vocalisations, ecology and geographical relationships' (Tobias *et. al.* 2010). Use of this taxonomy is simply because this is the system is used by BirdLife International and IUCN when applying the red list status to bird species. This can provide confusion for species in Samoa that have been split from a formerly wide-ranging species, and where the 'common' name has either been maintained for the species outside Samoa, or disbanded for use altogether. Table 4.2 (below) summarises name changes between IUCN (2017) and the identification guides (Pratt *et. al.* 1987, Watling & Talbot-Kelly 2004).

For example, the Crimson-crowned (or Purple-capped) Fruit-dove (*Ptilinopus porphyraceus*) ranged from Samoa, through Tonga and the Lau group in Fiji, and northwards to Ponape and Kosrae (Figure 4.2). Recent analyses has resulted in this taxon being split into 4 species, Kosrae Fruit-dove, *P. hernsheimi*, Pohnpei Fruit-dove, *P. ponapensis*, Tongan Fruit-dove *P. porphyraceus* and Samoan Fruit-dove, *P. fasciatus)* with the latter as restricted to Samoa and Western Samoa (del Hoyo & Collar 2014).

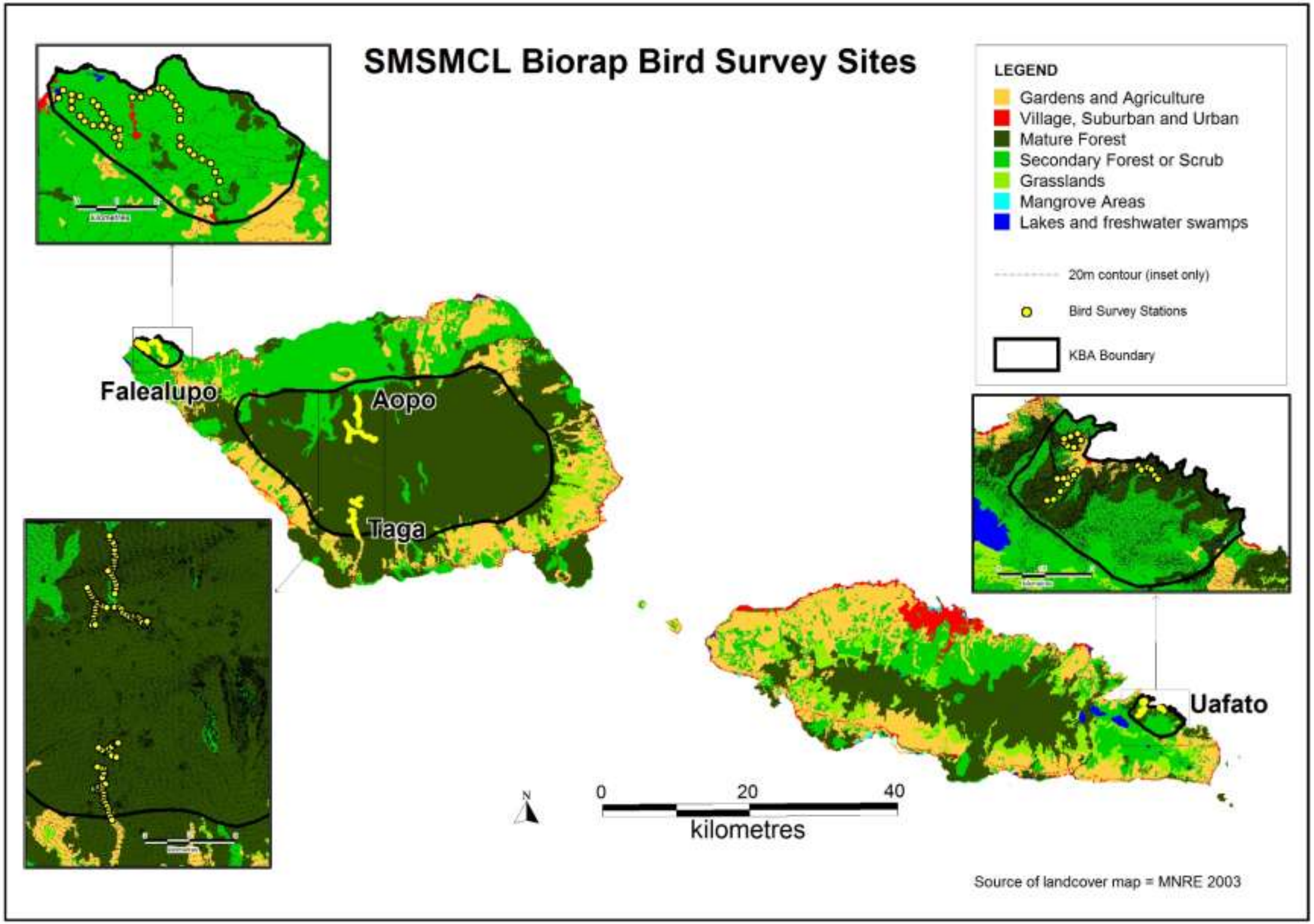
Figure 4.2 The Crimson-crowned (or Purple-capped) Fruit-dove (*Ptilinopus porphyraceus*).

The review by BirdLife International and HBW has now been published. However, there are still areas that need clarification. The Samoan subspecies of Island Thrush, Metallic (White-throated) Pigeon and Red-headed Parrotfinch have each, at times, been proposed as full species in their own right (Pratt & Mittermeier 2016, Watling & Talbot-Kelly 2004) which, if they came to acceptance, would change the global importance of the Samoan forest bird communities and the relative importance of individual sites considerably.

2. Methods

The teams used tracks, previously cut by forestry staff, as transects. Point counts were taken at c200m intervals along these tracks using the survey methods of Schuster *et. al.* (1999). All bird species seen or heard during a five minute period at the point were recorded. The number of individuals of each species was estimated, based on the variation in the distance and direction of the various calls. A short, five minute period is used to minimise the likelihood that individual birds will move from one singing post to another within the survey period. This short time period means, however, that some birds present at the site may not be recorded as they do not call within the timeframe. It is assumed that the large number of point counts at each of the sites will capture/detect all bird species present - and will provide information on the relative frequency of birds at each of the sites. A limitation of this method is that information available between the point counts, ie as surveyors walk from point to point, is ignored. This is remedied by maintaining a species list for each site that combines birds recorded on point counts with other species present. The estimates of bird numbers per point count cannot be compared between species, as different species have different detectability, but can be compared between the sites as the habitat is sufficiently similar that the detectability of an individual species is unlikely to vary. A map of survey sites is shown in Figure 4.3.

Figure 4.3 Bird Survey Sites



In the results we present a bar chart that indicates the variation in bird 'observed densities' between the sites surveyed in 2016 and 2014 (where the exact same survey methods were used). This indicates the variation between sites.

Second, we present a chart showing the variation in bird densities across the altitudinal range surveyed (Figure 4.4). All point counts within each 100m band were summed and the mean density displayed. The variation in the number of counts can be seen from the following chart. A high number of counts were reported for the 0-100m asl (above sea level) category, followed by the 700-800m asl category. Note the relatively small number of counts per band for the 1100-1600m asl categories. Variations in species densities reported in this range should be treated with caution.

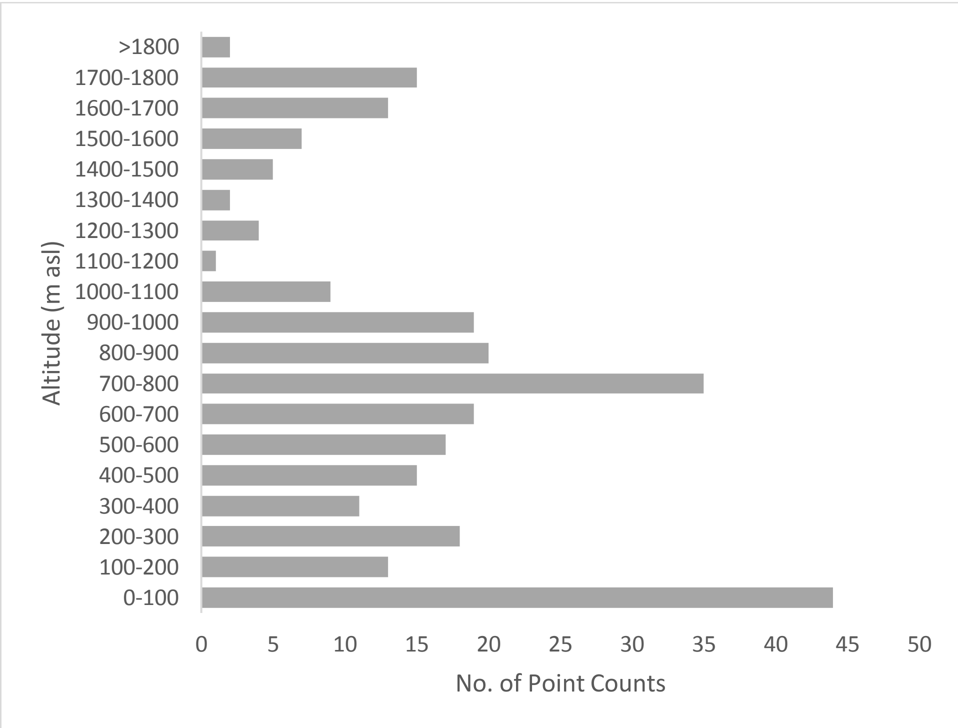


Figure 4.4. The number of point counts undertaken at a range of altitudes in the 2014 and 2016 surveys, all sites combined

The third measure that we report on is the extent to which each species represents a 'trigger' species – ie a species that determines whether a site qualifies as a Key Biodiversity Area based on its bird populations (if a site qualifies as a KBA for its bird populations then it automatically also qualifies as an Important Bird and Key Biodiversity Area).
The criteria for the identification of Key Biodiversity Areas has recently been updated (IUCN 2016). There are 5 main criteria, each of which are subdivided to determine the threshold number of individuals required to be present at a site in order for the site to qualify as a KBA. These main criteria are:

A. Threatened Biodiversity
    1. Threatened species.
    2. Threatened ecosystem types.

B. Geographically Restricted Biodiversity
    1. Individually geographically restricted species.
    2. Co-occurring geographically restricted species.
    3. Geographically restricted assemblages.
    4. Geographically restricted ecosystem types.
C. Ecological Integrity
D. Biological Processes.
    1. Demographic aggregations
    2. Ecological refugia.
    3. Recruitment sources
E. Irreplaceability Through Quantitative Analysis.

In this report only criteria A1, B1, B2 are considered for the analysis of the bird populations in forested areas in Samoa.

Under the new KBA criteria (IUCN 2016) we need to provide detailed information on the population of species at each site, and how that relates to the global population of the species. Much of this information has not previously been recorded for the species present in Samoa. While the current survey method is not best designed to capture this information (a Distance-sampling approach would have been preferable, but is a more complex method to employ and therefore deemed less suitable for the training purposes of the current survey) in order to estimate populations we have made a number of assumptions – which would warrant detailed assessment:

1. We calculated the average recorded density of birds across all 269 point counts surveyed in both 2014 and 2016. This provides an average recorded density for forested habitats in Samoa. We know that there is 1,710km^2 of forested habitat in Samoa, the total land area of which is 2830km^2.
   We know that different species show different preferences for forest habitats – Mao are highly dependent on forested habitats, while Polynesian Triller are not particularly dependent. We used the assessment presented by BirdLife International (2017) to categorise species into High, Medium or Low forest dependence. We assumed that the density in forests was 5, 2 or 1 respectively, times the density in non-forested habitats. For example, if we recorded a density of 5 birds/point count in the forested habitats, and the species was known to be highly dependent on forests then we assumed that the species density was 1 bird/point count in non-forested habitats. Conversely if the species was thought to show low dependence on forested habitats then the density was 5 birds/point count throughout.

2. We assessed the distance from the survey point that the species was likely to be recorded. We assumed, as a null value, that this distance was 100m – and then categorised species depending on whether they were loud-calling and obvious – in which case we presumed that we heard birds up to 200m distance – or relatively quiet and/or more frequently recorded by observation rather than call – in which case we presumed that most birds were reported within 50m of the observer. Consequently, the area of survey, at each point, was considered to be a circle of radius 50m, 100m or

200m. We calculated the mean density of birds per point count, based on these areas, and extrapolated to an observed population estimate of each species for Samoa. For example, if we considered that we recorded all birds within 100m of the centre of the point count then the area that we are surveying is π*radius^2. The radius is 100m/1000m or 0.1. Therefore we are surveying a circle of (22/7)*0.1*0.1 or 0.0314km^2. If we record 0.5 birds per point count then we can calculate the detectible density of birds as 0.5/0.0314, or 15.9 birds km^2.

3. For species that were not endemic to Samoa we extracted the land area of all the countries that the species occupied (BirdLife International 2017) and estimated the proportion of this that was represented by Samoa.

4. We extrapolated the densities recorded on point counts at each KBA and multiplied by the area of the KBA to derive a population estimate for the site, and then compared this with the Global population estimate.   The KBAs that we used to compare were Falealupo, Upper Savaii and Uafato.

5. We have only 12 point counts from Lake Lanoto'o as comparable information for the Apia Catchments KBA. Accordingly, we used information available via eBird for other sites in this KBA area in order to attempt to understand the frequency of occurrence of the bird species here. These other survey methods involve various different criteria for assessing effort input when surveying the site – and so direct comparisons with the 5 minute point count method are meaningless. We attempt to understand the frequency of occurrence of the species on checklists from the site. This is, by its very nature, rather coarse – and could certainly benefit from a lot more information for a range of sites within the Apia Catchments KBA area, which is easily accessible from the capital city.

3.Results

3.1 Surveys

Survey work was undertaken between mid July and early August (see Table 4.2). Two teams were able to complete up to ten 5-minute point-counts in each early morning session. Bird data were supplemented at other times of day – with any new species for the site being recorded.   Falealupo, Taga and Aopo are on Savaii, the latter two within the Central Savaii Rainforest IBA. Falealupo has not been registered as an IBA while Uafato, on Upolu, also forms part of an IBA. There was considerable variation in altitudinal range between the sites, with Falealupo and Uafato comprising primarily lowland forest while Taga and Aopo being much more upland areas.

Table 4.2. The number of point counts undertaken at each of the sites in 2016, dates on which those counts were completed, and the altitudinal range of each of the sites.

	Falealupo	Taga	Aopo	Uafato
No. five minute Point Counts	38	37	58	24
Dates	18-20 July	22-24 July	27-30 July	2-3 August
Minimum Altitude (m asl)	3	351	756	40
Maximum Altitude (m asl)	143	1066	1856	329

Detailed information on the location of individual point counts, their altitude, and the time of survey, are included in the Appendix – and can also be found, along with the bird numbers recorded at each site, on the global database, eBird (www.ebird.org).

3.2 The number of birds counted at each site

The estimated number of individuals of each species was recorded at each of the 157 5-minute point counts (see Table 4.3).

Table 4.3. The number of individuals of each species recorded at each of the sites surveyed in 2016. If a species was recorded at a site, but not during a Point count, then the Presence of the species is recorded with a P. Introduced species are marked with an 'I'.

Common Name	Scientific Name	Falealupo	Taga	Aopo	Uafato
Pacific Black Duck	*Anas superciliosa*	1	0	0	0
Red Junglefowl (I)	*Gallus gallus*	0	0	1	0
White-tailed Tropicbird	*Phaethon lepturus*	0	0	1	0
Buff-banded Rail	*Hypotaenidia philippensis*	P	0	0	P
Purple Swamphen	*Porphyrio porphyrio*	2	0	0	0
Brown Noddy	*Anous stolidus*	0	2	0	0
Common White Tern	*Gygis alba*	0	9	4	4
Feral Pigeon (Rock Dove) (I)	*Columba livia*	P	0	0	0
Metallic (White-throated) Pigeon	*Columba vitiensis*	12	2	16	7
Shy (Friendly) Ground-dove	*Alopecoenas (Gallicolomba) stairi*	P	0	0	0
Pacific Imperial-pigeon	*Ducula pacifica*	43	46	26	67
Many-coloured Fruit-dove	*Ptilinopus perousii*	8	0	0	9
Tooth-billed Pigeon	*Didunculus strigirostris*	P?	P?	0	P
Samoan (Crimson-crowned) Fruit-dove	*Ptilinopus fasciatus*	146	20	110	109
Blue-crowned Lorikeet	*Vini australis*	0	9	73	3
Long-tailed Koel (Cuckoo)	*Urodynamis taitensis*	0	0	0	0
Barn Owl	*Tyto alba*	0	0	0	0
White-rumped Swiftlet	*Aerodramus spodiopygius*	34	15	19	1
Flat-billed Kingfisher	*Todiramphus recurvirostris*	12	6	6	10
Samoan Triller	*Lalage sharpei*	7	1	2	2

Common Name	Scientific Name	Falealupo	Taga	Aopo	Uafato
Polynesian Triller	*Lalage maculosa*	48	15	13	7
Red-vented Bulbul (I)	*Pycnotous cafer*	3	0	0	5
Island Thrush	*Turdus poliocephalus*	0	3	55	0
Samoan Fantail	*Rhipidura nebulosa*	0	19	35	4
Samoan Flycatcher (Broadbill)	*Myiagra albiventris*	24	22	4	10
Pacific (Scarlet) Robin	*Petroica pusilla*	0	7	11	0
Samoan Whistler	*Pachycephala flavifrons*	25	16	35	17
Samoan White-eye	*Zosterops samoensis*	0	7	P	0
Ma'o	*Gymnomyza samoensis*	0	P	8	0
Polynesian Wattled Honeyeater	*Foulehaio carunculatus*	91	151	235	95
Cardinal Myzomela (Honeyeater)	*Myzomela cardinalis*	42	21	73	8
Polynesian Starling	*Aplonis tabuensis*	18	13	13	10
Samoan Starling	*Aplonis atrifusca*	83	78	65	66
Jungle Myna (I)	*Acridotheres fuscus*	P	0	0	0
Common Myna (I)	*Acridotheres tristis*	0	0	0	0
Red-headed (Samoan) Parrotfinch	*Erythrura cyaneovirens*	0	1	0	0
Samoan Flying Fox	*Pteropus samoensis*	14	4	2	3
Tongan Flying Fox	*Pteropus tonganus*	P	0	0	0

Thirty three species of bird, and both species of Flying Fox, were recorded on at least one site during the survey. Five of these bird species are introduced, with Red-vented Bulbul, Jungle Myna and Feral Pigeon being recorded on, or around, the lowland forest site at Falealupo while Red Junglefowl was considered to be calling from a feral population some distance from human-occupied areas at Aopo. We didn't record Common Myna around any of the forest study sites – this species is closely associated with human-modified habitats on Samoa.

The five most commonly recorded species were Polynesian Wattled-honeyeater, Samoan Fruit-dove, Samoan Starling, Pacific Imperial-pigeon and Cardinal Myzomela – for all these species numbers in excess of 100 individuals were recorded during the survey.
We recorded White-tailed Tropicbird, White Tern and Brown Noddy – all flying over the forested area, and also all present (as well as Brown and Red-footed Booby, and Bridled Tern) in the seas between Upolu and Savaii when we crossed on the ferry on 16th July, 2016. We noted no active nest sites in the forested areas for any of these species, however. July/August may not be the right time of year for these species to breed in Samoa. Globally-threatened Species.

There are 6 species of bird that are globally threatened and listed as regularly occurring in Samoa. One of these, Bristle-thighed Curlew (*Numenius tahitiensis*), is a long-distance migrant, associated with coastal and intertidal areas and does not form a part of this study. We recorded 4 of the remaining 5 terrestrial/forest-based globally-threatened species – with only Samoan Moorhen, a species that has not been definitely reported for over 100 years, being absent. Of the remaining species we located a single calling Shy Ground-dove at Falealupo – the 3rd known occupied site on Samoa for the species, a Tooth-billed Pigeon at Uafato, with possible calling birds at Falealupo and Taga, a number of calling Mao at Aopo, with a single calling bird at the high altitude campsite at Taga, and a number of calling Samoan White-eyes at Taga with birds also present at Aopo.

The current surveys reported here indicate that only one of the KBA sites contains sufficient numbers of globally threatened birds to trigger the site as a Key Site for Threatened Species.

The KBA criteria for the Threatened Species indicates that Central Savaii meets two thresholds that are relevant for species in Samoa:

A1a, >0.5% of the global population size AND >5 reproductive units of a CR or EN species, (in this case the Mao) and

A1b, >1% of the global population size AND >10 reproductive units of a VU species (in this case Samoan White-eye). In fact the Central Savaii Rainforest KBA holds 100% of the global Samoan White-eye population.

In addition, the number of Mao known to be present at Lake Lanoto'o , and a number of other sites within the Apia Catchments KBA, would indicate that Mao is likely to be a trigger species at this site.

The detailed analysis of Tooth-billed Pigeon distribution, being undertaken as a separate exercise, will likely indicate birds in sufficient numbers for this species to act as a trigger at one or a number of sites in Samoa.

Shy Ground-dove is a Vulnerable species, that is not endemic to Samoa. It is estimated to have a global population of 2500-9999 individuals (BirdLife 2017). One percent of this (25 individuals) is considerably in excess of any known site in Samoa (with the exception of the population on Nuutele, part of the Aleipata Marine Protected Area KBA).

3.3 Endemic Birds of Samoa

There are nine species of Endemic bird in Samoa. Four of these are also listed as globally-threatened. The remaining five are considered to be either Near-threatened (Samoan Triller and Samoan Flycatcher) or of Least Concern (Flat-billed Kingfisher, Samoan Whistler and Samoan Fantail).

The Flat-billed Kingfisher is endemic to Samoa, being replaced by the very similar, and much more widely distributed, Collared Kingfisher *T. chloris* in American Samoa. Flat-billed Kingfisher is distinguished by its smaller size, wider based, and shallowly keeled lower bill, lack of contrast in turquoise green mantle and scapulars such that colour is almost the same as on the wings and plain underparts with no scaling (Fig 4.5). This survey observed Kingfishers up to 1600m above sea level on Aopo, Savaii.

Figure 4.5. The Flat-billed Kingfisher *Todiramphus recurvirostris.*

These species can be considered as trigger species for KBAs under Criterion B 'Geographically Restricted Biodiversity' (IUCN 2016). The specific thresholds, of relevance to endemic birds in Samoa, are defined as follows.

B1: Individual geographically restricted species
Site regularly holds >10% of the global population and >10 reproductive units of a species, or
B2: Co-occurring geographically restricted species
Site regularly holds >1% of the global population size of 2 or more species restricted-range species (of bird).

The data available provide an estimate of density of birds (observed mean number per point count) at each of the sites surveyed, and also across all sites surveyed in 2014 and 2016. This overall estimate is restricted to forested sites. We know that some of the species show a preference for forested areas (ie are likely to be at higher densities in areas that included native forest trees). Forest preference has been considered for all species by BirdLife International (2017). We can derive an overall mean density for each species in Samoa as follows

Samoa Density = (OD * For/SamArea) + ((OD/Pref)*NonFor/SamArea)

Where

Samoa Density = Mean number of birds per point count assuming a random sample of point counts across the country

OD = Observed number birds/point count in current study
For = Area of Forest in Samoa (1710 km^2)

SamArea = Total land area of Samoa (2830 km^2)

Pref = Species preference for forest (where Low preference scores 1, Med = 2, High = 5)

NonFor = Area of non-forested land in Samoa (1120km^2)

The second important piece of information is to consider whether the Observed mean number of birds per Point Count at a given site is likely to represent 1% or 10% or more of the global population of that species. We can calculate this as follows

Proportion of global population at Site = PropSite * ODSite / Samoa Density

Where

PropSite is the proportion of Samoa covered by the individual KBA (Table 4.1)
ODSite = Mean number of birds / Count at site

Table 4.4. Observed (with standard error) and extrapolated density of non-threatened Endemic birds in Samoa, together with mean/count at each of the KBAs surveyed in 2016. A single asterisk indicates that the density of individuals represents >1% of the global population of the species at the site, a double asterisk indicates that the density represents >10%.

	Flat-billed Kingfisher	Samoan Triller	Samoan Fantail	Samoan Flycatcher	Samoan Whistler
Observed Mean/count	0.20 (0.14-0.30)	0.07 (0.02-0.14)	0.39 (0.25-0.49)	0.33 (0.26-0.5)	0.49 (0.45-0.73)
Forest preference	Low	Medium	Medium	High	Medium
Forest Area, Samoa	1710	1710	1710	1710	1710
Total Area, Samoa	2830	2830	2830	2830	2830
Samoa Mean/count	0.20	0.06	0.31	0.23	0.40
Observed mean per 5 minute point count at each KBA site					
Falealupo	0.32	0.18*	0.00	0.63*	0.66
Uafato	0.42*	0.08*	0.17	0.42*	0.71*
CSR (Taga, Aopo, Salafai)	0.14**	0.06**	0.37**	0.34**	0.56**

From this we can see that more than 10% of the Global Population of all 5 endemic species is likely to be present on the Central Savaii Rainforests Site. All 5 species exceed the threshold for KBA category B1, Individual Restricted Range Species.

We can also see that >1% of the global population of four species (Flat-billed Kingfisher, Samoan Triller, Samoan Flycatcher and Samoan Whistler) are estimated to be present at the

Uafato – Tiavea Coastal Forest site – meaning that the site exceeds the threshold under KBA category B2, Co-occurring Restricted Range Species.

Finally we can see that >1% of the global population of two species (Samoan Triller and Samoan Flycatcher) are estimated to be present at the Falealupo KBA site, meaning that this site also exceeds the threshold under KBA category B2, Co-occurring Restricted Range species, for birds.

3.4 Restricted Range Species

A number of other species present in Samoa are considered to be Restricted Range species, even though they are not endemic. Restricted Range species are those with a geographic range of <50,000km^2. Nineteen species of bird are considered to be restricted range species, and present in Samoa. These include the 5 endemic species and the 5 globally threatened species, discussed above. Seven of the 19 species were recorded widely during the current survey. The island groups that these Restricted Range species are recorded as occupying are listed in Table 4.5, together with the total area of land occupied by these species, and the fraction of that land that is present in Samoa. For two of the species, Blue-crowned Lorikeet and Polynesian Wattled Honeyeater the distribution in Fiji occurs only in the easternmost group of islands, the Lau group, which cover 487km^2 of land. The Many-coloured Fruit-dove occurs throughout the Fiji islands as far as the westernmost part of Viti Levu.

We do not have comparable information on the density of any of these species in countries outside of Samoa – so our best attempt at estimating whether >1% or >10% if the species is in the KBA would be to use the same formula as above, estimating the Global Proportion of the Population at the site and then multiply it by the fraction of Suitable habitat that is present in Samoa.

Table 4.5. The countries occupied by Restricted Range species not endemic to Samoa, and not Globally Threatened.

Country	Blue-crowned Lorikeet	Polynesian Wattled Honeyeater	Samoan Starling	Many coloured Fruit dove	Samoan Fruit Dove	Area (km^2)
Samoa	✓	✓	✓	✓	✓	2,830
American Samoa	✓	✓	✓	✓	✓	199
Tonga	✓	✓		✓		747
Fiji Lau Group	✓	✓				487
Fiji whole country				✓		18,300
Wallis & Futuna	✓	✓				142
Niue	✓					260
Extent Suitable Habitat (Km^2)	4,665	4,405	3,029	22,076	3,029	
Samoa fraction	61%	64%	93%	13%	93%	

Table 4.6. Observed, standard errors and extrapolated density of non-threatened non-endemic, restricted Range birds in Samoa, together with densities at each of the KBAs surveyed in 2016. A single asterisk indicates that the density of individuals represents >1% of the global population of the species at the site, a double asterisk indicates that the density represents >10%.

	Blue-crowned Lorikeet	Polynesian Wattled Honeyeater	Samoan Starling	Many coloured Fruit dove	Samoan Fruit Dove
Observed Mean/Count	0.54 (0.34-0.74)	3.64 (3.32-4.0)	1.86 (1.6-2.2)	0.11 (0.0-0.19)	2.45 (2.08-2.82)
Forest preference	Low	Med	Med	Medium	Med
Samoa Mean/count	0.28	2.23	1.13	0.07	1.68
Extent Suitable Habitat	4,665	4,405	3,029	22,076	3,029
Samoa fraction	61%	64%	93%	13%	93%
Observed mean per 5 minute count at individual KBA site					
Falealupo	0	2.39	2.18	0.21	3.84*
Uafato	0.13	3.96	2.75*	0.38	4.54*
CSR (Taga, Aopo, Salafai)	0.52**	3.23**	1.74**	0	1.35**

Note that other species, listed as Restricted Range (Stattersfield *et. al.* 1998), Polynesian Triller and Polynesian Starling are present as far west as Solomon Islands and Vanuatu. Samoa represents a tiny fraction of the overall terrestrial area occupied by these species, and so it is highly unlikely that these species will contribute to Restricted Range status at the KBAs in country. One other species, Red-headed Parrotfinch, is also listed as both a Near-threatened and a Restricted Range species (BirdLife International 2017). We recorded just a single Red-headed Parrotfinch during the 2016 survey – and so felt that we had insufficient information to justify assessing the relative importance of sites. The 'Samoan' Parrotfinch is clearly a scarce bird that would warrant more detailed surveys to confirm its current status.

From Table 4.6 we can see that more than 10% of the Global Population of a further 4 Restricted Range species is likely to be present on the Central Savaii Rainforests Site. All 4 species exceed the threshold for KBA category B1, Individual Restricted Range Species. We can also see that >1% of the global population of two of the species (Samoan Starling and Samoan Fruit-dove) are estimated to be present at the Uafato – Tiavea Coastal Forest site – meaning that these species exceed the threshold for the KBA category B2, Co-occurring Restricted Range Species.

Finally, we can see that >1% of the global population of one of the species (Samoan Fruit-dove) are estimated to be present at the Falealupo KBA site, meaning that this species exceeds the threshold for the KBA category B2, Co-occurring Restricted Range species, for birds.

3.5 Records of Flying Fox during the survey

Although not bird species, flying foxes are regularly recorded while undertaking bird surveys in Samoa. There are two species, not easy to distinguish in flight, in Samoa.

The Insular, or Pacific, Flying Fox *Pteropus tonganus*, is a widespread species recorded from Solomon Islands, Vanuatu and New Caledonia in the west through to American Samoa, Niue and Cook Islands in the east. Although it is classed as of Least Concern in the IUCN Red list it is apparent that the population is declining throughout its range. Insular Flying Foxes tend to be nocturnal, forming large daytime roosts with many 10s of individuals.

During this survey we noted one Insular Flying Fox colony somewhere in the Falealupo forest – where we recorded between 14 and 21 bats flying out of the roost site every 15 minutes between 16:30hrs and 17:30hrs. We noted a bat roost of at least 12 individuals, probably Insular Flying Fox, at S13.502, W172.774 in Falealupo.

The Samoan Flying Fox *Pteropus samoensis*, has a more restricted distribution – being present only in Fiji, Samoa and American Samoa. It is classed as Near Threatened in the IUCN Red List, and also is considered to have a declining population. Samoan Flying Foxes tend to roost alone or in small family groups. It is more likely to be active during daylight hours, and can sometimes be seen soaring above the forest cavity in broad daylight.

During this survey we noted bats that we considered to be Samoan Flying Fox on 4 occasions at Falealupo, on 8 occasions around Taga, at 1 site at Aopo (just over 1000m asl, S13.581, W172.506) and on 3 occasions at Uafato. The majority of Flying Fox records were of flying birds – making extrapolation to some estimate of population very difficult.

Figure 4.6*.* Samoan Flying Foxes. The roosting photograph was taken at Falealupo, while the soaring bats were at Taga.

Samoan Flying Foxes are not easy to identify from Insular Flying Fox (Figure 4.6). Features to consider include whether roosting bats are in single, or in small family groups – or large colonies. The gingery fur on the back is in contrast with Insular Flying Fox which tend to be more creamy brown on the nape – although there are variations. In flight the less angular shape of the wings suggests Samoan Flying fox.

4.Discussion

4.1 Altitudinal variation

Plots of bird density at different metres above sea level indicate that, there appears to be an upper altitudinal limit for 5 species, and a lower limit for 5 other species – at least during the time of year/season when our observations were made.

The high altitudinal limits of both Island Thrush and Samoan White-eye have been noted previously (Butler 2012, Pratt and Mittermeier 2016). These birds were only reported above 900m and 800m asl respectively. Samoan White-eye was only rarely recorded on this survey – contrasting with the upland Savaii survey in 2012. Whether the difference in proportion of observations is due to the time of visit is unclear, but worth further assessment (Upland Savaii was surveyed in May in 2012, and in late July in 2016). Island thrush were commonly recorded, and noisy, above 900m both in 2012 and 2016, lending further support to the likelihood that the species has been extirpated on Upolu in recent years.

Mao were more frequently recorded in the upland areas in this survey – being recorded on Point Counts only at Aopo, and also heard pre-dawn, by Art Whistler, at the high altitude camp site at Taga. Birds surveyed in 2014 at Lake Lanoto'o were at a lower altitude than any reported in this study, while the research reported by Stirnemann *et. al.* (2016) was focussed on small populations both at this, and another low altitude site on Upolu.

The number of blue-crowned lorikeet recorded were considerably higher on Aopo, at sites above 1600m asl, than elsewhere. These birds were almost invariably early morning fly pasts – suggesting a diurnal altitudinal movement. Closer observations of birds would indicate whether there is movement from a communal roosting area into the uplands, or vice versa.

Our studies suggest that the Scarlet (Pacific) Robin on Samoa is more commonly recorded above 600m asl, supporting the assertion by Pratt and Mittermeier (2016) that they are common, particularly at higher elevations, on both Savaii and Upolu. Dutson (2011) notes that 4 of 9 subspecies of Pacific Robin in Melanesia are restricted to high altitude areas.

All records of Shy Ground-dove in Samoa are from below 500m asl – with birds on Nu'utele and Falealupo being coastal – only the reported birds at Taga being rather higher than that. Shy Ground-dove have been reported in Fiji at rather higher altitudes (Masibalavu and Dutson 2006) so this may not be a precondition of distribution. Many-coloured Fruit-dove were also found more frequently below 500m asl than above – although individuals were present at >1200m asl at Aopo in 2012.

Neither Samoan Triller or Samoan Flycatcher were reported at sites above 1100m asl, while Flat-billed Kingfisher were rather more frequently recorded below 1300m asl – although individuals were recorded as present at both 1500 and 1600m asl.

Species restricted to high altitudes may find that increases in annual temperature for Samoa, as predicted by climate change models (eg Whan *et. al.* 2014), will further restrict their distribution. Two species, island thrush and Samoan white-eye were only recorded at higher altitudes on Savai'i, while a third (mao), was recorded more frequently in the Savai'i uplands than elsewhere. It is unclear how exactly temperature increases might affect altitudinal distributions of Samoan birds. For example, the mechanism may be due directly to the change in temperature itself, or the consequence of other factors, such as changes in the phenology of the species food source, changes in predation rates as the suitability of sites for introduced species varies. Studies on Mao in lowland areas indicate that there are high predation rates on nests by introduced black rats (*Rattus rattus*), and that this predation varies with distance from disturbed habitat (Stirnemann *et. al.* 2015). The relatively high density of Mao in the uplands of Savaii may be due to reduced predation (as black rats are at lower densities at high altitude and/or in natural habitats), or due to increased presence of their preferred food sources, either of which could be impacted by increased temperature.

Previous studies have found that there is an upper altitudinal limit for flat-billed kingfishers (Butler 2012, O'Brien *et. al.* (2014), Pratt and Mittermeier (2016). By contrast, this study recorded kingfishers up to 1600m asl. Fisher *et. al.* (2012) recorded lizards up to 1325m asl at Aopo (although the second highest lizard was at 990m) indicating very low density above 1000m asl. It would be interesting to monitor changes in the diet of the kingfishers with altitude and whether this might explain the presence of birds as high as 1600m asl in 2016. Another likely consequence of climate change is a reduction in frequency but increasing intensity of cyclones in the region. We do not have much detail on the impact of cyclones on bird populations. We know that species such as pigeons and honeyeaters move away from cyclone-flattened forests. We do not know how far the birds move, what their subsequent survival rates are, or how long it takes sites to become suitable for the species again. Answers to these questions can only come from observations of individually-recognisable birds that are subjected to cyclones.

One feature of cyclones is that their maximum impact is felt only at a local level. They are unlikely to destroy all forest in the whole of a species' range. Clearly, however, species most at threat from cyclones are those that already have a very restricted range, such as Samoan white-eye (on the uplands of Savai'i) or those whose range has already been restricted by other factors (such as habitat loss and/or the impact of invasive species). The tooth-billed pigeon and mao may meet these criteria. We can minimise the risk of cyclones to these species by ensuring healthy populations across their range so that a single cyclone is unlikely to eradicate them. Creating or maintaining suitable habitats for at risk species at widely-dispersed areas within their range, rather than concentrating in one particular area, should be a strong focus of mitigating the impact of extreme weather events, such as cyclones, on small/remnant bird populations. Given the likely impact of Climate Change on the severity of cyclones, this may well be one of the most practicable and effective options for mitigating the effects of Climate Change on the conservation status of endemic Samoan avifauna.

4.2 Key Biodiversity Areas

The Central Savaii Rainforest is, clearly, the most important KBA/IBA in Samoa for birds. The site qualifies as a KBA based on criteria A1a, for Mao, A1b for Samoan White-eye, B1 for 11 species, including all five endemic species and both the globally threatened species, and B2 for all 11 species. If Samoan Moorhen is not extinct then it, also, is likely to be solely present on this KBA – while the KBA is also the most likely site to hold five breeding pairs of Tooth-billed Pigeon. Within the Central Savaii Rainforest the Aopo area, clearly, is the more important of the sites – with the majority of Mao records. The White-eye was recorded at both Taga and Asau (Butler 2012), while Mao was only recorded at the high altitude site at the former. Neither species was recorded at Sites 2 & 3, undisturbed crater sites >1200m asl (Butler 2012) or the relatively low altitude surveys undertaken in 2014 on the Eastern slopes (<850m asl), indicating that the distribution of both species across the KBA, even at high altitude, is patchy.

The bird population at Uafato – Tiavea coastal Forest KBA trigger criterion B2 for 6 species – four endemic, and two restricted-range species, while Falealupo bird populations also trigger criterion B2 for two species, the endemic Samoan Triller and Samoan flycatcher. Falealupo had not previously been considered as an Important Bird and Key Biodiversity Area.

We have not undertaken detailed surveys around the Apia Catchments KBA, beyond the point counts undertaken at Lake Lanoto'o in 2014. However, the site is the second largest KBA in Samoa – covering 3% of the total land area of Samoa. Recent bird survey data from the area indicates that the site is likely to be important for the Samoan Endemics as well as some of the more Restricted Range species. In addition, there are at least 2 areas where Mao are known to breed. Accordingly, the site is likely to qualify as a KBA based on criteria A1a, for Mao, B1 for all 5 endemics as well as the 2 Restricted Range species Samoan Starling and Samoan Fruit-dove and B2 for at least these 8 species.

4.3 Comparisons with previous surveys

Dhondt (1976) spent six months in 1973 and nine months in 1974 in Samoa, while Child (1979) spent three weeks in 1978. These authors noted:

a) Tooth-billed pigeon were rare but still existed; Dhondt saw the species only once
b) No sightings of shy ground-dove
c) Dhondt recorded no sightings of mao (although the latter was possibly heard on two occasions)
d) White-browed crake was not common but was not restricted to marshland
e) Samoan triller was not common but not rare; seen on about 50% of visits to the bush (see also Child 1979)
f) Island thrush was common in the forest (this includes Upolu as well as Savai'i)

Bellingham and Davis (1988) spent some time at sites in both Upland Savai'i and on the Tafua Peninsula where they employed 5 minute point counts to compare bird populations in the upland and lowland forest areas. They noted that

a) Flat-billed kingfisher, Samoan Whistler, White-rumped Swiftlet and Polynesian Starling and Samoan Flycatcher, were at higher densities in the lowland than the upland forest.
b) Samoan Fantail, Pacific Robin and Cardinal Myzomela were at higher numbers in the upland forest.
c) They recorded Mao, Tooth-billed Pigeon and Samoan White-eye (and possibly Samoan Moorhen) only in the upland forest.

5.Conclusions and Conservation Recommendations

The main pressures on bird populations in Oceanic island environments are:
the impact of Invasive alien species, primarily mammalian predators but with alien weeds, invertebrates and mammalian graziers also of concern in certain circumstances
the loss or reduction in quality of native habitat, particularly in lowland, productive, areas.
Increasingly, the impact of changes in climate directly on bird populations, and indirectly on conditions that impact on bird populations (such as phenology of flowering plants, presence of injurious species).

Figure 4.7. Forest at Taga. This photo illustrates the nature of the forest at around 500m above sea level. The count here recorded Pacific Imperial-pigeon, Samoan Fruit-dove, Samoan Fantail, Samoan Whistler, Polynesian Wattled-honeyeater, Cardinal Myzomela and Samoan Starling.

There are three primary responses that conservation managers can use to help to reduce the impact of these pressures on bird populations.

5.1 Protect sufficient key areas

Identifying the key areas for biodiversity is the first step to developing a basis for an effective national conservation plan. This study supports the recommendations of Conservation International (2010) in identifying Central Savaii Rainforest, Uafato-Tiavea Coastal Forest and, to a lesser extent, Falealupo Peninsula as key areas for birds. The review of recent bird sightings in the Apia Catchments KBA indicate that this, also is a key area for birds. The remaining sites in the KBA report, in particular Eastern Upolu Craters and O le Pupu Pu'e

National Park, are likely to provide the remaining priority sites for a network of areas that are protected to benefit avian (and other) biodiversity. Considered planning is required to ensure that there are sufficient key conservation sites distributed in the landscape that can provide refugia following cyclones. Valleys (and craters) might be particularly important as refugia since it has been noted that, following past cyclones, many birds moved into forest sheltered from the cyclone that contained native vegetation with fruit, flowers and leaves; less sheltered areas had little leaves, flowers and fruit remaining on the trees (Elmqvist *et. al.*. 1994, Park *et. al.*. 1992, Schuster *et. al.*. 1999). Protected areas, clearly, need to be areas that afford protection to biodiversity in general, and those species that are dependent on the protected areas for future survival, in particular. This might include minimising or eliminating logging, encroachment of agricultural activities, hunting and any other potentially damaging operations.

5.2 Improve forest quality in key sites

Improving habitat within the above key areas by removing invasive weeds and replanting native species is likely to further benefit many bird species. This is, clearly, a long term plan that can help to improve sites over decades. There is an initial need to develop a canopy that will benefit most species, but then also to include species known to be most important to the avifauna – with nectar-bearing flowering trees being of particular importance for the honeyeaters, for instance. One of the immediate areas of concern would be the re-establishment of forested areas following cyclone damage. Improved understanding of how to minimise the spread and establishment of invasive species in storm damaged areas, and the extent to which this subsequently limits the recovery of native forest would be an area of study that would benefit our understanding of how to respond to extreme weather events.

5.3 Increase survival and reproductive success of key endangered species

Many key declining species are threatened by the increasing presence of non-native mammalian predators, particularly species that have been introduced (eg black rat), or become common, since the arrival of Western peoples (e.g. cats). In some species removing one predator, such as black rats, may benefit not just egg survival, but also adult survival. This appears to be true for mao where targeted rat control during the breeding season is predicted to increase both reproductive success and adult survival (Stirnemann *et. al.* 2016). Targeting the early breeding season, in Samoa for Mao this means May, June and July may have the greatest impact on adult and chick survival. Cat control may also improve survival of juveniles in the early weeks, post-fledgling. Predator control should occur in sites which are identified as being important for the at-risk species.

Among the Critically Endangered bird species in Samoa it seems highly likely that the Samoan Moorhen is extinct. Serra *et. al.* (2016) reported a possible encounter with the species by a hunter as recently as 2012 and so some further investigative work in that area would appear justified. The location was near to part of the survey sites on Aopo both in 2012 and the current survey – with no signs of the bird. However, a more long-term monitoring programme, using both camera-traps and acoustic recorders, may provide evidence of the continued existence of this species. Confirming extinction, however, is clearly a much harder objective.

The conservation of the Tooth-billed pigeon is now of greatest urgency. The species has been upgraded to critically endangered (IUCN 2016). A review of the known biology of the species has recently been published (Collar 2016) who provides a comprehensive review of historical information regarding the species, and a number of suggestions for further research into the species biology and conservation requirements. Recent island-wide surveys of the species have been undertaken through the deployment of acoustic recorders by both Stirnemann (*pers. comm.*) and Serra (*pers. comm.*), and by the use of Traditional Ecological Knowledge (Serra *et. al.* 2016).

A key need of these acoustic surveys is to be able to accurately identify the 'coo' of a Tooth-billed Pigeon from that of other species, primarily Pacific Imperial-pigeon and Metallic Pigeon. There is considerable variation in the call, in particular of Pacific Imperial Pigeon, such that it is challenging to be able to confidently identify the occasional Tooth-billed Pigeon call. Similarly, it is not unreasonable to expect the call of the Tooth-billed Pigeon to be variable. Beichle (1979) and Beichle and Baumann (2016) describes the Tooth-billed Pigeon call and in the latter field guide compares it with the call of Pacific Imperial Pigeon. Despite some differences, Beichle and Baumann (2016) state that, in the field, distinguishing between the species' calls is difficult. Notwithstanding this, analysis of the two substantial sets of acoustic data may provide considerable knowledge on the current distribution of the species – at least the three large bodied pigeons in Samoa (Tooth-billed, Pacific Imperial and Metallic (white-throated) pigeons). Further challenges are, however, apparent – for example, we deployed an acoustic recorder along the ridge at Uafato where we observed a Tooth-billed Pigeon on 2 separate days. Analysis of the recordings failed to produce a single 'coo' call of any of the pigeon species!

The Mao is considered to be a globally Endangered species (BirdLife 2017). Recent studies in lowland and mid-altitude sites have identified locally high densities of populations (Stirnemann *et. al.* 2016). These sites are, however, few and far between across Upolu and Savaii. The Central Savaii Rainforest appears to hold a lower density of Mao but across a considerable area of the site – such that over 50% of the remaining population may be in this one KBA. Comparing the breeding biology of the species in upland with the lowland sites will provide information on factors that impact on the distribution of the species across the lowland forest sites in Samoa.

The Species Recovery Plans (MNRE 2006 a,b) are now up for review for Mao and Tooth-billed pigeon and will need to focus on identifying site-based priority conservation actions based on the best available evidence.

6. Further surveys

1. The acoustic recording surveys have been undertaken across many areas of Samoa. These were established to record the presence of Tooth-billed Pigeon, but provide information on the presence/absence of all Samoan species. These recordings, together with the

recordings obtained in 2012 in Aopo, need to be properly analysed for the range of important bird species in Samoa (ie the globally threatened tooth-billed pigeon and Mao being top priority, the endemic species next and the restricted range species – particularly those with a relatively small extent of occurrence – as a lower priority). It should be a high priority that the recordings themselves are stored safely. The analysis of acoustic recordings is a rapidly developing area of research – it is quite likely that future automatic analysis techniques will be able to extract information on a range of species with a known level of confidence.

2. Surveys of the remaining forest Key Biodiversity Areas in Samoa, focusing on forest patches which would establish transects to provide access to a range of different altitudes. Transects established at the Uafato-Tiavea Forest and the O Le Pupu-Pu'e National Park would indicate the importance of these sites, and enable further assessment of the relationship between many of Samoa's endemic species and altitudinal range. Both sites were recently considered to hold significant populations of Mao and Tooth-billed Pigeon (Schuster 2011). There may also be opportunities to use citizen science to collect bird information elsewhere in the Apia Catchments IBA, such as along the Cross Island road, to supplement the data collected by researchers.
3. The species most threatened by climate change, being currently restricted to high-elevation forest on one island only, is the Samoan white-eye. Further surveys to confirm this species' current distribution, which appears to be greater than 1000 m a.s.l., on the Savai'i plateau, are required. The sites listed in the Savai'i 2012 survey remain priority sites to visit. These include:
    a. Mauga, Maugaloa and Muliauga, located on the NE slope of the central mountain plateau between 900 and 1200 m a.s.l. where the montane forest meets cloud forest.
    b. Upland area between A'opo and Asau. This is on the NW slope of the central montane plateau at 900 m-1200 m a.s.l.
4. Collar (2016) highlights the likely importance of the threat of introduced predatory mammals to the native avifauna of Samoa. There is little information on the relationship between the distribution of these introduced species and proximity to human-impacted areas, native vegetation and access (but see Stirnemann et. al., 2015). This study found cat scats containing the wing feathers of Polynesian Wattled Honeyeater, at the high altitude camp site on Mount Silisili. It seems likely that effective control of these introduced predators is the most effective way to immediately benefit the productivity and survival rates of Samoan species, particularly those threatened with extinction. Effective control would be a considerable challenge in a tropical forest environment, but, if appropriate funding was available to facilitate effective control, would likely provide the most realistic way of improving the resilience of species to both habitat loss and climate change.

Acknowledgements

The bird survey team particularly acknowledges the support of the management support team, in particular Schannel van Dijken and Danita Strickland. They bore the repeated questions, requests and changes of plan with great fortitude and should be commended on ensuring that we came to the conclusion of the project all reasonably satisfied. We would like to thank all the forestry and other staff who spent weeks beforehand cutting and clearing tracks to make access to sites that much easier. As always, researchers would like to have got further, higher and more out-of-the way than managed; the fact we got as far as we did is a great credit. We would like to thank the other taxa teams for their enthusiasm, companionship, support and stimulating discussions. One of the unreported outcomes of these surveys is the regular mingling and discussions between folk with various forms of expertise. Many thanks to BirdLife International and Conservation International for allowing MOB and VM to participate in the survey. Many thanks to the staff of MNRE, Forestry, other government agencies and also to the students of the University of Samoa for their companionship and support throughout the field work. We hope that you learnt as much from us as we learnt from you. Most importantly many thanks to all the communities who graciously allowed us access to their sites.

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Appendix 4.1. Systematic List

The systematic list follows the order recommended by HBW.

Metallic (White-throated) Pigeon, *Columba vitiensis*, LC

Recorded on all four sites in 2016 –with a total of 37 birds on the point counts during the survey. Note that the maximum density at any one site is only 10% of the maximum density of Pacific Imperial-pigeons across the same survey.

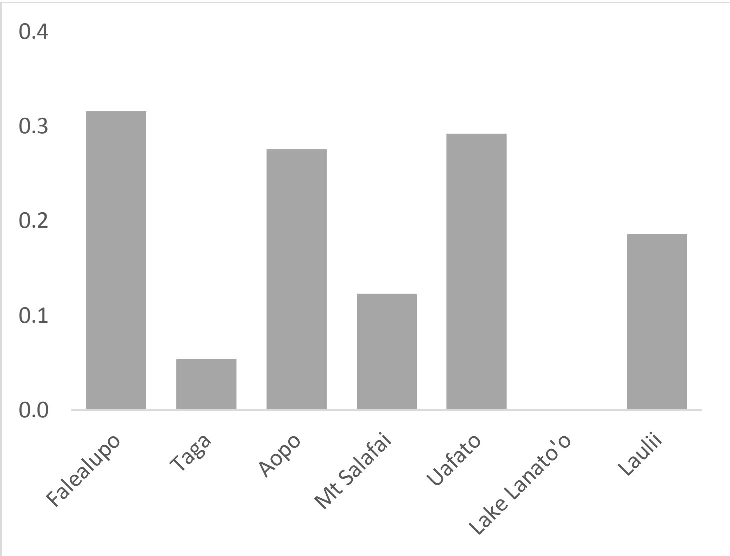

Figure 4.8. Variation in the number of Metallic Pigeon per point count at the different sites. Note that the 3 sites on the right hand side are on Upolu, while the 4 on the left are on Savai'i.

The species is a scarce bird in the Apia Catchments KBA, being present on one of six checklists at Dave Parker's Eco Lodge – but none of 9 checklists at Mt Vaea. It was also recorded at Malololelei Recreation Reserve, and two sites on the Cross Island Road.

There is no clear pattern to the distribution of Metallic Pigeon by altitude. The high numbers in the 1100-1300m asl range are based on a small number of counts (one and four counts respectively) so should be treated with caution.

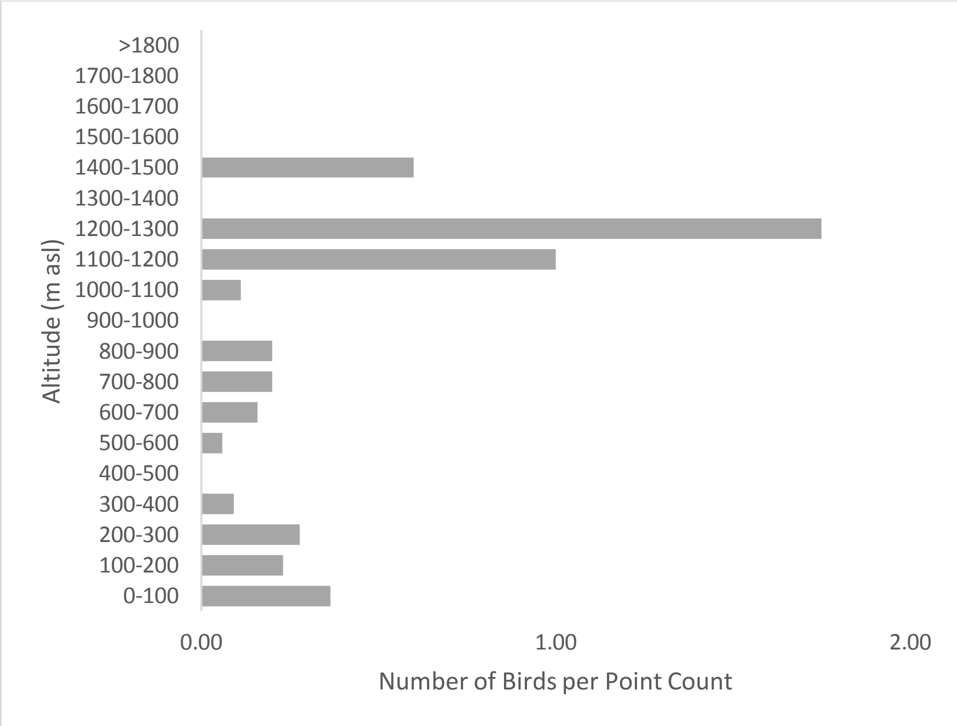

Figure 4.9. The distribution of Metallic Pigeon records by altitude in Samoa in 2014 and 2016.

The species is listed by IUCN as of Least Concern in the Red List. It does not qualify as a Restricted Range species. Samoa represents the easternmost point of the species distribution – where it occurs as far west as Malaysia, Philippines and Indonesia. The species has a distinctive coo call, rapidly repeated six or seven times. The call can be heard over 150m distance and is the main means by which the species is recorded in point count surveys. No overall species population estimate has been attempted, and the species does not qualify in any way to be a KBA trigger species.

Within Samoa, if we assume that the mean number of birds per point count was 0.2, that the bird is moderately associated with forested areas (and so density in forested areas is 2* density in other habitats), that the area over which birds can be heard calling is 200m then we can derive a population of 3,500 calling birds – presumably mature male birds. It seems likely that we do not capture all birds at a given location in the 5 minute point count – birds do not call for considerable lengths of time and so are not detectible. Accordingly, 3,500 birds in Samoa is likely to be a minimal estimate.

Shy (Friendly) Ground-dove, *Alopecoenas* (formerly *Gallicolumba*) *stairi*, VU (C2a(i))

A single bird was heard, calling repeatedly, at Falealupo during the current survey. Both survey leaders are familiar with the call, as the species is present in a number of native and secondary forest areas in Fiji.

There have been no recent reports of this species in the Apia Watersheds KBA.

A regional endemic – present in Fiji, Tonga, Wallis-Futuna, Samoa and American Samoa. The only known location in Samoa for years had been on the islands of Nu'utele and Nu'ulua. Recent TEK work has, however, identified a further population in the forest adjacent to Taga village.

The single bird was recorded at low altitude (11m asl). This mirrors the distribution on the Aleipata islands and also the population at Va'vau in Tonga. The Taga population is at a rather higher altitude – in the secondary forest above the village. Birds in Fiji have been recorded throughout the forested areas and show no obvious preference for low-lying areas, or indeed pristine forest.

Implications for KBA Status

The global population is estimated at 2,500-9,999 mature individuals (BirdLife 2016). The species is listed as Vulnerable, under the criterion C2ai.

As this species is listed as VU due to a declining population then category A1d is invoked. The two relevant figures here are 0.2% of total population and >10 pairs. Taking the lower population estimate would suggest that the minimum number of birds required in order to trigger a site as a KBA would need to be around 5 individuals. If we assume that only the males call, then we would need to hear at least 3 calling males. However, the >10 pairs criteria now becomes the relevant figure. There would need to be at least 10 calling birds for a site to qualify as a KBA under criterion A1. Currently only Nu'utele qualifies in Samoa.
Shy Ground-dove is also a Restricted Range species. The criteria here is that the site should hold 1% (ie 25 individuals) of the global population of the species. None of the sites surveyed held 25 or more mature individuals.

Tooth-billed Pigeon, *Didunculus strigirostris*, CR

Tooth-billed Pigeon is the most sought after species of bird in Samoa. Its population has declined significantly in the last 20 years. We were alerted to a potential calling bird at both Falealupo and Taga – the former we were unable to record, while there is a recording of the latter – although the irregular nature of the 'cooing' would suggest that it is not a tooth-billed pigeon (indeed it may not be a pigeon at all!). The identification of cooing tooth-billed pigeon from other species is an active research area at the moment (with recordings obtained from all sites surveyed as part of this project). Our contributions will be insignificant once those analyses become available and acceptable. Then, at Uafato, we were extremely lucky to observe a single bird fly past the observation lookout point in the forest on two separate days. We set an acoustic recorder at the site but were unable to obtain any recordings that may be attributed to the species.

The species has been recorded in the Apia Catchment KBA. There have been a number of sightings recently at Malololelei. A bird reported on eBird near the Cross Island road on 27 July, 2013 as "on private property, seen 2 of the 3 prior days my arrival. I saw it after a couple of hours waiting. It was seen in flight. Dark pigeon (dark throat), large bright colorful bill".

Implications for KBA Status

The species is listed as Critically Endangered by the IUCN Red list process, under the criteria C2a(i) – i.e. a Small and Declining population of less than 250 mature individuals, with less than 50 individuals in each subpopulation. We are currently only aware of single, or pairs of birds, at each of the five sites where we believe the bird to be present. This rather excludes the species currently being a trigger species at any one site – as there needs to be at least five reproductive units at each site.

Figure 4.10 View from the observation point at Uafato where Tooth-billed Pigeon was observed on two separate days by the bird teams. We set an acoustic recorded a little further along the ridge after the first observation, in the hope that we would capture some Manumea calls. Unfortunately failed to record a single 'coo' call. Photo by Mark O'Brien.

Pacific Imperial-pigeon, *Ducula pacifica*, LC

Pacific Imperial-pigeon was reported in good numbers at each of the 4 sites surveyed in 2016, with a total of 182 birds reported during the point counts.

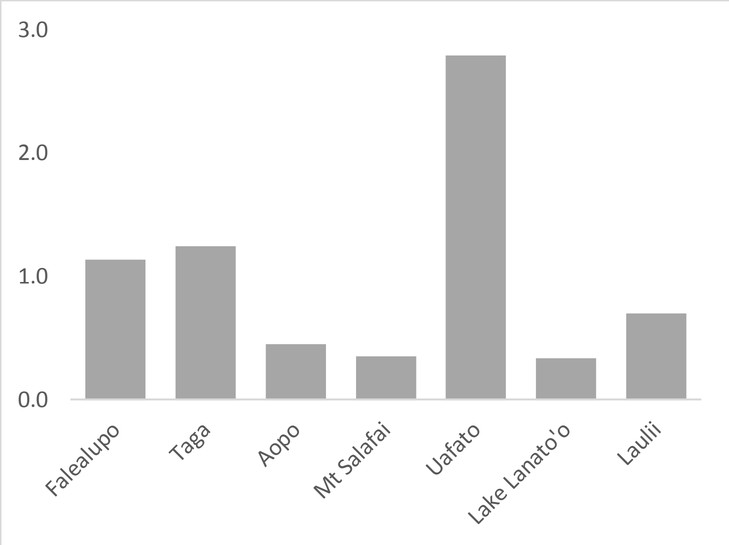

Figure 4.11. Variation in the number of Pacific Imperial-pigeon per point count at the different sites. Note that the 3 sites on the right hand side are on Upolu, while the 4 on the left are on Savai'i.

The species is regularly recorded at sites in the Apia Catchments KBA, including four birds on 12 point count sites at Lake Lanaoto'o in 2014. The species was recorded on five of the 9 checklists reported for Mt Vaea, and all six checklists reported from Dave Parkers Eco Lodge. It was also recorded at Malololelei, at two sites on the Cross Island road, and at Vaoala. It is likely to be as common in forested areas here as in other forested KBAs in Samoa.

The data suggest a bimodal peak in the distribution of Pacific Imperial-pigeon by altitude, with peaks around 100-300m asl and between 1200-1400m asl with a trough between 500 and 800m asl. Whether this is a real pattern or just a feature of the survey sites is unclear, but potentially of interest for further survey.

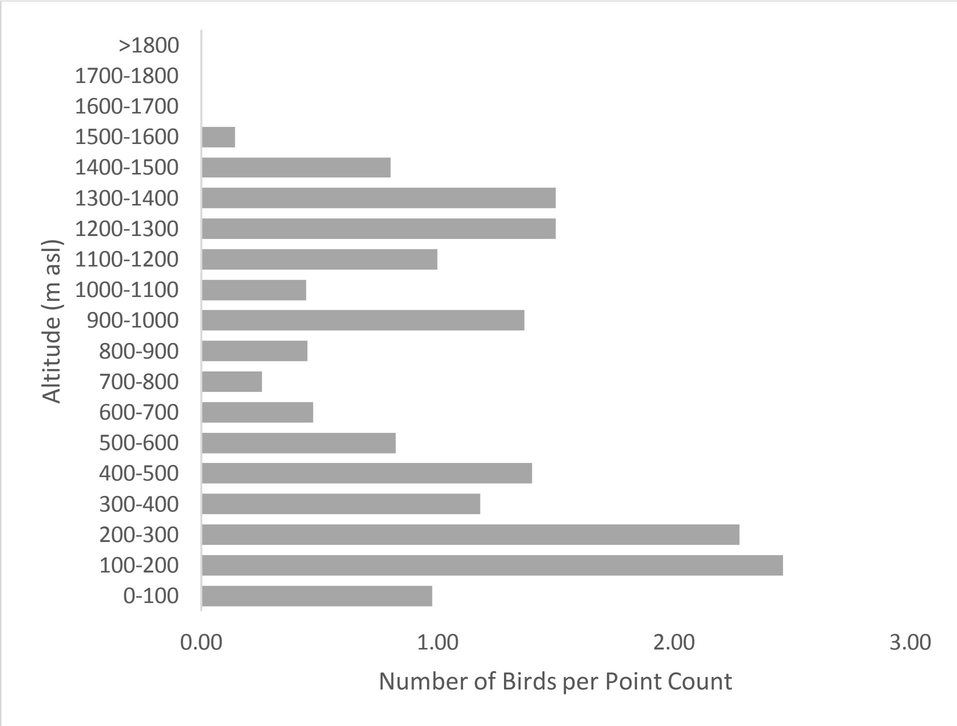

Figure 4.12. The distribution of Pacific Imperial Pigeon records by altitude in Samoa in 2014 and 2016.

Pacific Imperial-pigeon is a species of Least Concern, by IUCN Red list criteria. It is not considered to be a restricted range species, being distributed from Papua New Guinea in the west to American Samoa, Kiribati and the Cook Islands in the east. The species is thought likely to be declining, but at a slow rate commensurate with the loss of forested land. It is the primary target of hunters in Samoa, and can appear shy and elusive. However, its purr call is distinctive and can be heard from well over 150m distance. The coo call is its most common vocalisation - one form of which is frequently confused with a similar call by Tooth-billed Pigeon.

The likely large, at present unknown size, population of the species, and the fact that it doesn't qualify as a restricted-range species means that this is not a species that can act as a trigger for a KBA.

Within Samoa, if we assume that the mean number of birds per point count was 0.9, that the bird is moderately associated with forested areas (and so density in forested areas is 2* density in other habitats), that the area over which birds can be heard calling is 200m then we can derive a population of 15,500 calling, mature birds. It is unclear whether females call as much as males, so this estimate is likely to underestimate the total number of mature birds. It also seems likely that we do not capture all birds at a given location in the 5 minute point count – birds appear to not call for considerable lengths of time and so are not detectible. Accordingly, the estimate of 15,500 birds in Samoa is likely to be a minimal estimate.

Samoan (Crimson-crowned) Fruit-dove, *Ptilinopus fasciatus*, LC

One of the most commonly recorded species on the survey in 2016, with 385 individuals. Present at all sites, although surprisingly scarce at Taga.

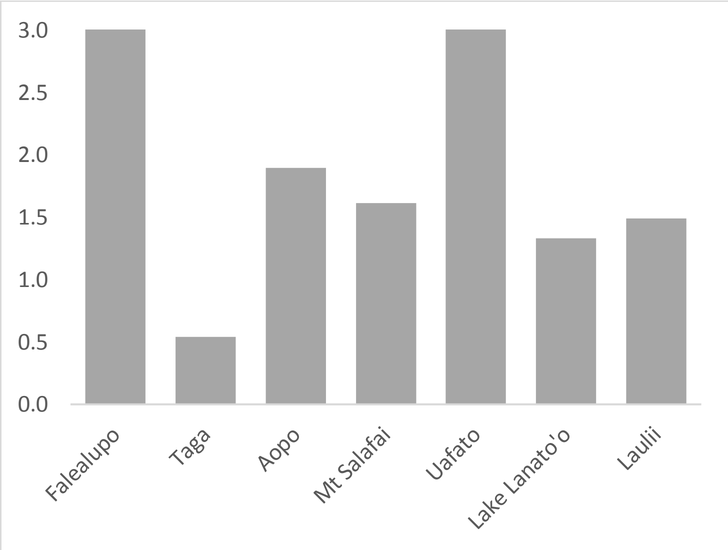

Figure 4.13. Variation in the number of Samoan Fruit-dove per point count at the different sites. Note that the 3 sites on the right hand side are on Upolu, while the 4 on the left are on Savai'i.

Commonly recorded on the Apia Catchments KBA including 16 birds recorded on 12 point counts at Lake Lanoto'o in 2014. In addition recorded on five of 9 checklists at Mt Vaea, all six checklists at Dave Parker's Eco Lodge. Also present at both sites on Cross Island road, Malololelei Recreation Reserve and Vaisigano Watershed.

The chart indicating the variation in density of Samoan Fruit-dove with altitude indicates a bimodal peak at low altitude and again at high (>1100m) altitude with low densities between 300 and 1100m asl. This pattern is similar for a number of species.

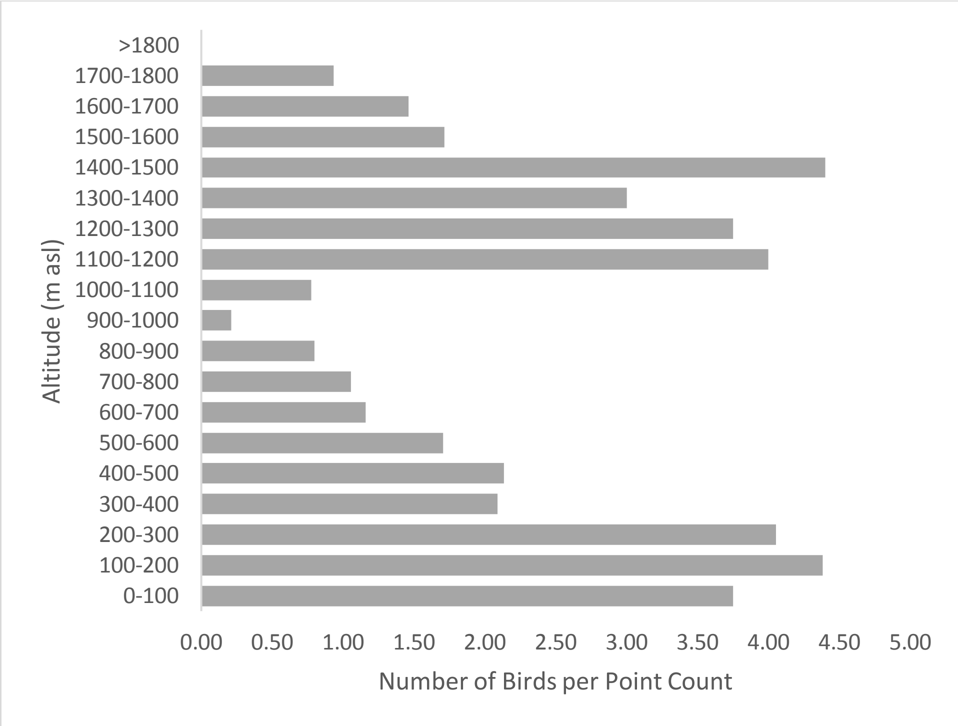

Figure 4.14. The distribution of Samoan Fruit-dove records by altitude in Samoa in 2014 and 2016.

Samoan/Crimson crowned Fruit-dove is a newly-recognised restricted range species, being found only in Samoa and American Samoa. Formerly it was included as part of the Crimson-crowned (Purple-capped) Fruit-dove complex *Ptilinopus porphyraceus*. Although restricted to a relatively small range (Extent of Occurrence is just 3,100 km^2) it is considered to be a species of Least Concern, according to the IUCN Red list criteria. There has been no attempt to estimate the population size, while population trend is regarded as stable in the absence of evidence for any declines or substantial threats. The species is considered to be moderately dependent on forest habitats.

Implications for KBA Status

The recorded density of Samoan Fruit-doves in this survey was 2.1 birds/point count. Birds call regularly during the survey period so this is likely to represent a significant proportion of the calling birds (just males?) around the survey point. The call can be heard from a considerable distance, certainly over 100m, but because the species is considered to be moderately dependent on forests we consider that the density in non-forested habitats is just half of that recorded in the current survey. Accordingly, the overall recorded density across Samoa and American Samoa (assuming similar densities in both countries) is likely to be around 1.7 birds per count. By dividing this figure by the area of survey (a radius of 200m around point) and multiplying by the total area available we derive a recorded population estimate of 40,500 calling birds.

Samoan Fruit-dove qualifies as a Restricted-range species and is therefore eligible to qualify as a trigger species for a KBA under criteria B1 and B2. The number of birds at the Savaii

Uplands KBA is estimated to be just short of 20% of the global population – qualifying Samoan Fruit-dove as a B1 species at this site. In addition more than 1% of the global population is also present at Falealupo and Uafato and, if the density at Lake Lanoto'o is representative, Apia Catchments, thus meaning that the species acts as a trigger for the B2 criteria at these sites.

Many-coloured Fruit-dove, *Ptilinopus perousii*, LC

We recorded Many-coloured Fruit-dove at two of the four sites surveyed in 2016. Eight individuals were reported at Falealupo and 9 at Uafato during the 5 minute point counts. In addition we recorded six individuals flying across the road in a 60 minute observation at Falealupo and five individuals from 8 hours of observation at the lookout at Uafato.

The species is regularly recorded at sites within the Apia Catchments KBA. It has been reported on six out of 9 checklists at Mt Vaea, and all six checklists at Dave Parker's Eco Lodge as well as at the Bahai Temple Grounds and a couple of other locations in the KBA.

The species has only been reported at low elevations during the surveys in 2014 and 2016, although single individuals were reported around Mt Silisili and at Asau in 2012.

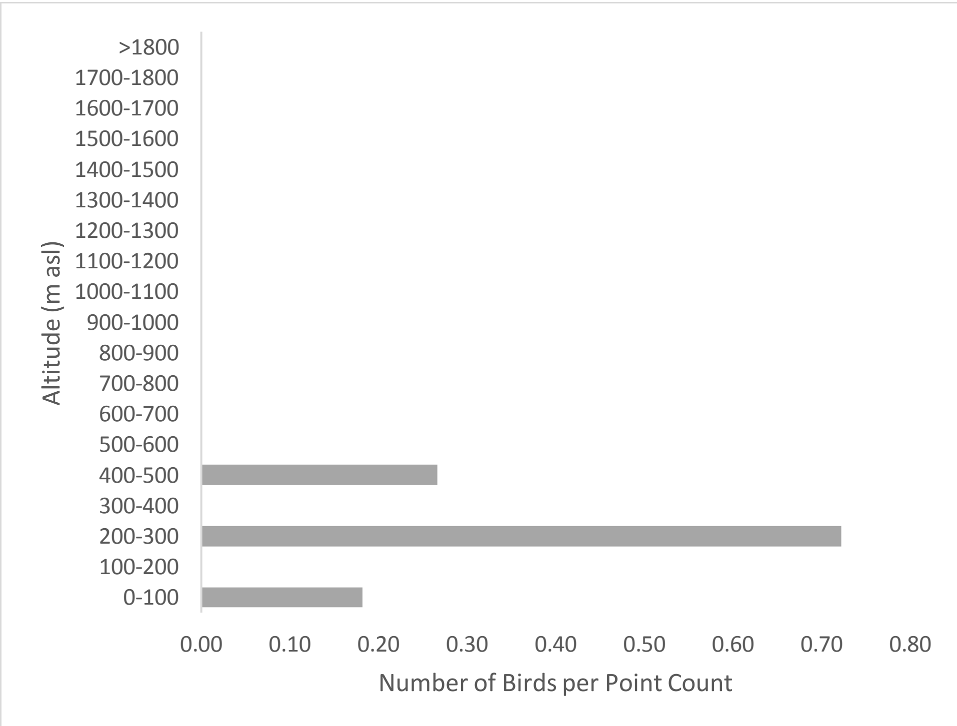

Figure 4.15. *The distribution of Many-coloured Fruit-dove records by altitude in Samoa in 2014 and 2016.*

Implications for KBA Status

Many-coloured Fruit-dove is a restricted range species, classified as of Least Concern in the IUCN Red-list process. It is present in Samoa, American Samoa and also Tonga and Fiji. It is thought to be in decline in Samoa and Tonga – while numbers in Fiji appear to fluctuate. Its occurrence is seasonally variable and presumably associated with the timing of flowering trees. No population estimate has been attempted for the species, and it is beyond the scope of the current study to attempt an estimate from the data available.

White-rumped Swiftlet, *Aerodramus spodiopygius, LC*

143 birds were recorded on the point counts – present at all sites (although just one individual was recorded at Uafato.

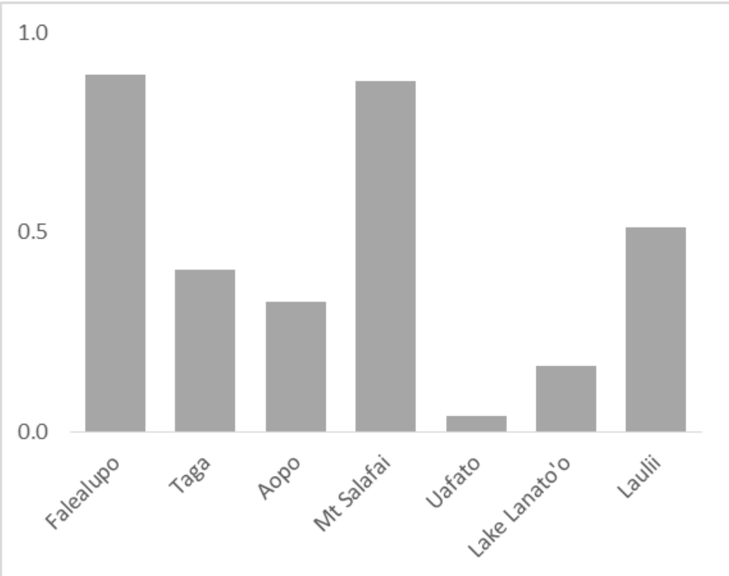

Figure 4.16. Variation in the number of White-rumped Swiftlets per point count at the different sites. Note that the 3 sites on the right hand side are on Upolu, while the 4 on the left are on Savai'i.

White-rumped Swiftlet is a commonly recorded bird throughout the Apia Catchments – with high numbers regularly recorded around Mt Vaea, and along the Cross Island Road.

There is little consistent variation in the distribution of White-rumped Swiftlet by altitude (Fig 4.16), although the high count around the 300-400m mark is based on 20 individuals counted across 11 counts.

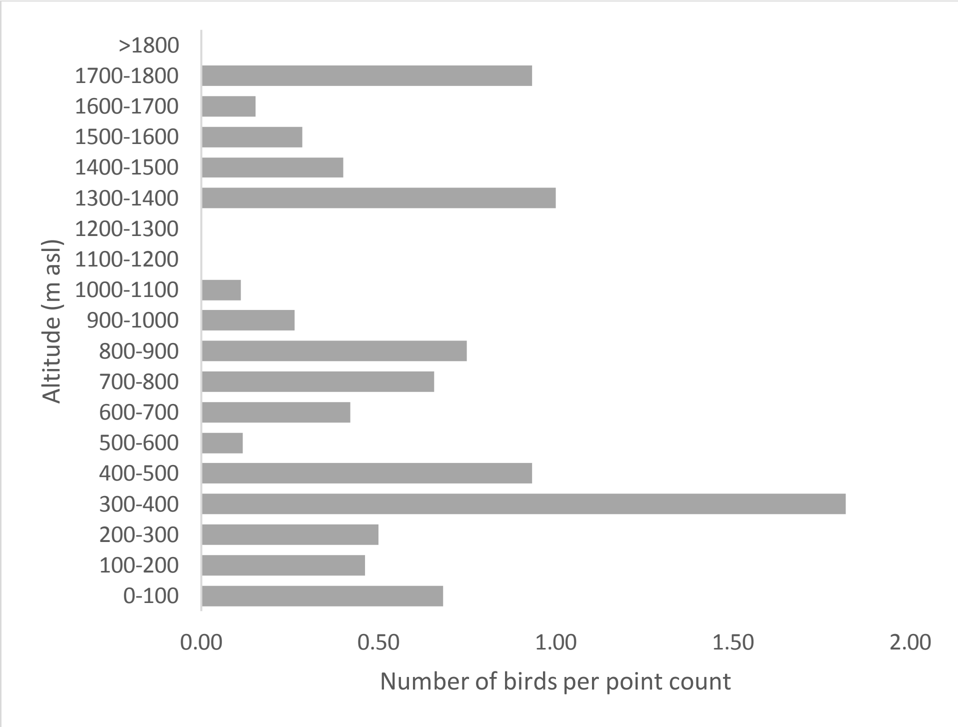

Figure 4.17. The distribution of White-rumped Swiftlet records by altitude in Samoa in 2014 and 2016.

The use of point counts is an inappropriate way of recording the number of white-rumped swiftlets – as the birds are continually in flight, and not restricted to one location. This, combined with the fact that the species is a wide-ranging species occurring from Manus, Papua New Guinea in the west through to Samoa in the east means that sites on Samoa are unlikely to be globally important for the species.

Flat-billed Kingfisher, *Todiramphus recurvirostris*, LC

Recorded at all four study sites in Samoa in 2016, with a total of 34 individuals reported during the point counts in 2016.

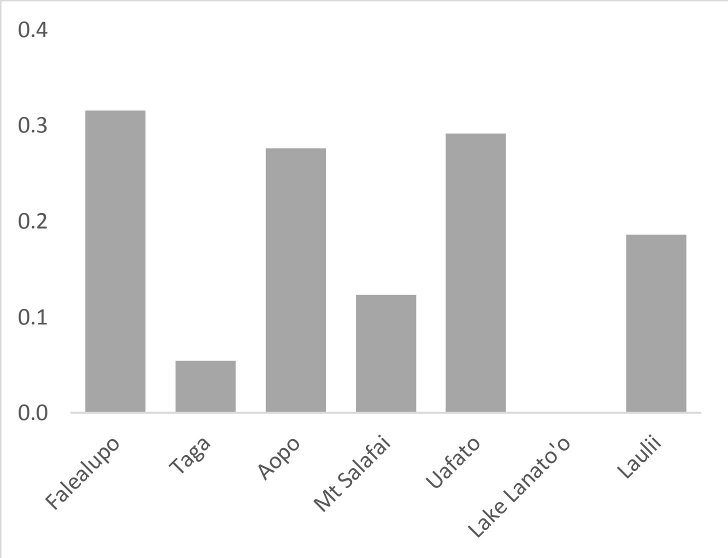

Figure 4.18. Variation in the number of Flat-billed Kingfisher per point count at the different sites. Note that the 3 sites on the right hand side are on Upolu, while the 4 on the left are on Savai'i.

The Kingfisher is regularly reported in the Apia Catchments KBA – a single bird was recorded at the Lake Lanoto'o survey in 2014, it has been recorded on four of 9 checklists at Mt Vaea, and four of six checklists at Dave Parker's Eco Lodge. It has also been recorded at the Vaisigano Watershed, at two locations on the cross island road and a number of other sites within the boundary of the KBA.

The Flat-billed Kingfisher is endemic to Samoa. It is listed as of Least Concern in the IUCN Red List. There has been no attempt to estimate the global population of the species.

Previous suggestions that the species is restricted to lower altitude sites, perhaps in association with the altitudinal distribution of reptiles – its main prey item, appear invalid following the surveys at Aopo this year.

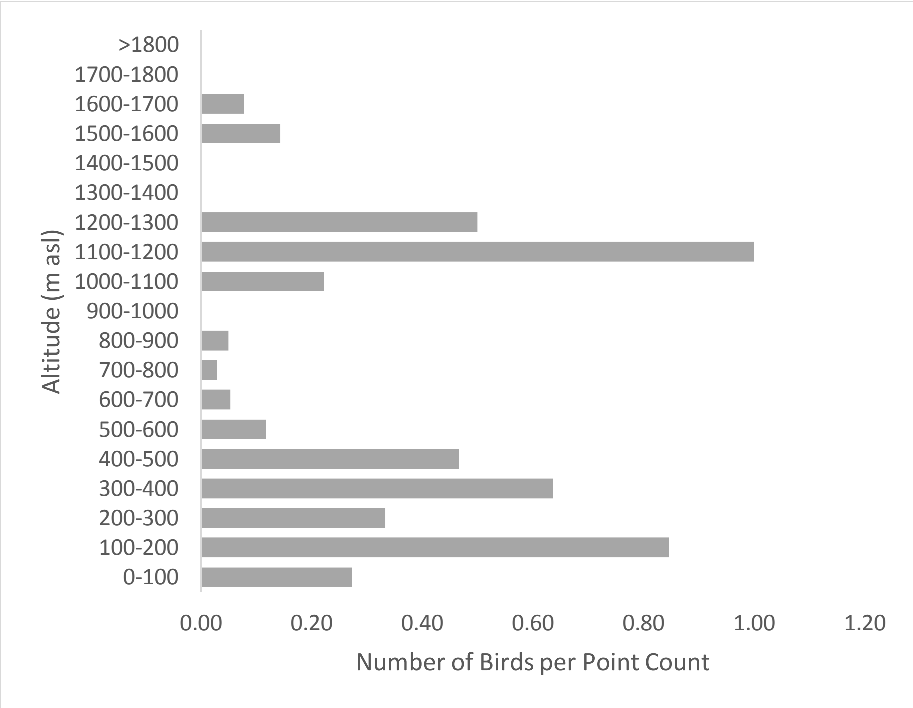

Figure 4.19. The distribution of Flat-billed Kingfisher records by altitude in Samoa in 2014 and 2016.

Seven birds were recorded at altitudes in excess of 1000m asl – with a single individual being reported as high as 1600m asl (out of 13 point counts in this band).

Implications for KBA Status

The mean recorded density of Flat-billed Kingfishers in the survey was 0.2 birds per point count. There is little evidence that the species is restricted, or even prefers, forested areas so we can assume that this is a reasonable estimate across the island as a whole. Kingfishers are normally recorded by their long, loud, laughing call. These can be heard over a distance in excess of 150m from the survey site – so we assume that the counts l estimate the number of birds within a 200m radius of the site. We don't know whether both male and female kingfishers emit the call – so the estimate of 4,600 calling birds should to be considered a conservative estimate of mature individuals. While the call is loud and easily identifiable, it is unclear how frequently a bird is likely to make the call, and so how likely it is to be recorded on a 5 minute point count. Subjectively, it would appear that there is a reasonable chance that many birds do not get detected as they remain quiet. The 4,600 calling bird estimate is likely to considerably underestimate the total number of birds in the population.

Extrapolating the mean density of kingfishers in the Savaii Uplands site gives a population of 816 birds – or 18% of the total calling population. The Flat-billed Kingfisher can be considered a trigger species for KBA criterion B1 at Savaii Uplands as the population at the site exceeds 10% of the global population of the species. In addition, we estimate 76 calling birds at Uafato – 1.7% of the global population, so the species can help to trigger KBA criterion B2 at this site.

Blue-crowned Lorikeet, *Vini australis*, LC

Blue-crowned Lorikeets were recorded at three of the four sites in 2016 – being absent only from Falealupo. Nine individuals at Taga and 3 at Uafato were 'swamped' by 73 individuals reported from Aopo.

Lorikeets can be seen in the Apia Catchments KBA. Three birds were recorded at the Lack Lanoto'o site in 2014, it has been recorded on four of 9 checklists at Mt Vaea, and five of the six checklists from Dave Parker's Eco Lodge. It has also been noted at the Cross Island Road and the Vaisigano Watershed.

The high number of records at Aopo are reflected in the apparent strong preference for high altitude sites at this time at least. It is unclear whether this accurately reflects a preference, or simply indicates that birds are more easily detectible at high altitude sites when they are most frequently seen flying and calling in pairs, or small flocks as they move, presumably from a roost site to the feeding areas.

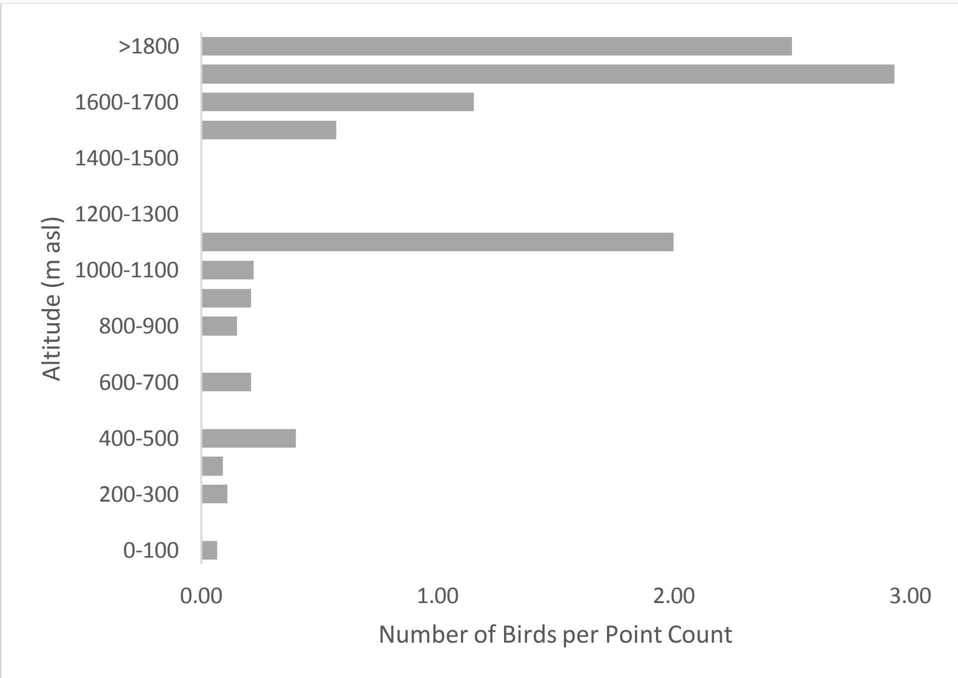

Figure 4.20. The distribution of Blue-crowned Lorikeet records by altitude in Samoa in 2014 and 2016.

Blue-crowned Lorikeets are a Restricted Range species, being recorded from the Eastern Isles of Fiji east through Tonga, Wallis and Futuna and Niue, through to Samoa and into American Samoa as the easternmost distribution.

Implications for KBA Status

A global population estimate has not been calculated. It is likely that the single largest population of Blue-crowned Lorikeet occurs in Samoa. Estimating numbers is, however, very difficult as most of the birds reported would be individuals, or pairs of birds flying overhead and calling.

The vast majority of Blue-crowned Lorikeets on Samoa were recorded on the Savaii Uplands KBA. Since Samoa is likely to contain the highest global population of the Lorikeet, it is likely that the proportion of the global population on the Savaii Uplands KBA will exceed 10% of the global population, and so qualify as a trigger species for the site under KBA criteria B1. It is also, therefore likely to be a trigger species under KBA criteria B2. Lorikeet numbers at other sites are likely to be too low for the species to be considered as a trigger species under KBA criteria B2.

Mao, *Gymnomyza samoensis*, EN (B1ab(ii,iii,v);C2a(i))

Birds were only recorded at Aopo (8 birds were heard, 6 single and 2 paired, at 6 point count locations) and Taga, where Art Whistler reported a bird calling pre-dawn at the high altitude (950m asl) camp site. The Aopo birds were between 1400 and 1800m asl. There were no records of the species at Falealupo or Uafato in 2016. Previous reports suggest that the bird has been present at Uafato in recent times (Conservation International 2010).

Mao has been reported from 8 separate locations within the Apia Catchments KBA area since 2010. eBird provides information on recent sightings (since 2010). A single record from Mt Vaea appears unlikely given the nature of the site (reported on only 1 of 9 checklists) – although an individual was regularly heard for a while around the SPREP Campus in 2012/13. Otherwise birds have been reported from the Papasaea Sliding Rocks site (1 from 1), from Dave Parkers Eco-lodge (reported on 2 of 6 checklists), Lake Lanatoo (during the 2014 ICCRIFS survey), and also at the Bahai Temple Grounds, the Malololelei Restricted Area and a couple of locations from the cross island road. Much work in this area has been reported by Stirnemann (pers comm). The Apia Catchments area remains a stronghold for the species – particularly in the relatively low-lying forested valleys in the area.

Mao is currently endemic to Savaii and Upolu in Samoa. It was formerly on Tutuila, American Samoa, but has been extirpated there for at least 40 years. A reintroduction programme has been proposed. The population is thought to number around 500 mature individuals (officially recorded as 250 to 999 mature individuals) with the majority being present, at low density, in the high altitude forests of Savaii. Birds do occur in remaining patches of lowland forest at higher density, but these patches are becoming fewer and more fragmented, raising concern about the conservation status of the species.

The species has been reported at the highest densities at high altitude sites, between 1400 and 1800m asl. The records from 700-800m refer to observations at Lake Lanoto'o in 2014.

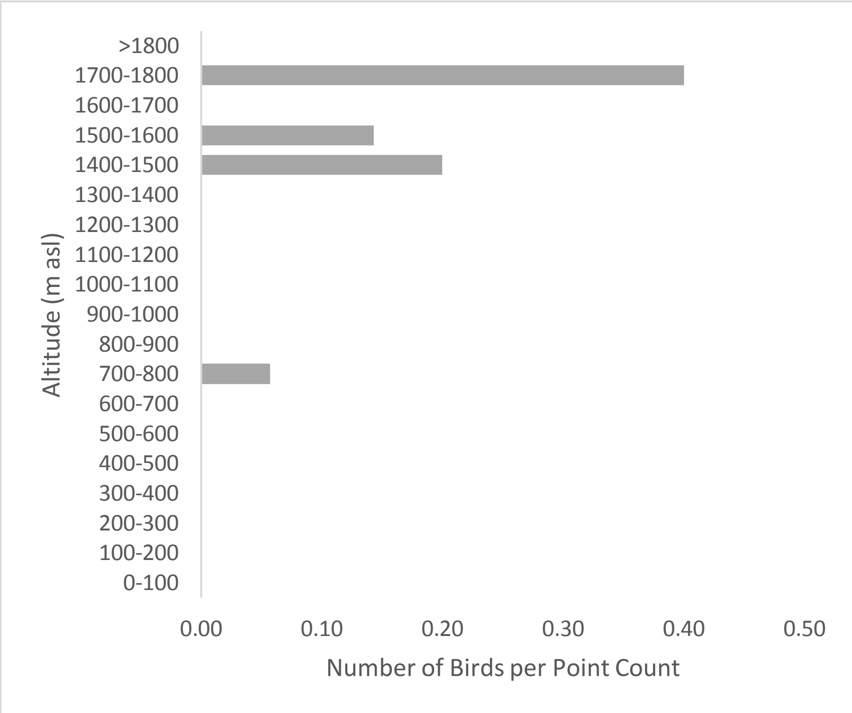

Figure 4.21. The distribution, by altitude, of Mao records during surveys in 2014 and 2016 in Samoa.

Implications for KBA Status

10 Mao were recorded across the 269 point counts – producing an overall density of 0.04 birds per point count. Mao is a native forest specialist species, and unlikely to be reported from many secondary forest or other habitat landscapes. If we assume that the density on native forests is 5* the density in other habitats then we derive an overall likelihood of recording Mao of 0.02 per point count. If we assume that the bird can be heard up to 200m from the point then we can derive an approximate Samoa population of about 500 calling birds. While it is likely that birds can be heard from a greater distance than 200m, it is also likely that birds remain undetected within the area during the course of a 5 minute point count.

KBA criteria A1a appears appropriate to the Mao population. For this classification there needs to be >0.5% (3+ singing birds) and more than 5 breeding pairs/units. The upland forest of Savaii, around Aopo, together with other upland areas above 1000m (SPREP 2012) clearly hold a larger population than this, and so this site would qualifies under A1a. Similarly the number of sites within the Apia Catchments KBA that have recorded Mao would suggest that here, too, the species triggers KBA criteria A1a.

The high numbers on the Savaii uplands indicate that more than 10% of the total population is present here – thereby also triggering KBA category B1, Individually geographically restricted species. Rather fewer birds are present at Apia Catchments, but the population probably still exceeds 1% of the global population (i.e. >5 birds), and so the species may be considered as contributing to B2, co-occurring geographically restricted species.

Polynesian (Eastern) Wattled Honeyeater, *Foulehaio carunculatus*, LC

By far the most frequently recorded species on the surveys in 2016 – with 572 individuals present, in large numbers, at all four study sites. Constant peak density of four observed birds per count at Taga, Aopo, Uafato and Lake Lanoto'o might represent peak carrying capacity.

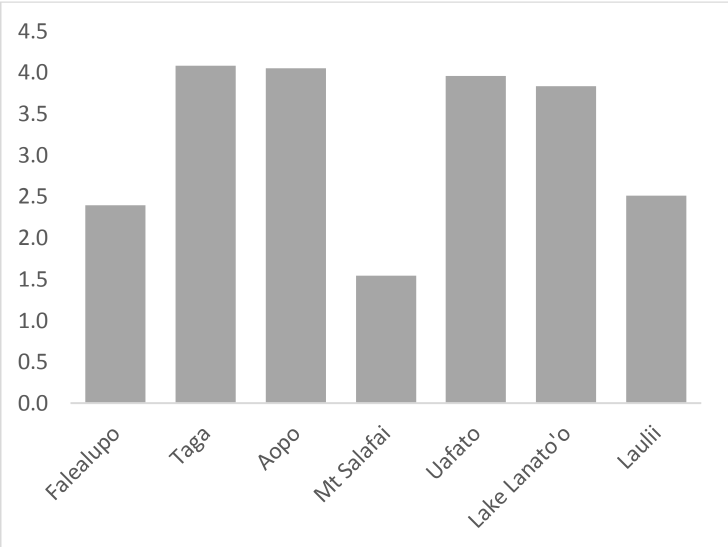

Figure 4.22. Variation in the number of Wattled Honeyeater per point count at the different sites. Note that the 3 sites on the right hand side are on Upolu, while the 4 on the left are on Savai'i.

A commonly recorded bird in the Apia Catchment KBAs – with 46 birds recorded on 12 point counts at Lake Lanoto'o. In addition recorded on seven of 9 checklists at Mt Vaea, at Papaseea Sliding Rocks, and five of six checklists at Dave Parker's Eco Lodge. Also reported at both Cross Island sites, Vaoala, Vaisigano Watershed, Bahai Temple grounds and Malololelei Recreation Reserve.

There is little pattern to the variation in density across the altitudinal range. Densities may be highest in the high altitude sites – but there are additional peaks around 200-300m and 1100-1200m asl.

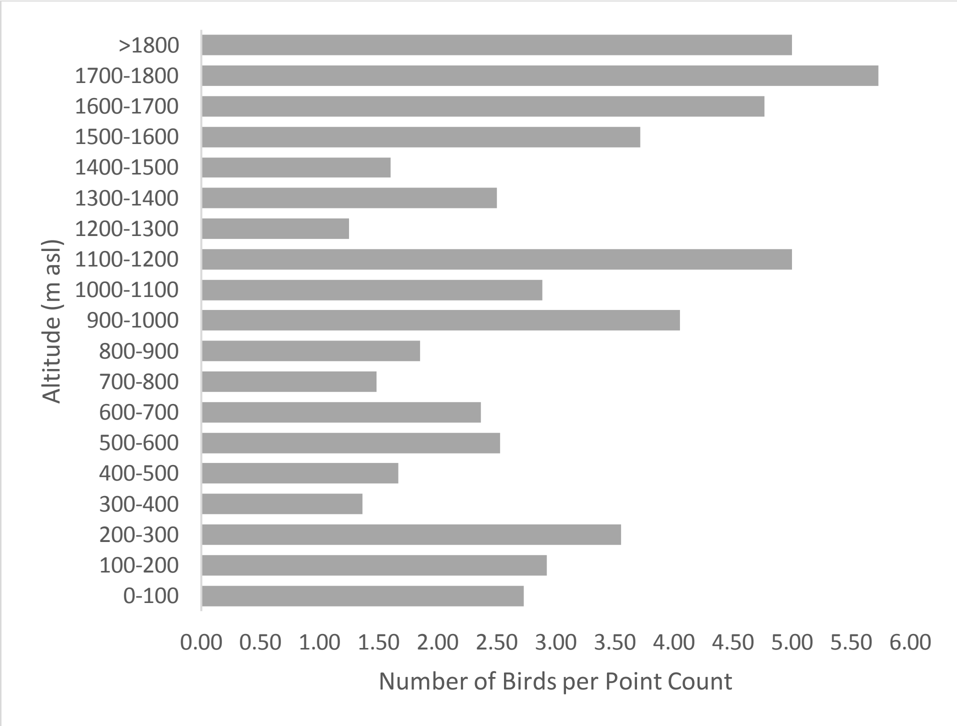

Figure 4.23. The distribution of Wattled Honeyeater records by altitude in Samoa in 2014 and 2016.

Wattled Honeyeater is a Restricted Range species with a distribution from Fiji, in the west, through Wallis-Futuna and Tonga, to Samoa and American Samoa at the easternmost part of its range. Note - some authorities consider this to be a group of species – with Polynesian Wattled Honeyeater being present in Northern and Southern Lau, Fiji, Tonga, Samoa and American Samoa. This provides an estimate of the extent of occurrence of the species to be 21,700km^{2}, indicating that Samoa constitutes 13% of the total area. The species is considered to be of Least Concern, according to the IUCN red list criteria. It is considered to show a moderate dependency on Forested habitats. A coarse estimate of the global population puts the figure around 1-2.5 million individuals. Trends are suspected to be declining due to perceived competition with introduced bird species.

Implications for KBA Status

The mean reported density of Polynesian Wattled Honeyeaters was 2.8 birds per count. The species is considered to be moderately associated with forested habitats, and so the density in non-forested areas is postulated as 50% of the above record. Within Samoa this means that the overall density is about 2.3 birds per point count. The song of Wattled Honeyeater is loud and can be heard considerably more than 100m from the survey location – accordingly we assume that the survey area around each count is a 200m radius. If we sum these figures we derive an estimate of just over 50,000 individuals. If we assume that the birds calling are all males, and that the ratio of mature individuals is 1:1 then we can assume that there are about 100,000 mature individuals across Samoa.

Wattled honeyeater is considered to be a restricted range species. Samoa constitutes only 13% of the range. If we assume that the Samoa recorded population estimate is 13% of the global estimate then we recognise just one site, Samoa Uplands KBA, where the species qualifies with >1% of the global population as a trigger species under criterion B2.

Cardinal Myzomela, *Myzomela cardinalis*, LC

A total of 144 Cardinal Myzomela were recorded on all four sites surveyed in 2016 making this one of the more common species on the survey. Densities across all study sites is similar – although numbers at Uafato are, perhaps surprisingly, rather low.

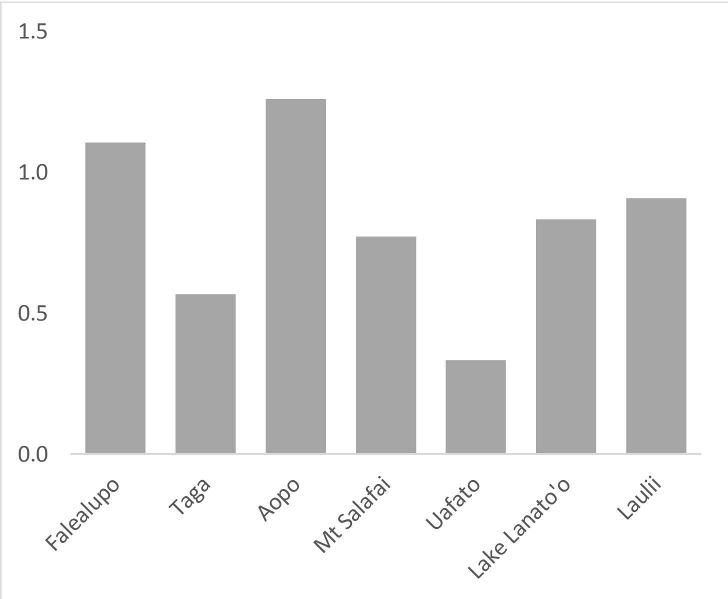

Figure 4.24. Variation in the number of Cardinal Myzomela per point count at the different sites. Note that the 3 sites on the right hand side are on Upolu, while the 4 on the left are on Savai'i.

The species has been commonly recorded at Apia Catchments KBA. Densities at Lake Lanoto'o are similar to, or higher than most other sites surveyed in 2014 and 2016 (Fig 4.24). The bird was recorded on six of 9 checklists from Mt Vaea, from Papaseea Sliding Rocks, and five of six checklists from Dave Parkers Eco Lodge. In addition it has been reported from Bahai temple grounds, Malololelei Recreation Reserve, two sites on the cross island road, Vaisigano Watershed, and Vaola.

Cardinal Myzomela are distributed evenly throughout the altitudinal range with, perhaps a slight increase in density in the highest altitude sites. The high density in the 1500-1600 metre range is interesting –based on seven counts, recording 21 birds.

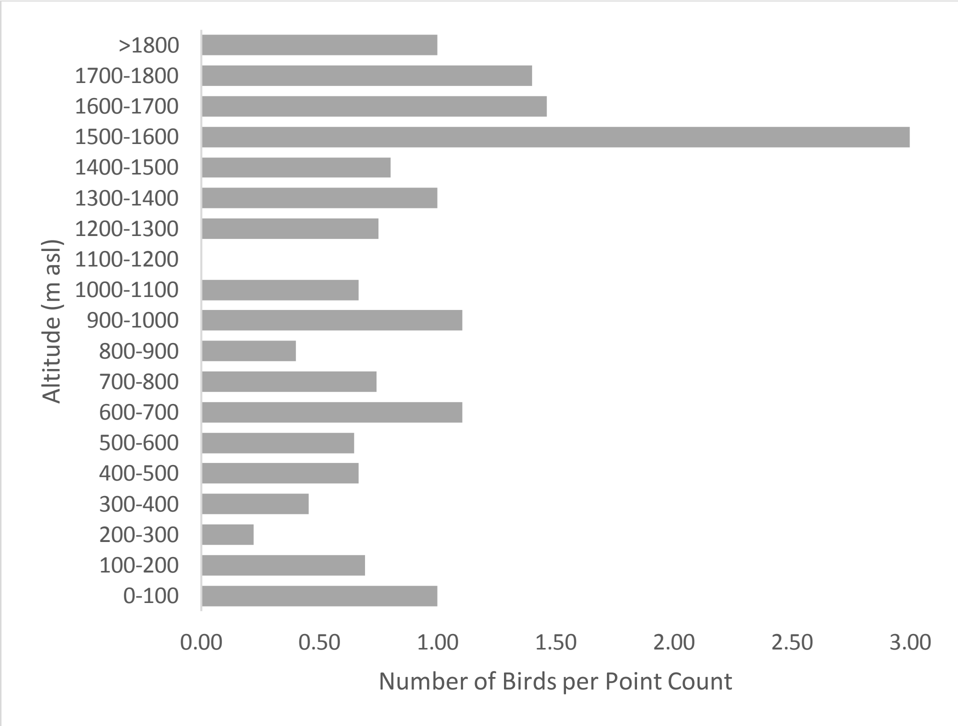

Figure 4.25. The distribution of Cardinal *Myzomela* records by altitude in Samoa in 2014 and 2016.

Implications for KBA Status

The global distribution of Cardinal Myzomela ranges from Makira and Rennell in the Solomons to the west, through Vanuatu, New Caledonia islands and into Samoa and American Samoa in the east. Intriguingly it is absent from both Fiji and Tonga. This gives an Extent of Occurrence of 22,300km^2. The species is classed as of Least Concern under the IUCN Red list criteria. The species is considered to show a Low dependency on forested areas and, indeed, can readily be seen in urban areas and gardens. There has been no assessment of the global population size.

The observed density of Cardinal Myzomela across the point counts surveyed in 2014 and 2016 was 0.9 birds/count. There is no evidence to indicate that this density varies considerable across habitats. Most birds are recorded by call within 100m of the survey location. Given this information we can extrapolate that the Samoan population of calling birds is around 79,000. It is not clear whether these calling birds are predominantly males or both sexes – but we assume that they represent mature individuals.

Cardinal Myzomela is classed as a Restricted Range species in the Samoan Islands Endemic Bird Area list. Accordingly it can qualify as a trigger species under KBA criteria B1 or B2. Samoa represents just 10% of the total Extent of Occurrence of the species. If we assume that Cardinal Myzomela density in Samoa is similar elsewhere in the species range then no one site in Samoa can qualify under B1. However, Savai'i Uplands KBA is estimated to contain

25% of all Samoa Myzomelas – which equates to 2.5% of the global population, indicating that Cardinal Myzomela might be considered a B2 trigger species for this site.

Samoan Whistler, *Pachycephala flavifrons*, LC

A total of 93 Samoan Whistler were recorded on all four study sites in 2016 – making this one of the more common species surveyed. It can be seen that the density is similar across all sites surveyed in both 2014 and 2016.

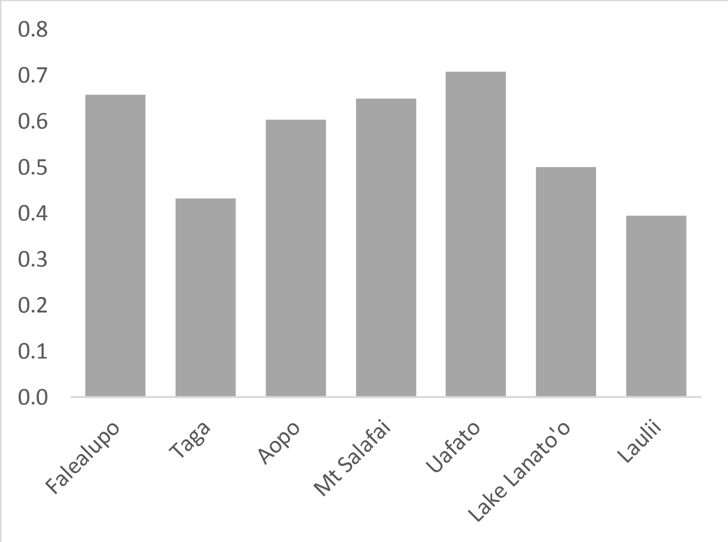

Figure 4.26. Variation in the number of Samoan Whistler per point count at the different sites. Note that the 3 sites on the right hand side are on Upolu, while the 4 on the left are on Savai'i.

Samoan Whistler is commonly recorded in the Apia Catchments KBA. Figure 4.26 indicates that recorded densities at Lake Lanoto'o in 2014 are not dissimilar to densities elsewhere. Seven of the 9 checklists from Mt Vaea but only one of six checklists from Dave Parkers Eco Lodge recorded Samoan Whistler, as did two sites on the Cross Island road, Malololelei Recreation Reserve and Vaoala.

The distribution of Samoan Whistler by altitude appears to show no pattern. There appears to be a high density at both low and high (>800m asl) altitudes. The apparently low density between 300 and 800m asl is based on a high number of point counts (97) so is unlikely to be a sampling artefact.

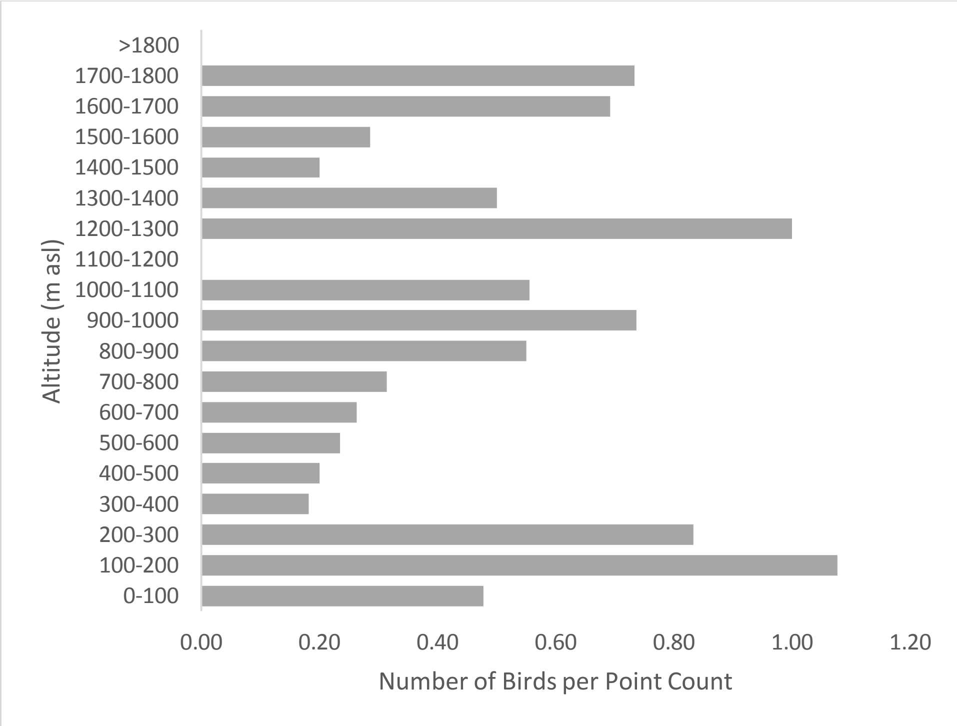

Figure 4.27. The distribution of Samoan Whistler records by altitude in Samoa in 2014 and 2016.

Implications for KBA Status

Samoan Whistler is endemic to Samoa, but is listed as of Least Concern in the IUCN Red List. There has been no previous attempt at assessing the population of the species. It is considered to show Medium Forest Dependency. Most records of the bird during point counts are of singing individuals presumably mature males.

The density of recorded birds in the current studies equates to 0.5 per point count. If we assume that the density in non-forested habitats is half that in forested then we can recalculate the likely overall density across all Samoan habitats to be around 0.4 birds per count. If we assume that we record all birds within 100m of the survey point, and that all birds recorded are singing males then we can estimate the population as comprising around 35,700 singing males.

Samoan Whistler is a restricted range species and qualifies as a trigger species B1 for the Savaii Uplands KBA (with an estimated 36% of the global population present at this site). It also qualifies as a trigger species, B2, for Uafato, and probably Apia Catchments. Although densities are high at Falealupo the population doesn't quite achieve 1% of global population levels.

Polynesian Triller, *Lalage maculosa*, LC

Polynesian Triller was recorded at all four study sites in 2016, with a total of 83 birds recorded on the 5 minute point counts. The number of birds can be seen to be highest at the low-lying site at Falealupo – where numbers in excess of one bird per point count were reported.

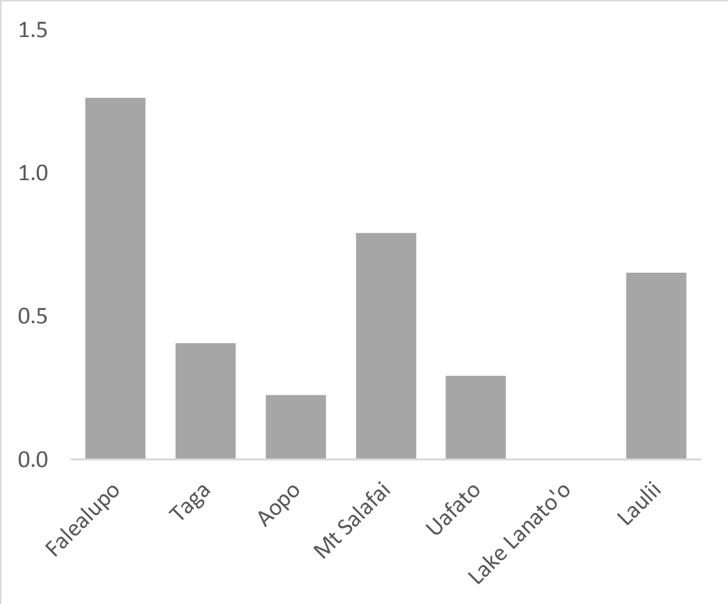

Figure 4.28. Variation in the number of Polynesian Triller per point count at the different sites. Note that the 3 sites on the right hand side are on Upolu, while the 4 on the left are on Savai'i.

Polynesian Triller is regularly recorded at sites in the Apia Catchments KBA. It was recorded on four of the 9 checklists reported from Mt Vaea, and all six checklists at Dave Parker's Eco Lodge. In addition it was recorded at two sites on the Cross Island road, at Malololelei Recreation Reserve, and at Vaisigano Watershed.

Polynesian Triller is a Restricted Range species classified as of Least Concern on the IUCN Red List. It is present, but scarce, in Solomon Islands and Vanuatu, and common in Fiji, Tonga and Samoa. Perhaps surprisingly it is not present on American Samoa, although it does occur on Niue and on Wallis & Futuna.

Polynesian Triller can be seen to be present at higher densities at altitudes below 100m asl (the figure for 1300-1400m asl is based on a single individual). 127 birds were recorded on 211 point counts below 1000m asl, while just seven were recorded on 58 point counts above 1000m asl.

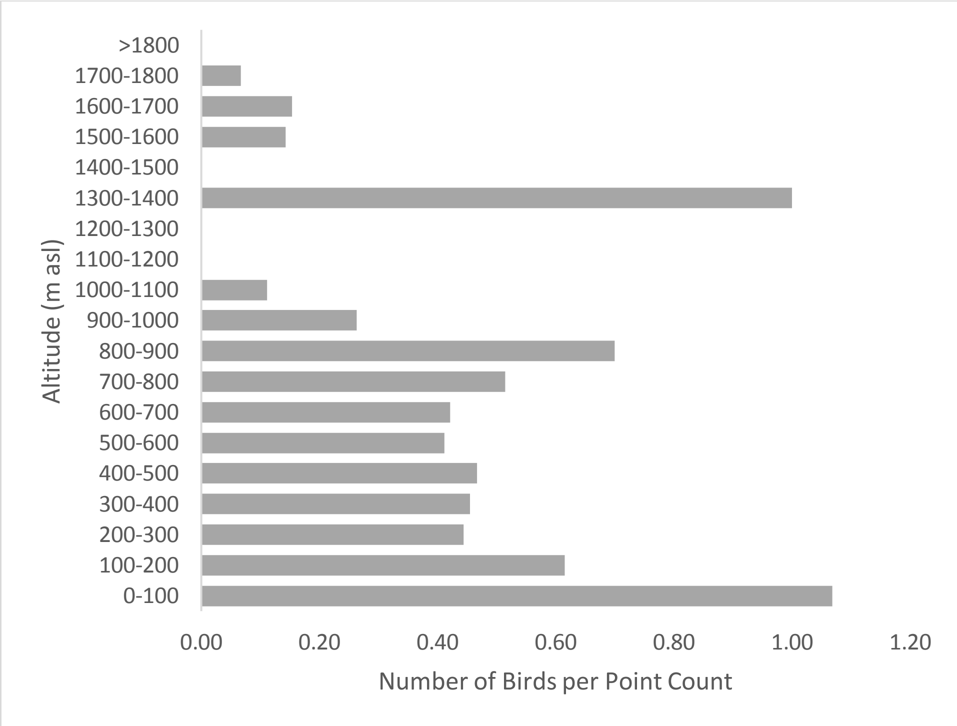

Figure 4.29. The distribution of Polynesian Triller records by altitude in Samoa in 2014 and 2016.

Implications for KBA Status

There is no global population estimate for Polynesian Triller. Considerable numbers are present on both Fiji and Tonga, as well as Samoa. Within the present survey we estimated an overall density per point count of 0.5 birds. Most of these birds will have been identified by their song – which can be heard over a distance of at least 100m Polynesian Trillers are generalist in their habitat preferences – and can be seen just as easily in parks in the middle of Apia as in forested areas. Accordingly we make no adjustment for habitat types and assume that the 0.5 birds per count is a reasonable estimate. Extrapolating this to the 2830km^2 land area of Samoa provides an estimate of c36,000 individuals. It is likely that this will include both males and females as many registrations were of pairs of birds calling, responding and chasing each other around the canopy.

Polynesian Triller is a restricted range species so could, in theory, act as a trigger species under criteria B2i. It is possible that the Savaii Uplands hold greater than 1% of the global population of the species – the uplands hold an estimated c30% of the Samoa population, while Samoa covers 8% of the extent of the distribution of the species (35,400km^2).

Samoan Triller, *Lalage sharpei*, NT (B1ab(ii,iii,v);C1)

Birds were recorded at all 4 sites surveyed in 2016. A single bird was present at Taga, 2 individuals at each of Aopo and Uafato and 7 birds at Falealupo (Figure 4.30).

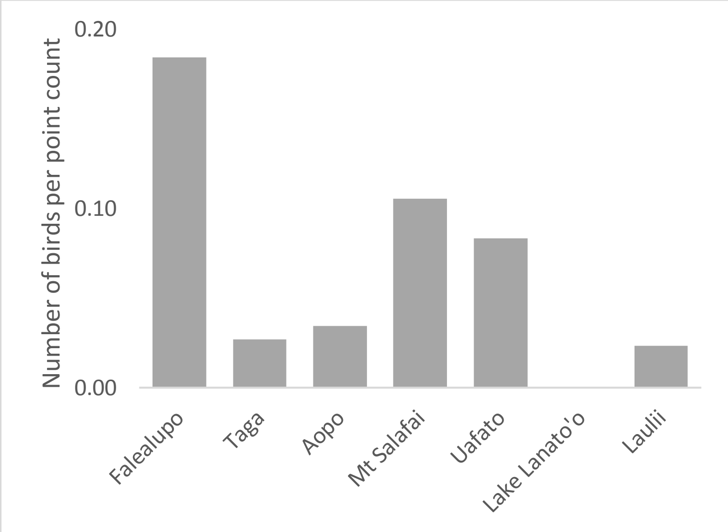

Figure 4.30. Variation in number of Samoan Triller per point count at the different sites. Note that the 3 sites on the right hand side are on Upolu, while the 4 on the left are on Savai'i.

Within the Apia Catchments area the bird has been reported from Mt Vea, Lake Lanoto'o (but not during the 2014 survey), Cross Island Road and the Dave Parker Eco resort.

Samoan Triller is endemic to Savaii and Upolu, Samoa. It is regarded as uncommon overall, perhaps more common on Savaii than on Upolu. Each island has its own subspecies.

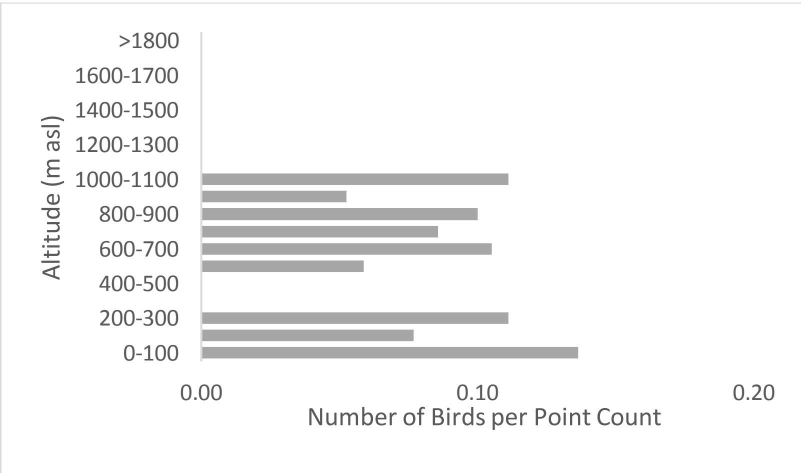

Figure 4.31. The distribution of Samoan Triller records by altitude in Samoa.

The species is rarely recorded above 1100m asl, but appears to be thinly but evenly distributed up to that altitude.

Implications for KBA Status

There have been no previous estimates of the density, or population, of Samoan Triller. 19 birds were recorded on the 269 point counts surveyed in 2014 and 2016, a mean recording rate of 0.07 birds per point count. Samoan Triller can be recorded in a variety of habitats, from old growth rain forest through secondary forest to gardens, and agriculture. We consider, therefore, that they are loosely associated with natural forested areas and we presume that the rate at which birds have been recorded on this survey is twice the detectability rate on non-forested areas across Samoa – giving an average observation of 0.06 birds per survey for all sites.

In our experience most Samoan Trillers were found by sight or call from a bird singing close to the observer. Accordingly the area surveyed at each point count can be estimated to be a 50m radius from the location. Given this, we can estimate that the total population is c20,000 individuals – or 10,000 pairs (we have no reason to believe that we see more males than females).

Samoan Triller is classed as Near-threatened under IUCN Red list criteria. It is a restricted range, endemic species. Consequently, it can only be a trigger species for a KBA if it attains B1 or B2, restricted range, species qualifying levels.

Extrapolation of the data indicates that one site, Savaii Uplands, is likely to hold more than 10% of the global population – 1000 pairs – so B1 is appropriate here. If we extrapolate the point count data for 2 of the other sites, Falealupo and Uafato, we find that Samoan Triller may reach 1.7%, 1.2% of the total population at these respective sites. Accordingly, the Triller represent one of the species that can contribute to KBA category B2 at these sites.

Figure 4.32. The Samoan Triller is another of the endemic birds of Samoa. This individual was photographed at 1400m above sea level on the old trail down from the campsite at Mount Silisili. Most of the observations of Samoan Triller were observations rather than calling birds. Note the distinctive orange bill and, when visible, pale eye. We recorded only a few Samoan Trillers, probably because we were only detecting birds in a small radius around each of our point counts. Photos by Mark O'Brien.

Samoan Fantail, *Rhipidura nebulosa*, LC

Samoan Fantail was recorded at three of the four sites surveyed in 2016 – with 58 birds being recorded at Taga, Aopo and Uafato. It has previously been noted that the species is, unaccountably, absent from low altitude sites on Savaii, and is absent both from Falealupo and Mt Salafai, on the eastern slopes of the Savaii Uplands KBA.

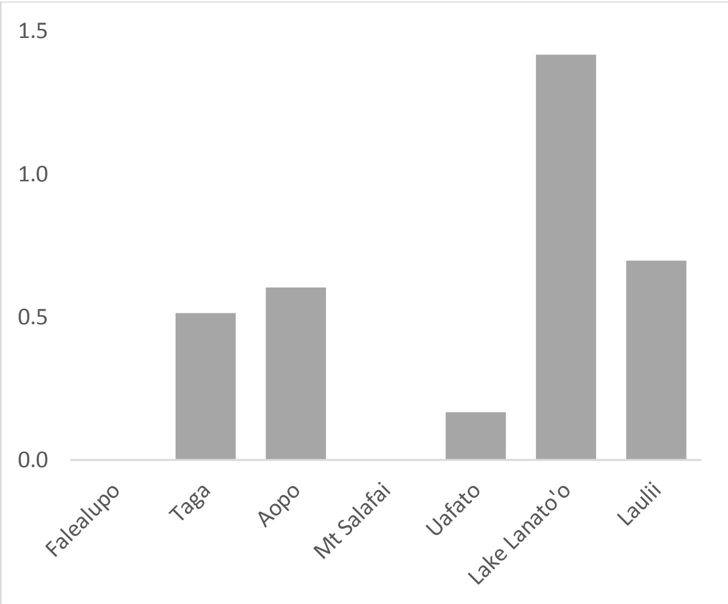

Figure 4.33. Variation in the number of Samoan Fantail per point count at the different sites. Note that the 3 sites on the right hand side are on Upolu, while the 4 on the left are on Savai'i.

Samoa Fantail is regularly recorded in the Apia Catchments KBA. As the graph shows, densities at Lake Lanoto'o in 2014 were higher than at any other site surveyed in either 2014 or 2016. The species was reported on six out of 9 checklists for Mt Vaea, and four out of six checklists at Dave Parkers Eco Lodge. It was also reported at Vaisigano Watershed, at Bahai Temple Grounds, and Malololelei Recreation Reserve and at two sites along the cross island road.

Samoan Fantail is endemic to Samoa, but considered to be of Least Concern, according to the IUCN Red list system. It is moderately associated with native forest, but can also be found in secondary forest areas. There has been no previous attempt at estimating the global population of the species.

Samoan fantail shows little overall variation in density with altitude despite it not being observed in low altitude sites in Savaii.

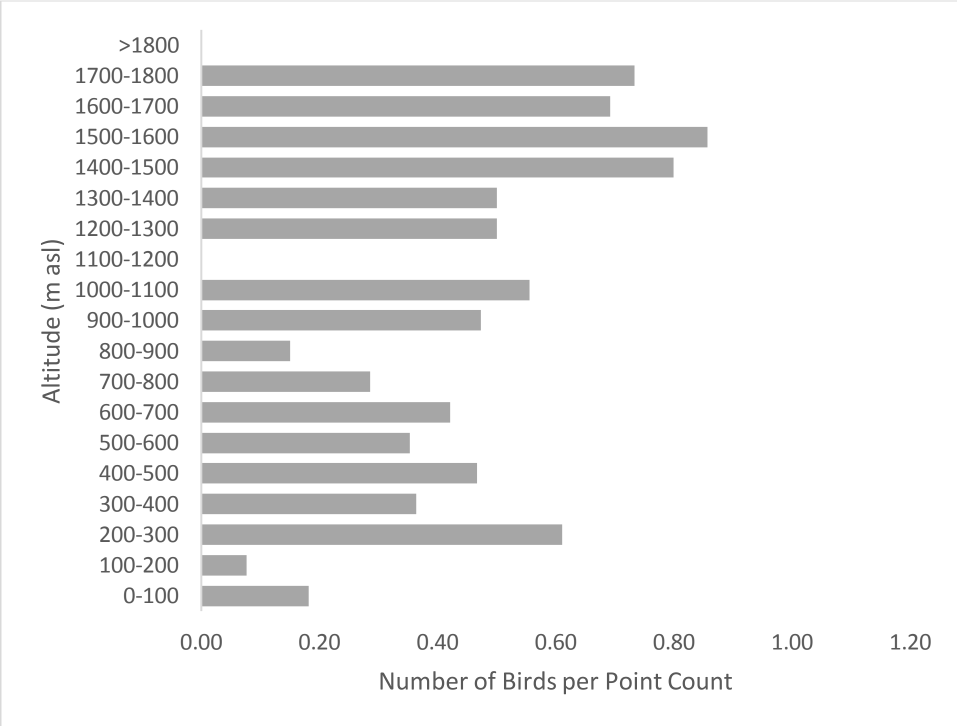

Figure 4.34. The distribution of Samoan Fantail records by altitude in Samoa in 2014 and 2016.

Implications for KBA Status

In the current survey the density of calling birds recorded from the point counts averaged 0.4 birds per count. If we assume that the density of calling birds in forest is twice that of other habitats in Samoa then we can calculate an overall mean of 0.3 birds per count. Samoan Fantails are easily identifiable by their scolding calls and song – hence the vast majority of records will be based on calling birds within 50m of the count. Given these figures we can extrapolate a Global Population in the range of 113,000 mature individuals. Most birds are singing and/or calling birds – although it is not clear whether both males and females will be involved.

As the species is of Least Concern, but of Restricted Range it can only trigger a KBA through categories B1 and B2. Our estimate of the number of birds on the Savaii Uplands indicates that as many as 30% of the global population is likely to be present here – the majority above 500m asl. This triggers B1 for the KBA. It also seems likely that the high numbers at Lake Lanoto'o and regular presence elsewhere in Apia Catchments KBA means that the species is likely to be one of the triggers for B2 at the site.

Samoan Flycatcher (Broadbill), *Myiagra albiventris*, NT

Samoan Flycatcher were recorded at all 4 sites surveyed in 2016, although with much lower numbers, and density, at Aopo than the other three sites.

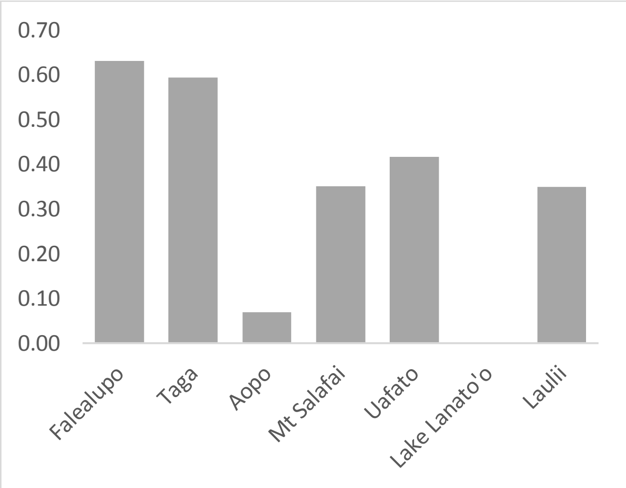

Figure 4.35. Variation in the number of Samoan Flycatchers per point count at the different sites. Note that the 3 sites on the right hand side are on Upolu, while the 4 on the left are on Savai'i.

Within the Apia Catchments no individuals were recorded at Lake Lanoto'o during 5 minute point count surveys in 2014, and the species has not been reported at this Hotspot in recent years. The species is regularly recorded at Mt Vaea (3 of the 9 checklists from this eBird hotspot), and also on 1 from 6 checklists from the Dave Parker's Eco lodge eBird hotspot. It is likely to be quite widespread in the lowland forested areas within the KBA.

Samoan Flycatcher is endemic to Samoa. It is a forest specialist species, although can be seen along forest edges and in mangrove areas.

The flycatcher is a predominantly lowland forest species, with no records above 1100m asl, hence its relative scarcity at Aopo. It altitudes below 1100m it averages 0.4 birds per point count, with a maximum in excess of 0.7 birds per count in the 800-900m altitudinal range.

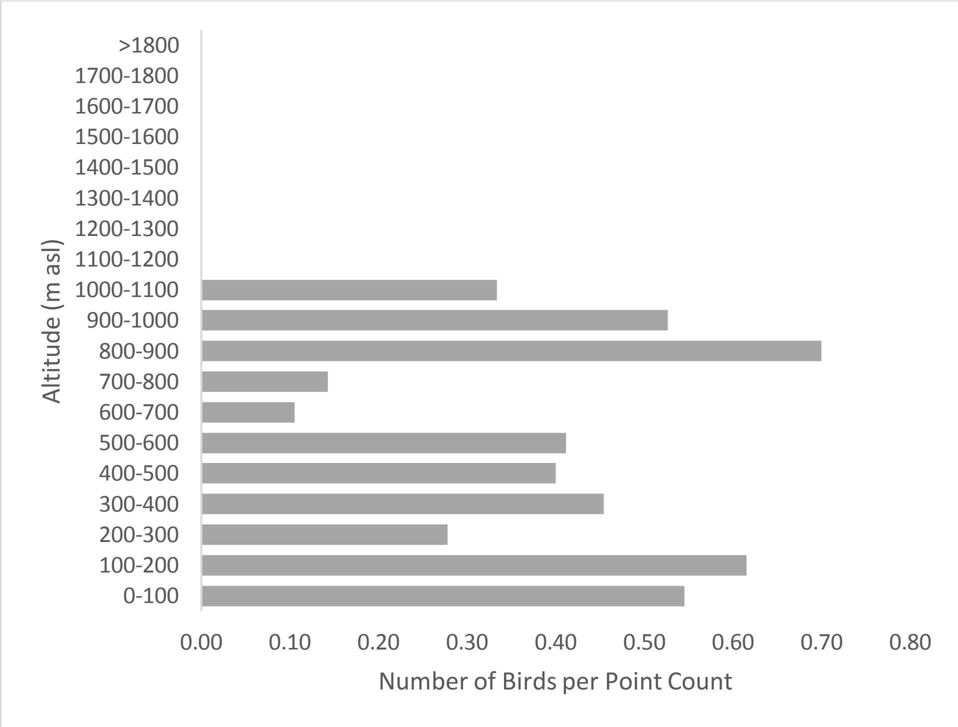

Figure 4.36. The distribution of Samoan Flycatcher records by altitude in Samoa.

The population is estimated to number 2,500-9,999 individuals (or 1,500-7,000 mature individuals) based on an assessment of known records, descriptions of abundance and range size (BirdLife International 2016).

Implications for KBA Status

We estimate that the number of birds per point count averages about 0.4 for forested areas below 1100m, and about 0.33 birds per count for all counts combined. The majority of birds are recorded based on singing individuals and contact/alarm calls of paired birds, and therefore represent mature individuals. If we assume that the birds recorded come from a radius of 100m around the count location, and that the density of birds in forested areas is 5 times the density in non-forested areas then we estimate that the species population is nearer to 20,000 mature individuals.

Alternatively, if we averaged the density of calling birds across the various 100m altitude categories, we find that there are just 0.24 birds per count, which extrapolates to a population estimate of just over 14,000 mature individuals. While our density estimate for birds in all forests across Samoa may be high, we have assumed much lower densities in non-forested areas (only 20% of forested area). It seems likely that this is overly conservative.

Samoan Flycatcher is classed as Near-threatened under IUCN Red list criteria. It is a restricted range, endemic species. Consequently, it can only be a trigger species for a KBA if it attains B1 or B2, restricted range, species qualifying levels.

Extrapolation of the data indicates that one site, Savaii Uplands, is likely to hold more than 10% of the global population – 2000 individuals – so B1 is appropriate here. If we extrapolate the point count data for the other sites, Falealupo and Uafato, we find that Samoan Flycatcher may reach 1.5% of the total population at each of these sites. Accordingly, the Flycatcher can represent one of the species that contribute to KBA category B2 at these sites.

Pacific (Scarlet) Robin, *Petroica pusilla* (multicolor), LC

Pacific Robin was recorded at two of the four sites surveyed in 2016. A total of 18 birds were present at the two sites in the Savaii Uplands KBA.

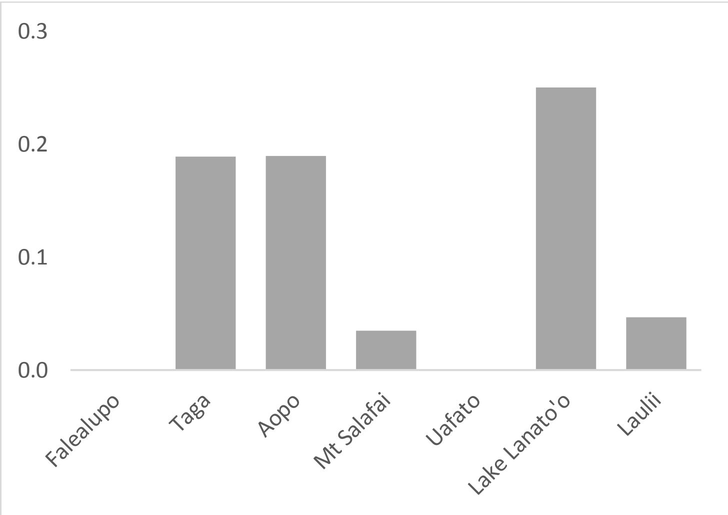

Figure 4.37. Variation in the number of Pacific Robin per point count at the different sites. Note that the 3 sites on the right hand side are on Upolu, while the 4 on the left are on Savai'i.

Pacific Robin is not common in the Apia Catchments KBA. Three birds were recorded during the survey at Lake Lanoto'o in 2014. Otherwise the bird has been occasionally seen at Mt Vaea – on two occasions on the 9 checklists from the site – and regularly in the area. It is however an unobtrusive bird, easily missed if the quiet song is not identified or they just happen to not be calling at all – which is often the case.

The species shows a marked high altitude distribution – with no records below 600m asl. This is a feature that hasn't previously been noted, and is likely to be a true reflection – as over 100 point counts were undertaken at sites below 600m asl.

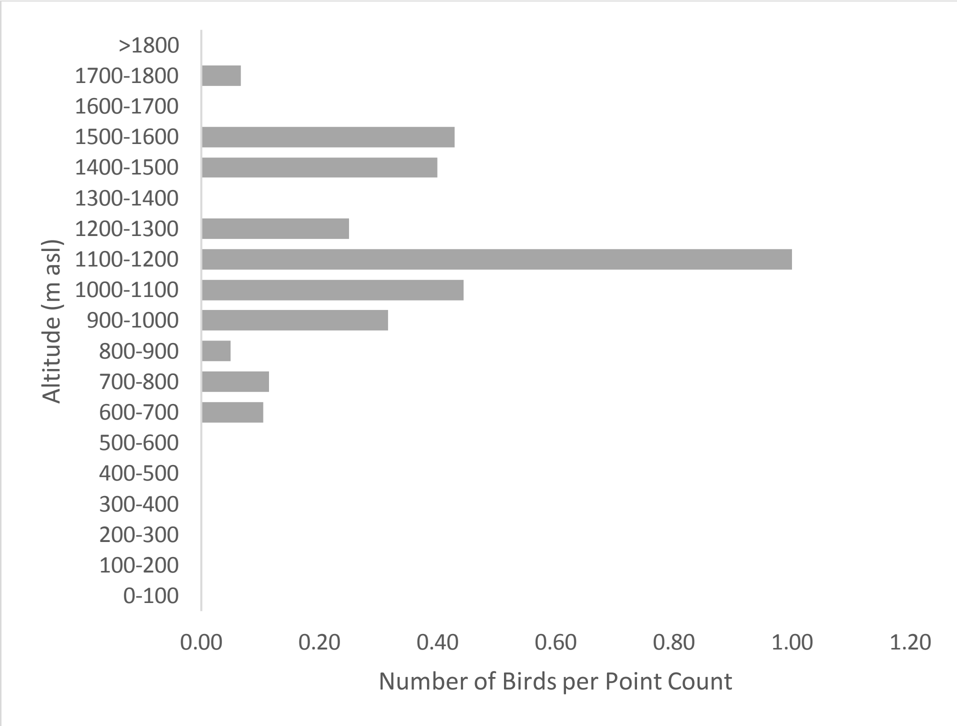

Figure 4.38. The distribution of Pacific Robin records by altitude in Samoa in 2014 and 2016.

The global population of Pacific Robin has not been estimated. It is a species of Least Concern, according to the IUCN Red list. It is not a Restricted Range species, being present from Bougainville, Papua New Guinea, in the west through to Samoa at the eastern edge of its range. This represents a considerable range of 594,000 km^2. It has been suggested that the Samoan subspecies, P. pusilla pusilla may be considered a separate species (Pratt & Mittenmeier 2016) which, given the apparent restricted distribution to upland areas would indicate another species potentially susceptible to increasing temperature through climate change.

Implications for KBA Status

Within Samoa the overall density of birds per point count was 0.1. If we assume that this is twice the density in non-forested areas then we can estimate a revised density in Samoa of 0.07. Pacific Robin are generally found by song, which is rarely heard more than 50m from the listener. Accordingly, dividing the revised density by the area surveyed, and multiplying this by the area available delivers a figure of 26,850 mature individuals. This figure seems high and may be an overestimate.

The species is classed as of Least Concern and is not a Restricted Range species and so does not qualify as a trigger species for a KBA.

Samoan White-eye, *Zosterops samoensis*, VU

Samoan White-eye is a single-island endemic, restricted to the uplands of Savaii. During the survey in 2016 we recorded it at two locations – at the Base campsite in Taga (c800m asl) where at least 6-8 individuals regularly passed over the campsite – but were not seen elsewhere in the vicinity. Similarly, a big flock of at least 15 individuals were seen around Taga 4 (at 1022m asl) on both occasions that the recorder walked from the upper camp site to the crater. We failed to record the bird at the high altitude site of Aopo, in Savaii, in 2016 which is surprising as, in 2012, the white-eye was recorded in 7% of all point counts undertaken at Aopo, Asau and the Craters site.

Information is limited, but this species is considered to number fewer than 2,500 individuals, and is placed in the range of 600-1700 mature individuals (BirdLife International 2016). It is a difficult species to survey as it moves around in flocks of 10-20 individuals. Five minute point counts may not be the most appropriate means to survey the species.

Implications for KBA Status

Samoan White-eye is listed as Vulnerable under the IUCN Red list process, under criterion D2 (Restricted area of occupancy or number of locations with a plausible future threat that could drive the taxon to CR or EX in a very short time.) Even within Savaii forest it is restricted to the higher altitude sites – and so is at potential risk through loss of forest, increasing temperatures further restricting suitable altitudinal range as well as the potential impact of Invasive species within the narrow altitudinal range that White-eye occurs.

The Savaii Uplands KBA holds 100% of the global population of Samoan White-eye. The species therefore qualifies as a trigger species under A1b (>1% of the global population size and >10 reproductive units of a VU species) and B1 (>10% of the global population of a restricted range species with >10 reproductive units)

Polynesian Starling, *Aplonis tabuensis*, LC

A total of 54 Polynesian Starling were recorded during the point count survey in 2016 – with birds present on all 4 sites surveyed.

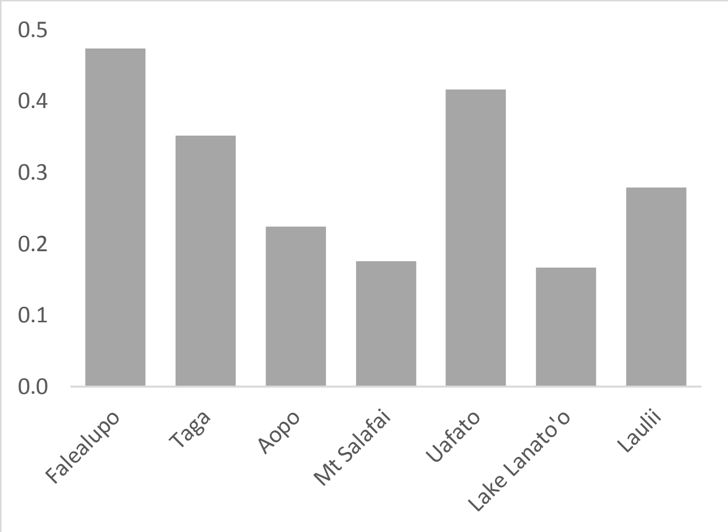

Figure 4.39. Variation in the number of Polynesian Starling per point count at the different sites. Note that the 3 sites on the right hand side are on Upolu, while the 4 on the left are on Savai'i.

Polynesian Starling is not uncommonly recorded in the Apia Catchments KBA. In addition to the numbers reported at Lake Lanoto'o in 2014 (two birds on 12 point counts) it has been reported on four of 9 checklists from Mt Vaea, at Papaseea Sliding Rocks and on three of six checklists at Dave Parkers Eco Lodge. It has also been reported at Cross Island Road, Bahai Temple Grounds, Malololelei Recreation Reserve and Vaoala.

There is little evidence of a significant altitudinal variation in density of Polynesian Starling. The apparently high density in the 1300-1400m asl range is based on numbers from just 2 surveys.

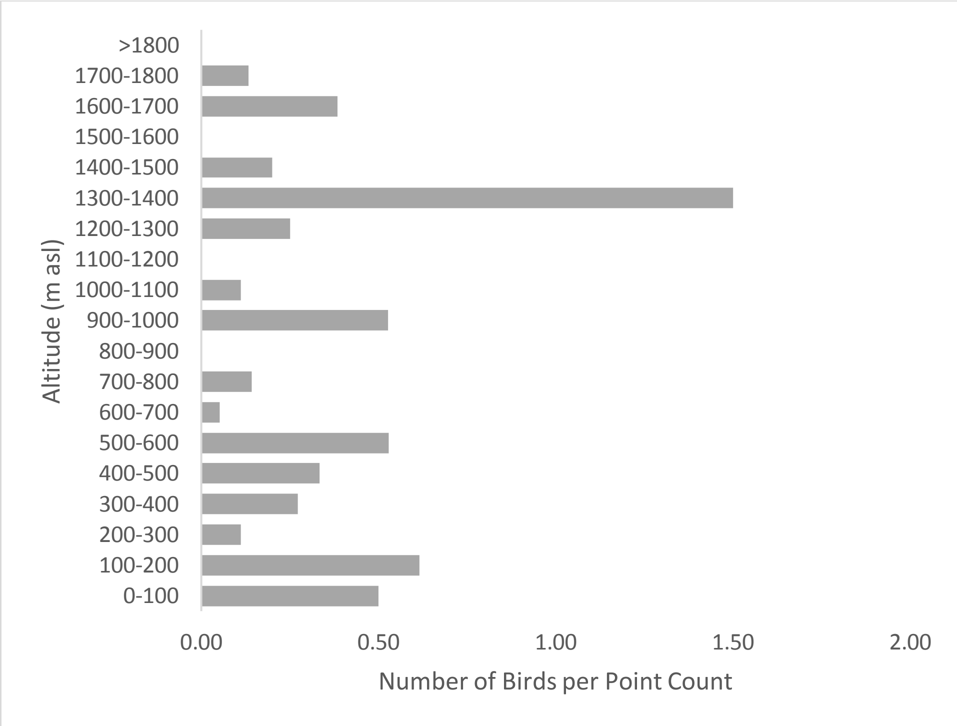

Figure 4.40. The distribution of Polynesian Starling records by altitude in Samoa in 2014 and 2016.

Implications for KBA Status

The species is regarded as a restricted range species within the Samoan Islands Endemic Bird Area. Its distribution ranges from the Temotu province in Solomon Islands, through Fiji, Wallis & Futuna and Tonga, to Samoa, American Samoa and Niue. It is considered to be of Least Concern under the IUCN Red List category. The Extent of Occurrence is estimated to be 23,300 km^2. There has been no global population estimate. It is considered to have a low dependency on forests.

The observed density on the point counts undertaken in 2014 and 2016 averages 0.3 birds/count. There is no evidence that this density is high in forests relative to other habitats so we assume that this is the density across all sites in Samoa. Birds are generally recorded by call/song which can be heard up to 100m distance. Given these figures we can extrapolate the calling population for Samoa to be just over 26,000 birds. We have no reason to believe that we record predominantly one sex – and so this figure represents the number of calling mature individuals on Samoa. We suspect that this is an underestimate of the 'true' population of Polynesian Starlings in Samoa as we don't think all individuals call regularly to be captured in a 5 minute point count.

Polynesian Starling is considered to be a Restricted Range species. The extrapolated population for the Savaii Uplands represents 22% of the total Samoa population. Samoa represents just 12% of the Extent of Occurrence of the species – so Polynesian Starling acts as a trigger for B2 for the Savaii Uplands KBA area.

Samoan Starling, *Aplonis atrifusca*, LC

One of the most common species on the surveys in 2016 – with 292 individuals recorded. The species was present at all four sites and at highest density at Uafato.

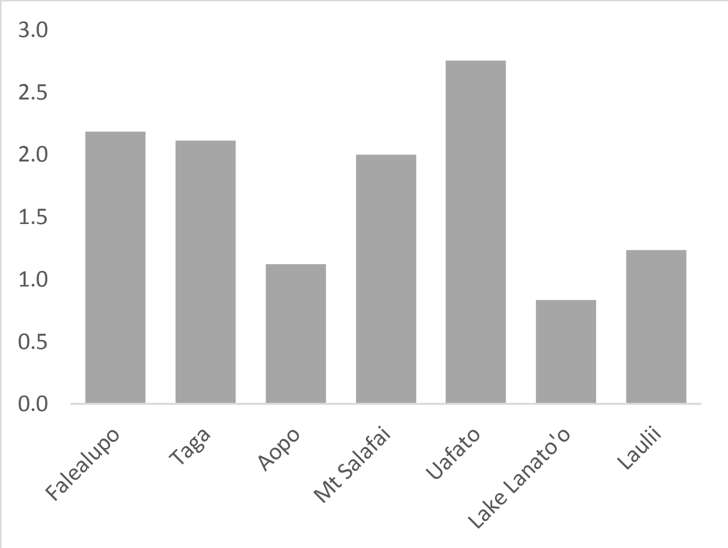

Figure 4.41. Variation in the number of Samoan Starling per point count at the different sites. Note that the 3 sites on the right hand side are on Upolu, while the 4 on the left are on Savai'i.

Samoan Starling is a commonly recorded species within the Apia Catchments KBA. 10 individuals were recorded in the 12 point counts undertaken at Lake Lanoto'o in 2014. In addition it is reported on four of 9 checklists at Mt Vaea, at Papaseea Sliding Rocks, on five of six checklists at Dave Parker's Eco Lodge and numerous sites throughout the KBA, such as both Cross Island Road sites, Malololelei Recreation Reserve, Bahai Temple grounds, Vaisigano Watershed and Vaoala.

There is no clear trend in the distribution of the species by altitude, with highest densities being at both low and mid altitudinal levels. There is a suggestion of a bimodal peak with a reduction in density between 500 and 900m asl compared with higher and lower altitudes.

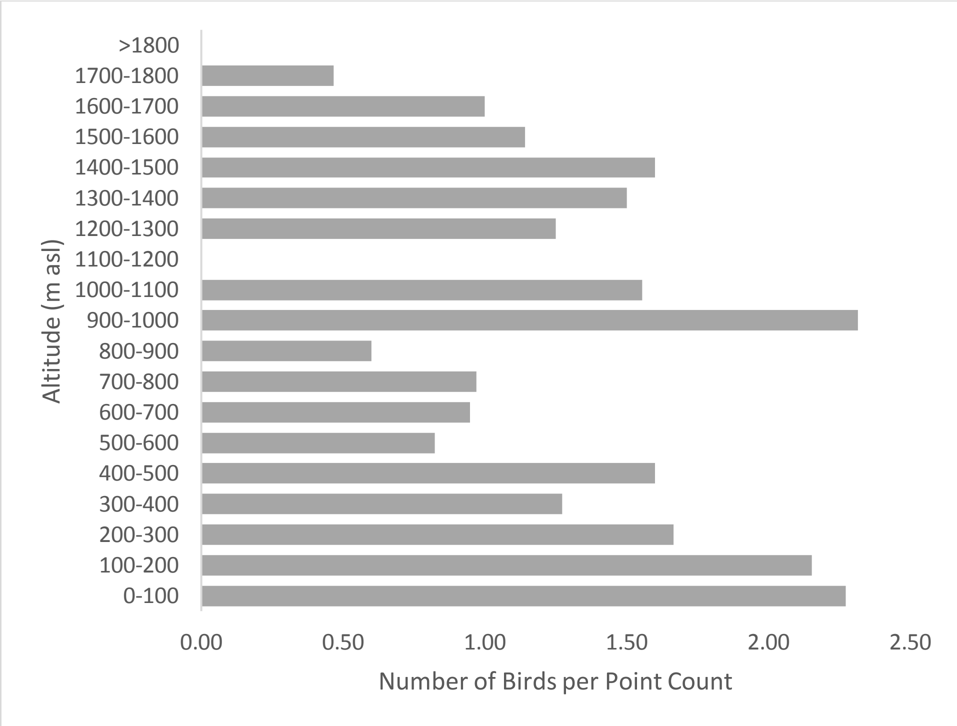

Figure 4.42. The distribution of Samoan Starling records by altitude in Samoa in 2014 and 2016.

Implications for KBA Status

Samoan Starling is a restricted range species, present only on Samoa and American Samoa, giving it an Extent of Occurrence of 3,100km^2. It is listed as a species of Least Concern in the IUCN Red List. The population size has not been quantified and the population trend is unknown. It is listed as having a medium dependency on forests – although it is a species that appears equally at home in urban areas with tall trees.

Samoan Starling is generally located by its loud call – which can be heard from well over 100m. It is considered to be moderately dependent on forest – and so the presumed density in non-forested areas is thought to be half the density in the forested areas surveyed (1.4 records/point count). This implies an overall recorded density of Samoan Starling of 1.1 records/point count. If we assume that the point count records all birds within 200m then we estimate a total population of 27,352 individuals. We assume that the number of individuals relates to both males and females – as we have no evidence to indicate that the calls are made predominantly by one sex. We suspect that this might be an underestimate of the total number of birds – as Samoan Starlings can be quiet for considerable periods of time – so easily missed even if present during a 5 minute point count.

Samoan Starling is a Restricted Range species and so is eligible as a trigger species in KBA under criteria B1 and B2. The population in the Savaii Uplands KBA is estimated to be 37% of the global population, this clearly qualifies the trigger species for this site under B1. Similarly, the species exceeds 1% of the global population at each of Falealupo, Uafato and Apia

Catchments (assuming the Lake Lanoto'o density to be representative) and so qualifies as a contributory species to B2.

Island Thrush, *Turdus poliocephalus*, LC

Island thrush was recorded at two of the four sites surveyed in 2016. Three birds were recorded at Taga, while 55 birds were present at Aopo. The species wasn't recorded on any of the sites surveyed in 2014.

Island thrush has not been recorded in the Apia Catchments KBA for a number of years. The last, unconfirmed, record was from Vaoala in June 2008.

Island Thrush is considered to be of Least Concern, according to the IUCN Red list. It has a very large range, from Taiwan, Indonesia, Malaysia and the Philippines in the east with Samoa being at the far eastern edge of the range. Island Thrush is a forest specialist throughout its range.

Unsurprisingly, the distribution of the species in Samoa appears to be strongly affected by altitude. The vast majority of individuals (n=54 were recorded above 1000m asl, with just a single bird being reported below this altitude. It should be noted that the species occurs at considerably lower altitudes elsewhere in its range. Fijian birds, for instance, can be found down to 200m asl.

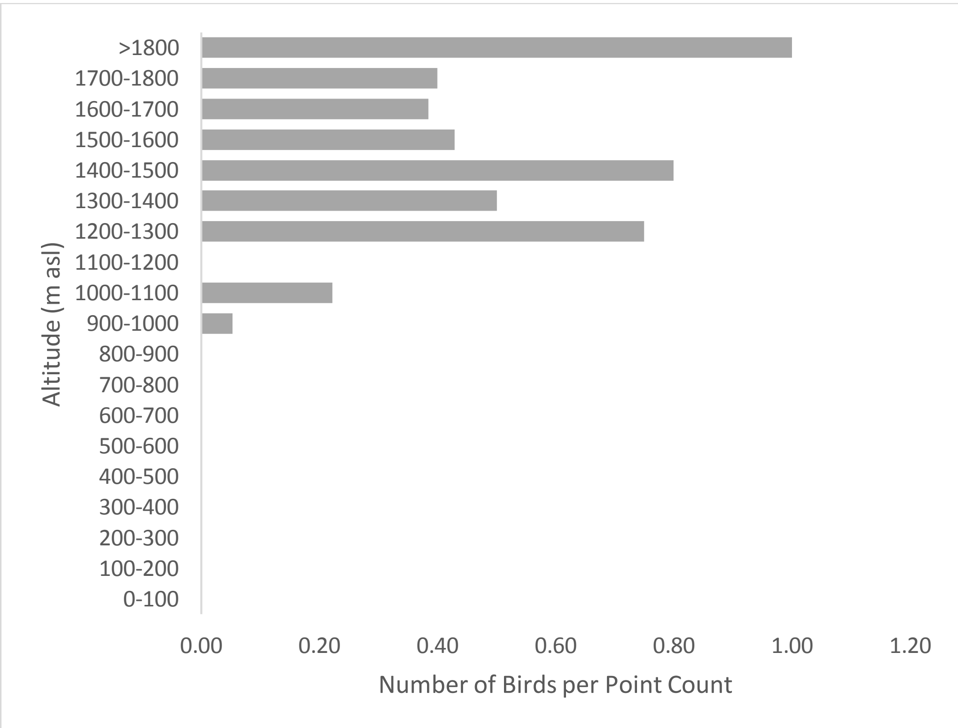

Figure 4.43. The distribution of Island Thrush records by altitude in Samoa in 2014 and 2016.

There has been no previous attempt to estimate the global population of Island thrushes. The global distribution of the species covers some 253,000km^2 indicating that the total land mass of Samoa, at 2830km^2, represents little more than 1% of the total area. If we assume that the mean observed density of Island Thrush on the Savaii Uplands is 0.34 birds per point count and that Island Thrushes within 100m of the survey point are recorded, then we can estimate that 7950 mature individuals may be present on the KBA. It seems unlikely that this represents anything like 1% of the global population of the species – although it does represent 100% of the Samoan subspecies.

The Island thrush is a complex of 52 subspecies, representing the most diverse assemblage of subspecies of bird known on earth. The species group ranges from isolated montane habitats and small islands from Taiwan and Sumatra through Melanesia and Polynesia as far east as Samoa (Pratt and Mittermeier (2016). There are around a dozen plumage variations, although when molecular data is analysed this does not necessarily indicate that similar morphotypes are the closest relatives. Consequently, it has been suggested that the Samoan Thrush should be considered a separate species in its own right (Peterson 2007, Pratt & Mittermeier 2016). If this were to eventuate then the extirpation from Upolu in recent years, combined with the restricted altitudinal range of the remaining birds on Savaii, would suggest that this would be classed as a Globally threatened, probably VU, species. The presence of 100% of the remaining population in the Central Savaii Rainforest would contribute further to the importance of this site.

Red-headed Parrotfinch, *Erythrura cyaneovirens*, LC

Only a single Red-headed Parrotfinch was recorded on the four study sites in 2016 – and that was an individual on the lowest of the point counts undertaken on the edge of a Taro field at Taga at 350m asl. Similarly, in 2014, only two birds were recorded, at between 300 and 500m asl at Lauli'i.

The bird has been reported in the Apia Catchments KBA area – reported on two of 9 checklists from Mt Vaea, and five of six checklists from Dave Parkers Eco Lodge. It has also been reported at Cross Island Road, Vaisigano Watershed and Malololelei Recreation Reserve. This would appear to make the Apia Catchments KBA an important site for the species in Samoa.

Red-headed Parrotfinch was formerly considered to be a country endemic although has now been 'lumped' with Royal Parrotfinch of Vanuatu, so remains a restricted-range species, considered to be Near Threatened under the IUCN red List category.

It is considered to show a low dependency on forests – although there are few records of the species away from forested areas in either Samoa or Vanuatu. There have been no global population estimates for this species.

If we assume that four birds in 269 counts is realistic then, even assuming all birds are recorded within 50m of the surveyor and there is no difference in density across all habitats, then the observed population estimate would be between 3,660 and 5,500 individuals. Most birds are recorded, in flight, by call – and so there is no reason to think that the number of individuals is biased by sex. However, parrotfinches are exceedingly difficult to survey by point count. A site in Fiji, where the maximum number of Fiji Parrot finches seen on a 5 minute point count is 3 birds, has marked, and individually recognised, over 120 individuals in a 30 month period (M. O'Brien *pers. obs*).

This is, probably, the least understood of the 'common' species with a distinctive type in Samoa and would be worth additional study.

Red-headed Parrotfinch is a restricted range species. Given the relatively high frequency of reports from the Apia Catchments area compared with the 2014 and 2016 point count surveys it is likely that this site holds sufficient numbers for the species to trigger KBA criterion B2. The lack of records from elsewhere means that it is difficult to judge these sites.

Appendix 4.2. Location of Point Counts, and other surveys for Birds, in 2016

1. Falealupo

Elevation (m ASL)	Latitude	Longitude	Date	Start Time	Protocol	Num Observers	Duration (min)
22	-13.499	-172.767	18-Jul-2016	06:38	stationary	5	5
21	-13.499	-172.765	18-Jul-2016	06:48	stationary	5	5
13	-13.4979	-172.763	18-Jul-2016	07:00	stationary	5	5
11	-13.497	-172.761	18-Jul-2016	07:11	stationary	5	5
12	-13.497	-172.76	18-Jul-2016	07:22	stationary	5	5
15	-13.498	-172.759	18-Jul-2016	07:33	stationary	5	5
20	-13.499	-172.758	18-Jul-2016	07:46	stationary	5	5
24	-13.5009	-172.757	18-Jul-2016	07:59	stationary	5	5
26	-13.502	-172.756	18-Jul-2016	08:14	incidental	5	5
30	-13.504	-172.756	18-Jul-2016	08:28	stationary	5	5
13	-13.4974	-172.783	18-Jul-2016	06:40	stationary	4	5
13	-13.4983	-172.781	18-Jul-2016	06:56	stationary	4	5
25	-13.4988	-172.779	18-Jul-2016	07:18	stationary	4	5
30	-13.4999	-172.776	18-Jul-2016	07:44	stationary	4	5
29	-13.5009	-172.775	18-Jul-2016	08:10	stationary	4	5
39	-13.5026	-172.774	18-Jul-2016	08:50	stationary	4	5
34	-13.504	-172.773	18-Jul-2016	09:10	stationary	4	5
39	-13.5058	-172.772	18-Jul-2016	09:35	stationary	4	5
40	-13.5054	-172.774	18-Jul-2016	09:45	stationary	4	5
31	-13.5063	-172.77	18-Jul-2016	10:10	stationary	4	5
143	-13.522	-172.75	19-Jul-2016	07:05	stationary	5	5
138	-13.521	-172.748	19-Jul-2016	07:14	stationary	5	5
117	-13.518	-172.747	19-Jul-2016	07:30	stationary	5	5
99	-13.516	-172.748	19-Jul-2016	07:49	stationary	5	5
91	-13.514	-172.749	19-Jul-2016	08:05	stationary	5	5
81	-13.513	-172.751	19-Jul-2016	08:19	stationary	5	5
73	-13.512	-172.753	19-Jul-2016	08:35	incidental	5	5
64	-13.511	-172.754	19-Jul-2016	08:51	stationary	5	5
52	-13.51	-172.756	19-Jul-2016	09:06	stationary	5	5
3	-13.5082	-172.756	19-Jul-2016	09:26	stationary	5	5
48	-13.5099	-172.77	19-Jul-2016	08:25	stationary	4	5
40	-13.508	-172.771	19-Jul-2016	08:45	stationary	4	5
44	-13.5053	-172.776	19-Jul-2016	09:15	stationary	4	5
44	-13.5044	-172.778	19-Jul-2016	09:25	stationary	4	5
45	-13.5032	-172.779	19-Jul-2016	09:35	stationary	4	5
43	-13.5016	-172.781	19-Jul-2016	09:51	stationary	4	5
37	-13.4997	-172.781	19-Jul-2016	09:58	stationary	4	5
32	-13.4992	-172.784	19-Jul-2016	10:08	stationary	4	5

2. Taga

Elevation (m ASL)	Latitude	Longitude	Date	Start Time	Protocol	Num Observers	Duration (min)
956	-13.697	-172.512	22 July 2016	07:23	stationary	5	5
933	-13.6966	-172.513	22 July 2016	07:28	stationary	5	5
951	-13.696	-172.514	22 July 2016	07:50	stationary	5	5
971	-13.6947	-172.516	22 July 2016	08:03	stationary	5	5
940	-13.6979	-172.509	22 July 2016	08:45	stationary	5	5
926	-13.6994	-172.508	22 July 2016	09:03	stationary	5	5
904	-13.7004	-172.505	22 July 2016	09:23	stationary	5	5
634	-13.716	-172.514	22 July 2016	07:25	stationary	3	5
650	-13.7145	-172.514	22 July 2016	07:39	stationary	3	5
683	-13.7126	-172.514	22 July 2016	07:54	stationary	3	5
719	-13.7111	-172.513	22 July 2016	08:09	stationary	3	5
754	-13.7093	-172.513	22 July 2016	08:26	stationary	3	5
800	-13.7072	-172.513	22 July 2016	08:47	stationary	3	5
800	-13.7068	-172.515	22 July 2016	09:05	stationary	3	5
794	-13.7061	-172.517	22 July 2016	09:25	stationary	3	5
954	-13.6953	-172.51	23 July 2016	07:00	stationary	5	5
962	-13.694	-172.508	23 July 2016	07:11	stationary	5	5
981	-13.6927	-172.507	23 July 2016	07:22	stationary	5	5
1022	-13.692	-172.506	23 July 2016	07:39	stationary	5	5
1066	-13.6918	-172.505	23 July 2016	08:09	stationary	5	5
1062	-13.6917	-172.504	23 July 2016	08:40	stationary	5	5
551	-13.7194	-172.519	23 July 2016	07:13	stationary	3	5
578	-13.7192	-172.517	23 July 2016	07:25	stationary	3	5
594	-13.7182	-172.516	23 July 2016	07:39	stationary	3	5
602	-13.7175	-172.514	23 July 2016	07:55	stationary	3	5
612	-13.7165	-172.512	23 July 2016	08:10	stationary	3	5
576	-13.7193	-172.514	23 July 2016	08:51	stationary	3	5
556	-13.721	-172.514	23 July 2016	09:01	stationary	3	5
531	-13.7227	-172.513	23 July 2016	09:15	stationary	3	5
514	-13.7245	-172.513	23 July 2016	09:27	stationary	3	5
490	-13.7265	-172.513	23 July 2016	09:43	stationary	3	5
475	-13.7281	-172.512	24 July 2016	08:01	stationary	1	5
455	-13.7299	-172.511	24 July 2016	08:15	stationary	1	5
419	-13.7321	-172.51	24 July 2016	08:39	stationary	1	5
400	-13.7341	-172.51	24 July 2016	08:41	stationary	1	5
381	-13.736	-172.509	24 July 2016	08:54	stationary	1	5
351	-13.738	-172.508	24 July 2016	09:06	stationary	1	5

3. Aopo

Altitude (m asl)	Latitude	Longitude	Date	Start Time	Protocol	Num Observers	Duration (min)
1627	-13.6101	-172.506	27 July 2016	07:33	stationary	5	5
1745	-13.6104	-172.504	27 July 2016	07:49	stationary	5	5
1749	-13.61	-172.503	27 July 2016	08:01	stationary	5	5
1760	-13.6112	-172.502	27 July 2016	08:15	stationary	5	5
1751	-13.6135	-172.501	27 July 2016	08:36	stationary	5	5
1743	-13.6148	-172.499	27 July 2016	08:51	stationary	5	5
1735	-13.616	-172.497	27 July 2016	09:09	stationary	5	5
1729	-13.6167	-172.495	27 July 2016	09:23	stationary	5	5
1740	-13.6155	-172.494	27 July 2016	09:39	incidental	5	5
1738	-13.6158	-172.492	27 July 2016	09:53	stationary	5	5
1631	-13.6104	-172.511	27 July 2016	07:20	stationary	5	5
1613	-13.6095	-172.513	27 July 2016	07:32	stationary	5	5
1605	-13.6085	-172.514	27 July 2016	07:43	stationary	5	5
1584	-13.6071	-172.516	27 July 2016	07:54	stationary	5	5
1564	-13.6065	-172.518	27 July 2016	08:10	stationary	5	5
1535	-13.6048	-172.519	27 July 2016	08:20	stationary	5	5
1500	-13.6034	-172.52	27 July 2016	08:30	stationary	5	5
1466	-13.6016	-172.521	27 July 2016	08:45	stationary	5	5
1432	-13.5999	-172.522	27 July 2016	09:00	stationary	5	5
1394	-13.5984	-172.523	27 July 2016	09:15	stationary	5	5
1617	-13.6075	-172.517	28 July 2016	07:50	stationary	5	5
1645	-13.6092	-172.517	28 July 2016	08:10	stationary	5	5
1636	-13.6109	-172.518	28 July 2016	08:24	stationary	5	5
1639	-13.6128	-172.518	28 July 2016	08:37	stationary	5	5
1653	-13.6146	-172.518	28 July 2016	08:49	stationary	5	5
1655	-13.6165	-172.519	28 July 2016	09:02	stationary	5	5
1668	-13.6184	-172.519	28 July 2016	09:14	stationary	5	5
1692	-13.6197	-172.52	28 July 2016	09:29	stationary	5	5
1698	-13.6209	-172.52	28 July 2016	09:42	incidental	5	5
1707	-13.6206	-172.518	28 July 2016	09:56	stationary	5	5
1565	-13.6021	-172.506	28 July 2016	08:10	stationary	5	5
1587	-13.6002	-172.506	28 July 2016	08:20	stationary	5	5
1550	-13.5982	-172.505	28 July 2016	08:41	stationary	5	5
1481	-13.5961	-172.505	28 July 2016	09:04	stationary	5	5
1467	-13.594	-172.506	28 July 2016	09:17	stationary	5	5
1413	-13.5919	-172.507	28 July 2016	09:35	stationary	5	5
1755	-13.6166	-172.491	29 July 2016	09:05	stationary	5	5
1753	-13.6179	-172.49	29 July 2016	09:17	stationary	5	5
1752	-13.6195	-172.489	29 July 2016	09:28	stationary	5	5
1748	-13.6207	-172.487	29 July 2016	09:40	stationary	5	5

Altitude (m asl)	Latitude	Longitude	Date	Start Time	Protocol	Num Observers	Duration (min)
1774	-13.62	-172.486	29 July 2016	09:54	stationary	5	5
1827	-13.6185	-172.485	29 July 2016	10:11	stationary	5	5
1856	-13.6186	-172.486	29 July 2016	10:28	stationary	5	5
1364	-13.5902	-172.508	29 July 2016	08:10	stationary	3	5
1293	-13.5881	-172.507	29 July 2016	08:10	stationary	3	5
1200	-13.5865	-172.507	29 July 2016	08:40	stationary	3	5
1232	-13.5871	-172.509	29 July 2016	08:55	stationary	3	5
1257	-13.5883	-172.51	29 July 2016	09:20	stationary	3	5
1166	-13.5847	-172.506	30 July 2016	07:13	stationary	2	5
1097	-13.5829	-172.506	30 July 2016	07:26	stationary	2	5
1037	-13.5811	-172.506	30 July 2016	07:47	stationary	2	5
996	-13.5793	-172.505	30 July 2016	07:58	stationary	2	5
940	-13.5774	-172.506	30 July 2016	08:13	stationary	2	5
887	-13.5752	-172.506	30 July 2016	08:32	stationary	2	5
845	-13.5726	-172.506	30 July 2016	08:59	stationary	2	5
814	-13.571	-172.507	30 July 2016	09:11	stationary	3	5
791	-13.5688	-172.509	30 July 2016	09:24	stationary	3	5
756	-13.5671	-172.509	30 July 2016	09:34	stationary	3	5

4. Uafato

Elevation (m asl)	Latitude	Longitude	Date	Start Time	Protocol	Num Observers	Duration (min)
125	-13.953	-171.501	02 August 2016	08:30	stationary	5	5
137	-13.9541	-171.5	02 August 2016	08:43	stationary	5	5
162	-13.9534	-171.498	02 August 2016	09:04	stationary	5	5
210	-13.954	-171.497	02 August 2016	09:27	stationary	5	5
202	-13.9558	-171.496	02 August 2016	09:48	stationary	5	5
234	-13.9569	-171.495	02 August 2016	10:06	stationary	5	5
43	-13.9547	-171.519	02 August 2016	07:35	stationary	4	5
72	-13.9569	-171.521	02 August 2016	07:50	stationary	4	5
77	-13.9583	-171.522	02 August 2016	08:08	stationary	4	5
112	-13.9605	-171.524	02 August 2016	08:25	stationary	4	5
150	-13.9629	-171.526	02 August 2016	08:45	stationary	4	5
179	-13.9631	-171.528	02 August 2016	09:40	stationary	4	5
40	-13.9545	-171.519	03 August 2016	07:30	stationary	5	5
83	-13.9557	-171.52	03 August 2016	07:45	stationary	5	5
129	-13.9564	-171.522	03 August 2016	08:00	stationary	5	5
190	-13.9567	-171.523	03 August 2016	08:25	stationary	5	5
258	-13.9568	-171.525	03 August 2016	08:48	stationary	5	5
50	-13.9456	-171.518	03 August 2016	07:30	stationary	4	5
143	-13.9477	-171.52	03 August 2016	07:50	stationary	4	5

Elevation (m asl)	Latitude	Longitude	Date	Start Time	Protocol	Num Observers	Duration (min)
220	-13.9472	-171.522	03 August 2016	08:05	stationary	4	5
296	-13.9461	-171.523	03 August 2016	08:20	stationary	4	5
329	-13.9452	-171.523	03 August 2016	08:50	stationary	4	5
268	-13.9445	-171.521	03 August 2016	09:15	stationary	4	5
234	-13.9437	-171.519	03 August 2016	09:30	stationary	4	5

4a. Uafato Lookout

Elevation (m asl)	Latitude	Longitude	Date	Start Time	Protocol	Num Observers	Duration (min)
129	-13.9564	-171.521	01 August 2016	08:30	Stationary	7	30
129	-13.9564	-171.521	01 August 2016	09:00	Stationary	7	30
129	-13.9564	-171.521	01 August 2016	09:30	Stationary	7	30
129	-13.9564	-171.521	01 August 2016	10:30	Stationary	7	30
129	-13.9564	-171.521	01 August 2016	11:00	Stationary	7	30
129	-13.9564	-171.521	01 August 2016	11:30	Stationary	7	30
129	-13.9564	-171.521	01 August 2016	12:00	Stationary	7	30
129	-13.9564	-171.521	01 August 2016	12:30	Stationary	7	30
129	-13.9564	-171.521	01 August 2016	13:00	Stationary	7	30
129	-13.9564	-171.521	01 August 2016	13:30	Stationary	7	30
129	-13.9564	-171.521	01 August 2016	14:00	Stationary	7	30
129	-13.9564	-171.521	01 August 2016	14:30	Stationary	7	30
129	-13.9564	-171.521	01 August 2016	15:00	Stationary	7	30
129	-13.9564	-171.521	01 August 2016	15:30	Stationary	7	30

Annex 1. Predicted changes in the distribution of 36 native Samoan trees by 2090 (MNRE 2015b)

Tree Species	Vegetation community tree is most commonly found in	Elevational range (Whistler 2002 and 2004)	Ability to adapt to future climate	Predicted Future Range and Distribution
Alphitonia zizyphoides	Lowland Forest, Montane Forest	1-1060	High?	Spread upslope, increased range?
Bischofia javanica	Lowland Forest, Montane Forest	1-1120	High?	Spread upslope, increased range?
Calophylum inophyllum	Coastal Forest	1-?	High?	Decreased range due to damage to coastal forest?
Calophyllum neo-ebudicum	Lowland Forest	1-650	High?	Spread upslope, increased range?
Canarium harveyi	Lowland Forest	1-600	High?	Spread upslope, increased range?
Canarium vitiense	Lowland Forest	1-800	High?	Spread upslope, increased range?
Diospyros elliptica	Coastal Forest	1-300	High?	Spread upslope, increased range?
Diospyros samoensis	Coastal Forest	1-350	High?	Spread upslope, increased range?
Dysoxylum huntii	Montane Forest, Cloud Forest	150-1860	Medium?	Spread upslope, decreased range?
Dysoxylum maota	Lowland Forest	1-450	High?	Spread upslope, increased range?
Dysoxylum samoense	Lowland Forest, Montane Forest	1-1120	High?	Spread upslope, increased range?
Elattostachys falcata	Lowland Forest, Montane Forest	30-1530	High?	Spread upslope, increased range?
Fagraea berteroana	Lowland Forest, Montane Forest	50-1080	High?	Spread upslope, increased range?
Ficus obliqua	Lowland Forest	30-700	High?	Spread upslope, increased range?
Ficus prolixa	Lowland Forest	1-150	High?	Spread upslope, increased range?
Garuga floribunda	Lowland Forest	1-450	High?	Spread upslope, increased range?
Hernandia moerenhoutiana	Montane Forest, Cloud Forest	100-1300	High?	Spread upslope, increased range?
Intsia bijuga	Lowland Forest	1-250	High?	Spread upslope, increased range?
Manilkara samoensis	Coastal Forest, Lowland Forest	0-150m	High?	Decreased range due to damage to coastal forest?

Tree Species	Vegetation community tree is most commonly found in	Elevational range (Whistler 2002 and 2004)	Ability to adapt to future climate	Predicted Future Range and Distribution
Myristica inutilis	Lowland Forest	1-600	High?	Move upslope, increased range?
Myristica hypargyraea	Lowland Forest, Montane Forest	1-1000	High?	Spread upslope, increased range?
Neonauclea forsteri	Lowland Forest, Montane Forest	1-1050	High?	Spread upslope, increased range?
Palaqium stehlinii	Lowland Forest	150-750	High?	Spread upslope, increased range?
Planchonella garberi	Lowland Forest	1-500	High?	Spread upslope, increased range?
Planchonella samoensis	Lowland Forest, Montane Forest	1-1080	High?	Spread upslope, increased range?
Pometia pinnata	Lowland Forest	1-500	High?	Spread upslope, increased range?
Reynoldsia lanutoensis	Montane Forest, Cloud Forest	500-1110	Low?	Spread upslope, decreased range?
Reynoldsia pleiosperma	Montane Forest, Cloud Forest	320-1820	Low?	Spread upslope, decreased range?
Rhus taitensis	Lowland Forest	1-700	High?	Spread upslope, increased range?
Syzygium clusiifolium	Lowland Forest	1-450	High?	Spread upslope, increased range?
Syzygium dealatum	Lowland Forest	1-300	High?	Spread upslope, increased range?
Syzygium inophllyoides	Lowland Forest, Montane Forest	1-1120	High?	Spread upslope, increased range?
Syzygium samarangense	Lowland Forest, Montane Forest	1-930	High?	Spread upslope, increased range?
Syzygium samoense	Lowland Forest, Montane Forest	180-1200	High?	Spread upslope, increased range?
Terminalia catappa	Coastal Forest, Lowland Forest	1-280	High?	Spread upslope, increased range?
Terminalia richii	Lowland Forest	1-830	High?	Spread upslope, increased range?

Annex 2. Baseline surveys of intertidal fauna in Falealupo and Uafato-Tiavea KBAs

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Team Members: So'oalo Tito Alatimu (MNRE), Clive Fala (MNRE), Fualaga Pemita (MNRE), Benjamin Liau (National University of Singapore)

Summary

Coastal surveys during low-tide at two sections of coast near Falealupo and one section near Uafato indicated that at least 16 species of fauna use the rocky intertidal zone of these shorelines. These are mostly molluscs (snails, chitons and bivalves) as well as echinoderms (sea cucumbers) and crustaceans (barnacles and crabs). Most of these species had greatest abundances in low-shore zones, but some species were able to colonise higher zones of the shore if rock-pools were present. Seven of the species found are harvested for subsistence, and for these species in particular, it would be valuable to continue sampling to monitor population trends over time as part of coastal natural resource management.

Introduction

Very little information is available about the population status of fauna on the rocky intertidal reefs of Samoa. Some past information is available about commercially important species such as sea cucumber (Friedman et. al. 2010) and Palolo worm (Caspers 1984), as well as subtidal corals (Zann 1994) and algae (Skelton & South 2002). There is, however, a range of other intertidal species, particularly gastropod molluscs, which are subsistence harvested in Samoa and have generally not been incorporated in assessments of fisheries stocks or biodiversity assessments. It is important that baseline surveys of these species are undertaken to ensure management interventions can be planned in the event of unacceptable declines in population sizes or biodiversity levels for these species (Edgar et. al. 2004). In order to develop a preliminary dataset on the current baseline population status of intertidal fauna, and to provide methodological training to Government Natural Resource Management staff, Coastal surveys of the intertidal zone at Falealupo and Uafato were incorporated into the 2016 BIORAP programme.

Methodology

The rocky shorelines of Samoa are mostly basaltic, and can also be comprised of coral base-rock. Intertidal fauna were measured on randomly selected areas of coast including both these rock types. The counts were taken using transect lines (50m measuring tapes) laid along the vertical profile of the shoreline during low tide. The transect lines started where the waves were breaking and continued until the first vegetation was reached above the shore, incorporating emergent rock as well as fauna within rock-pools. All fauna that were at least 1cm in size and which occurred within one metre of either side of this line were recorded and photographed so that species could later be identified to species level where possible. When transects passed over areas of moist sand adjacent to rocks, the top 10cm of sand was dug away to search for bivalves in the sand, which are sometimes found in this type of habitat. Four transects were done on the short length of rocky shoreline east of Uafato, and 20 transects were done across two sites on the more extensive Falealupo rocky shore (Fig. 1).

Figure 1 – locations of the 2 sections of coast in Falealupo and 1 section in Uafato where sampling was done.

Intertidal species are greatly affected by the height on the shore, with some species being adapted to high on the shore and others requiring regular and prolonged submersion. The pattern of zonation across heights on the shore is one of the basic patterns that require understanding before the ecology of a shore can be understood (Harley & Helmuth 2003). To help develop a basic understanding of coastal zonation for Samoa, we measured zonation patterns during the coastal BIORAP sampling. This was done by dividing the transects into four equally proportioned zones; the lowest quarter of transects (closest to the breaking waves) was classified the “low-shore”, the next quarter up was classified “mid-shore”, then “high-shore” and the “spray-zone” was the highest zone, immediately before the coastal vegetation was reached and which are mostly influenced during high-tide by spray from breaking waves.

The 2-dimenstional areas that were included in the different zones of each transect were calculated and average (mean) densities of the most common species were calculated and compared among the different areas of zonation. Comparisons of mean densities were also compared between Falealupo and Uafato. For less common species, these were included in a species list showing presence or absence at Falealupo and Uafato.

Results

A variety of mollusc species were the most commonly occurring fauna on the rocky intertidal of both Falealupo and Uafato. Two snails were the most consistently found species, being the predatory whelk *Vasum ceramicum* and the algal grazer *Nerita plicata*. *V. ceramicum* was found across the four sampled zones (Fig. 2), often due to its presence in high zones in rock-pools. *N. plicata* was more common at Falealupo, especially in the mid-shore, but were also found in variable zones in Uafato (Fig. 3). Another gastropod was very common, the limpet *Siphonaria normalis*, but this was invariably found only in the low-shore zone, in similar densities between Falealupo and Uafato (Fig. 4).

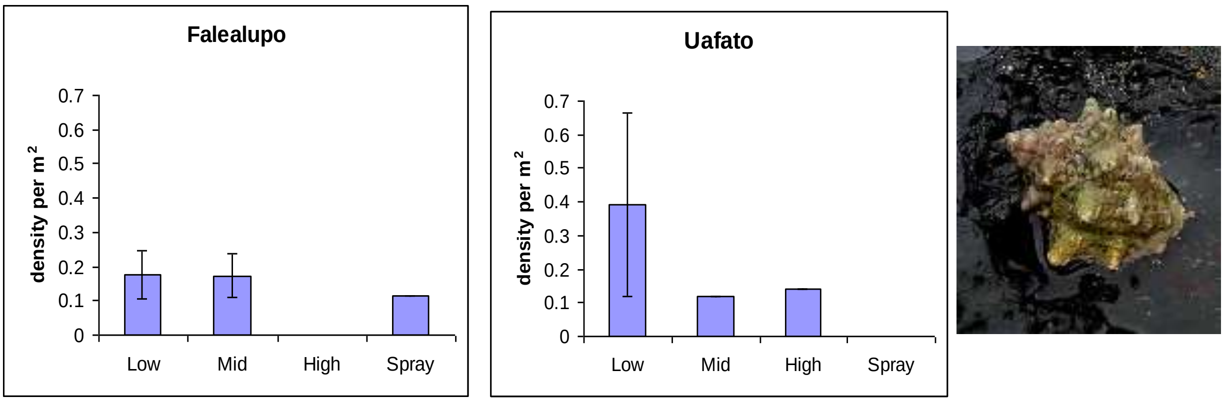

Figure 2 – average densities of the whelk *Vasum ceramicum* in four different shore zones at the two locations. The low shore is the closest to the water and the spray zone is immediately before the boundary where the vegetation begins. The averages are calculated as the mean of densities across all transects within each location. Lines above and below the graph values show the standard error, which indicates the level of variability within the average.

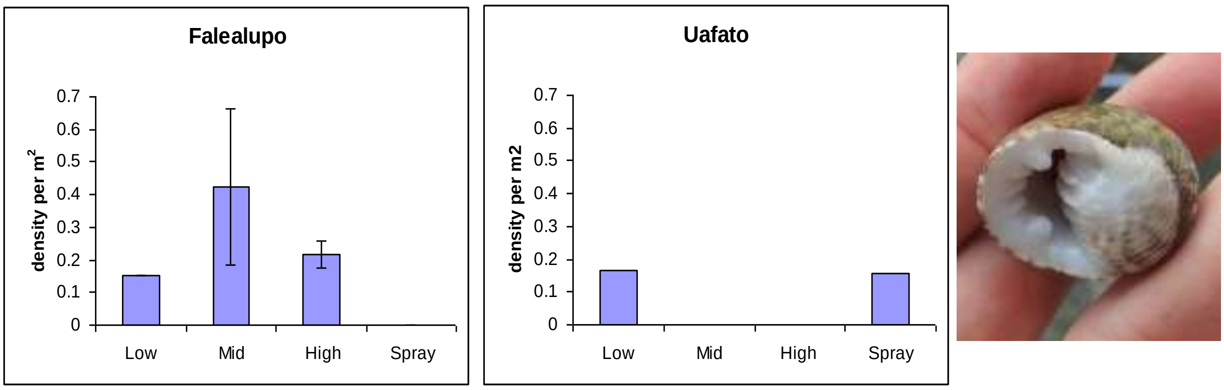

Figure 3 – average densities of the snail *Nerita plicata* in the four different shore zones at the two locations.

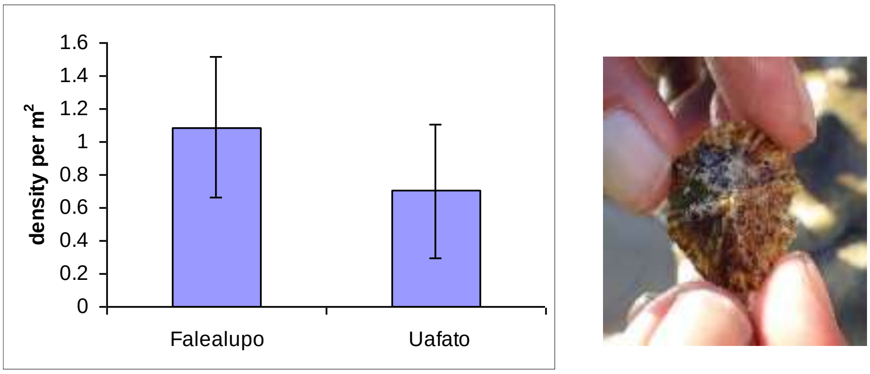

Figure 4 – average densities of the limpet *Siphonaria normalis* at the two locations. This species was only found in the low-shore zone.

Sea cucumbers were the other group of species that had widespread abundances across the sampling sites. In particular, the edible species *Holothuria atra* was found at both Falealupo and Uafato. In most instances it occurred in the low-mid zone, but in one instance a large density was found in a rock-pool in the high-shore at Uafato (Fig. 5).

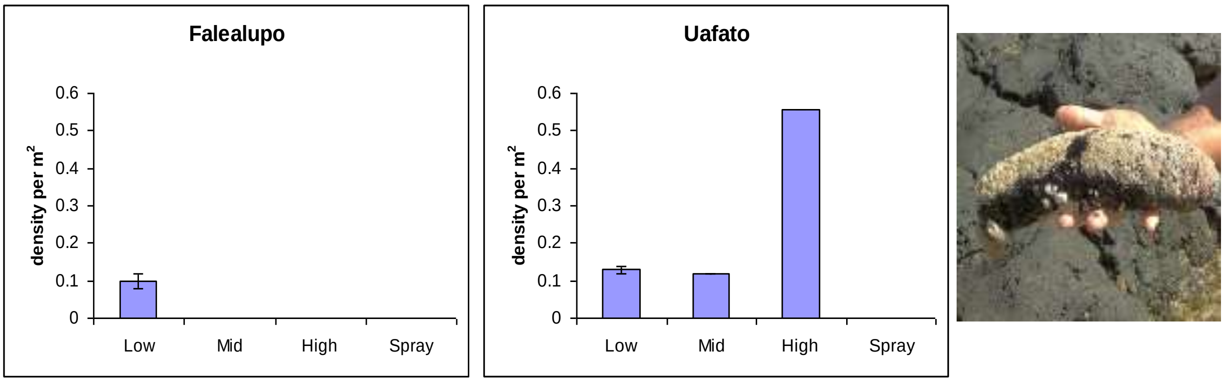

Figure 5 – average densities of the sea cucumber *Holothuria atra* in the four different shore zones at the two locations. The large number n the high-shore zone at Uafato occurred because of a high-shore rock pool that contained a large density of the species.

Slightly more species were found at Falealupo (13 species) compared to Uafato (9 species) (Table 1). This may be related to the lower number of transects that were done at the latter location, and also the lower diversity of different habitat types there, as Falealupo had longer shores with more extensive rock-pools and adjacent beach habitat. The shoreline at Uafato appeared to be more exposed to waves, which explains the presence there of exposed-shore species such as rock barnacles and gooseneck barnacles (Table 1).

Table 1 – list of fauna species identified during the surveys, and whether they were present or absent from Falealupo or Uafato.

Scientific name	Samoan name	Common name	Falealupo	Uafato
Vasum ceramicum	Patu patu	Heavy whelk	x	x
Nerita plicata	Sisi	Plicate nerite	x	x
Siphonaria normalis	Ipo	False limpet	x	x
Holothuria atra	Loli	Black sea cucumber	x	x
Cypraea mauritiana	Pule	Humpback cowrie	x	
Grapsus tenuicrustatus	Ama ama	Lightfoot crab	x	
Ocypode ceratophthalmia	Avivi	Horned ghost crab	x	
Linckia laevigata		Blue seastar	x	
Holothuria leucospilota	Apulu pulu	Black sea cucumber	x	
Coenobita spp.		Hermit crab	x	x
Acanthopleura gemmata		Spined chiton		x
Ophiomastix spp.	Aveau	Brittle star	x	x
Pollicipes mitella		Gooseneck barnacle		x
Chthamalus intertexus		Rock barnacle		x
Bohadschia argus	Fugafuga	Leopard sea cucumber	x	
Periglypta reticulata	Pipi	Reticulated venus	x	

Discussion

The baseline data of species densities provided by this sampling can be compared with similar densities measured in future sampling events to determine trends in abundances of these species, as well as their presence or absence. This is particularly relevant for harvested species. Seven of the 16 species found are known to be regularly harvested on a subsistence level, these include the gastropods *Siphonaria normalis* and *Cypraea mauritiana,* the chiton *Acanthopleura gemmata,* the beach bivalve *Periglypta reticulata*, and the three species of sea cucumber.

The sampling showed that locations spread widely over the Samoan archipelago have similar species assemblages, as most species were shared between these two distant locations. This would be expected for species with large-scale larval dispersion, which includes all the species represented in the samples. Comparisons between zones showed that many species are adaptable concerning the vertical positions they can tolerate on the shore. In many cases, this was related to the presence of rock pools. These were often high-up on the shore, even in the spray-zone, and allowed a range of species to occur there that would otherwise be limited to lower zones. Future sampling should be planned to take the presence of rock-pools into account during the sampling procedures. Any future sampling should use comparable methods as those outlined here in order to produce relatable data. New locations should also be sought, particularly where important populations of harvestable species require on-going monitoring.

Recommendations

- Monitoring is continued within the sites targeted here, with data from different times compared to determine populations trends.
- Monitoring is expanded to new locations, particularly where important populations of harvestable species occur, or where new disturbances are detected.
- Community members from villagers nearby sampling sites are trained in monitoring methods and encouraged to participate (i.e. “citizen science”).

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