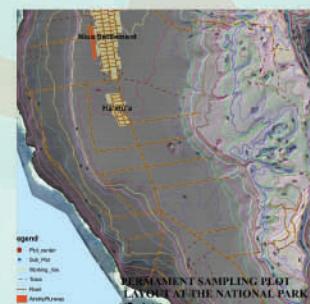


Integrated Island Biodiversity Technical Series

Field Surveys to Complete the Permanent Vegetation Plots on 'Eua National Park

Kingdom of Tonga July 2013



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FIELD SURVEYS TO COMPLETE THE PERMANENT VEGETATION PLOTS ON 'EUA NATIONAL PARK

JULY, 2013

Ministry of Lands, Environment, Climate Change and Natural Resources (MLECCNR)

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PREFACE

The 'Eua National Park has received very little attention from conservationists of the Ministry of Lands, Environment, Climate Change & Natural Resources until very recently. Now it is realised that as well as being fascinating plant species and birds for scientific study, they are also suffering from both nature and human pressures. The park has become of the oldest national park in Tonga as conservationists have increased attention and aims to provide as much information as they can to preserve the plants and bird species that exist on 'Eua National Park.

The first report on 'Eua island was written and published back in 2004 by a project called "The Eua Man and Biosphere project and compiled on 2004 by officers from the Ministry of Lands, Environment, Climate Change and Natural Resources. The main focus of the 'Eua Man & Biosphere Project was to attempt at a working model for sustainable development in the Kingdom of Tonga by balancing economic development, natural resource conservation, and cultural integrity. One of the primary activities of this project is awareness in the communities of 'Eua.

One of the Environmental Issues that was highlighted at the 'Eua Man & Biosphere project back in 2004 were land degradation and deforestation of the National Park, however conservationists within the Ministry of Lands, Environment, Climate Change & Natural Resources are receiving attention through our participation in the Community Awareness and workshops during 2004.

Since 2004, GIZ (Deutsche Gesellschaft fur Internationale Zusammenarbeit) project came into existence to the Ministry of Environment and Climate Change on 2010 where they focus on Coping with Climate Change in the Pacific Island Region Programme. One of the project's priority is focussed on planting variety of fruit tree and other plant species that sustainably withstand climate change and it is still ongoing until 2016. Part of the GIZ work at the 'Eua National Park was establish vegetation plot and that is where the Integrated Island Biodiversity Project continue its work from the permanent plot established on 2010.

The 'Eua National park is too special to be ignored as it consists variety of plant and bird species which they are native, however only plant species were recorded and analysed during the survey. Therefore, we are sincerely hope that this report will raise awareness on the importance of the permanent plots which highly required to be closely monitored in the future.

ACKNOWLEDGEMENT

The writers would like to acknowledge the Ministry's Minister, Lord Ma'afu for allowing the project to be implemented by the Ministry of Lands, Environment, Climate Change & Natural Resources, Chief Executive Officer Mr. 'Asipeli Palaki for his vision to complete the output of the Integrated Island Biodiversity Project within the 'Eua National Park.

We are grateful to acknowledge the support of the Deputy Director of the Environment Division for her support on the implementation of the 'Eua survey by the officers from MLECCNR and MAFFF. The hard work of the performed by the survey officers involved in collecting data to support the creation of this report. This includes GIS officers, Maka Fifita and Sione Sunia for providing all of our GIS needs from designing sample to preparing maps and for contributed to snap some good shots at the National Park; Sitiveni Hamani assisted us with the challenges of provided data sheets, lead the team during the one month survey. Conservation Officers from the MLECCNR, Hoifua 'Aholahi, Samuela Pakileata, Daisuke Yumiya for collecting data in the field, Samuela Lile and Saia Fonokalafi for assisting the team in reading the clinometre during the survey and Heimuli Likiafu for recording the plant species with their local name.

To all the town officers and town districts in 'Eua, your support and input during our four days consultations were highly appreciated by the the IIB project. Without your sacrifices to travel from your villages to join the open discussion in order to achieve the output of the IIB project.

We would like to thank the Global Environment Facility (GEF) for providing the financial support necessary for the preparation of the Vegetation plot activity which was held at the 'Eua National Park.

Finally, we have been privileged to be allowed to stay in the Government's Representative home during our one month survey in 'Eua. His hospitality of welcoming and feed us during this month, we will never forget.

EXECUTIVE SUMMARY

- This report covers the field survey to establish vegetation plots according to data collected during a one month survey on 'Eua National Park from 24th July-6th August 2013.
- Six plots were plotted at the national park using a GPS equipment and a compass with the assistance of plot #15 that plotted by the GIZ project in 2010. However, the plots was difficult to plot due to bad weather.
- Information gathered during the last survey in 2010 was insufficient to minimize the work that we done on locating the remaining six plots at the national park.
- Fewer information were located from collecting of birds and other fauna and insects at the national park.
- However, this survey found out many of our native plants to be survived and healthy in good numbers whereas little information collected on birds.
- The greatest challenge faced by the team during the survey is having bad weather which postponed the survey lest fine weather.
- Surveyed focus only on plant species on each plot and found out that majority of the plots were covered by the *Dysoxylum tongense* (Mo'otamea), *Myristica hypargyraea* (Kotone), *Ficus obliqua* (Masi'ata) and *Dendrocnide harveyi* (Salato).
- Lack of data on avifauna, entomology, reptile, which highlighted lack of experts onthis areas to conduct the survey.
- Species of plants were identified and recorded on each plots yet still required confirmation of their status at the IUCN Redlist.
- It is important to enforce the existing Parks and Reserves Acts regulation to assist with monitoring of the permanent plots.
- Build a strong relationship within the relevant stakeholders to ensure successful monitoring of the ENP.
- It is encouraged to provide more trainings for local villages and environment conservation staffs to carry out the monitoring activities on ENP.
- It is recommended to do a follow up survey to monitor all records of six permanent vegetation plots on ENP.

LIST OF ACRONYMS & ABBREVIATIONS

EFP	'Eua ForestPlantation
ENP	'Eua NationalPark
GEF	Global EnvironmentFacility
GIS	Geographical InformationSystem
GIZ	Deutshe Gesellshaft fur Internationale Zesammenarbeit
IIB	Integrated Island Biodiversity
MAFFF	Ministry of Agriculture, Food, Forestry andFisheries
MLECCNR	Ministry of Lands, Environment, Climate Change & NaturalResources
SPA	Special ProtectedArea
SPREP	Secretariat of the Pacific Regional EnvirionmentalProgramme
UNEP	United Nations Environment Program

1. INTRODUCTION

The section provides information on background information of the 'Eua National Park, Description of the National Park, its land area and Legislative framework. Vegetation survey and mapping of 'Eua National Park is currently practised by Ministry of Lands, Environment, Climate Change and Natural Resources (MLECCNR) where officers from Geographic Information System (GIS) Department, Department of Climate Change and Environment and expert from the Ministry of Agriculture, Food, Forestry and Fisheries (MAFFF) based in 'Eua works together to provide methods for the capture, record, interpretation and management of vegetation data and information in compliance with national and international standards.

1.1 Background of 'Eua National Park

The 'Eua National Park, locates in the oldest island in the Pacific known as 'Eua island with 20km southwest of Tongatapu with an area of 81sq km. The island is also known as the third largest island in Tonga. The National Park has been surveyed several times in the past and vegetation data is required for a number of purposes and at different levels of detail and similarly is required at various scales and levels of attribute information. Historically, plotting of vegetation within the national park was one of the main target of the Ministry of Lands, Environment, Climate Change & Natural Resources (MLECCNR) as it collaborate with the Department of Forestry (DOF) under the Ministry of Agriculture, Food, Forestry and Fisheries in surveying, plotting and mapping new six plots within the national park.

1.2 Description of 'Eua National Park

'Eua National Park was developed for the recognition of its ecological values and socio-economic potentials of the forests whereby the Government endorsed the establishment of 'Eua Forestry Farm in 1951 for forestry conservation purposes.

Since the enactment of Forest Acts to become a Law in 1961, the Department of Forestry has fully responsibility for the management and protection of forest resource so its land that unallocated to the Government. However, even though Forestry department is responsible for the management and protection of forest resource but the authority and designation and allocation of land still rest with the Ministry of Lands, Survey and Natural Resources (MLSNR) back in the days. Due to increasing of pressures from farmers, leaseholds and tax allotments in this best forests resources area, Department of Forestry proposed for the protection of the indigenous forests on the eastern part of the 'Eua island as a National Park.

A biological survey was conducted on the Eastern part of the island where they highlighted in their reports the importance of plant communities and therefore proposed a national park for the conservation of the biological diversity of 'Eua as a whole.

In 1992, the government approved recommendations from the protection of its largest remaining rain forests and been gazetted to be known as 'Eua National Park (ENP).

1.3 'Eua National Park Land and Plan Areas

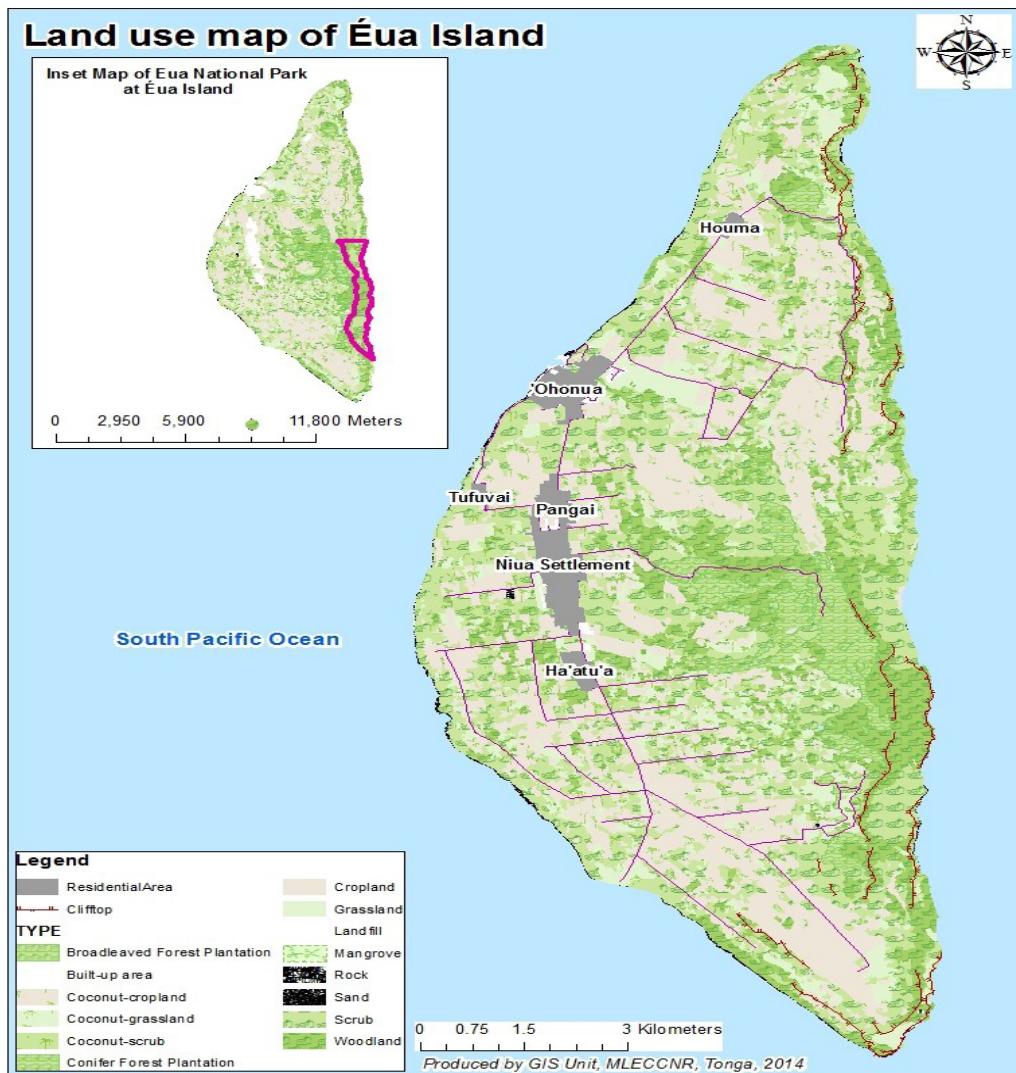


Figure 1.1: Land Use Map of 'Eua designated the 'Eua National Park;
Source: GIS Unit, MLECCNR, 2014

'Eua National park with a total area of 449.4 hectares (449.4 ha) occupies most of the coastal south-eastern part of the island (figure 1.1). Naturally, the area is protected due to its remoteness, inaccessibility and very rugged terrain.

The vegetation within the national park is mostly by rain forest where it covers the largest area of continuous forest left on 'Eua which represents the largest areas of rain forest left in Tonga (photos 1-4). 'Eua national park is also known for its rich flora and fauna that are unique to the whole of Tonga and only endemic to 'Eua island.



Photo 1-4: Rainforest within the 'Eua National Park'; Source: Photo taken by Ana.Fekau

1.4 Legislative Framework

'Eua national Park is legal protection under the legal framework established under the Parks and Reserves Act 1977[Cap 89] and other relevant policies and legislations consisting the:

- National Forestry Policy 2010
- Forest Act 1961
- Land Act 1927

Even though legislations and Acts are there but enforcement of these Acts is the main issue that we currently faced with.

1.5 Objectives and Expected Output

Overall objectives and target output of the survey:

- Identifying the variety of vegetation associations occurring in the 'Eua National Park and then establish six vegetation plots on different locations within the Park.
- Complete vegetation plot survey in 'Eua National Park.
- Surveyed in the National Park to complete island wide programme.
- Map vegetation therein, the current extent and distribution of plant species, map scale was on the unit of metre, aiming to establish a baseline for long term monitoring and management of plant species.
- Compile vegetation plot survey data across 'Eua National Park.
- Build the capacity of the MLECCNR staffs to record management and monitor the effects of these species of vegetation.

2. SURVEYS SCHEDULE AND METHODOLOGY

The survey team consisted of local expert from the Department of Forestry in 'Eua and one JICA volunteer, Daisuke Yumiya from Japan that works for the Department of Environment, two officers from GIS Unit of Department of Lands, one officer from Forestry of Tongatapu and five officers from Department of Environment. There were two teams that established with five members each lead by local experts and supported by local staffs from the Ministry of Lands, Environment, Climate Change & Natural Resources (MLECCNR) and Ministry of Agriculture, Food, Forestry and Fisheries.

Team A: Local Experts

Sitiveni Hamani(Team leader, Forestry Division supervisor-Department of Forestry).
Hoifua 'Aholahi(Senior Conservation officer-Department of Environment)
-Samuela Pakileata (Assistant Conservation officer-Department of Environment)
Daisuke Yumiya(JICA expert volunteer-Department of Environment)
-Makameone Fifita(GIS senior officer- Department of Lands and Survey)

Team B: Local Experts and Trainees

-Heimuli -(Department of Forestry-Lab extention at Vaini Farm)
-Saia Fonokalafi- (Department of Environment)
-Samuela Lile- Environment Trainee- (Department of Environment)
-Sione Sunia- GIS trainer (Department of Lands and Survey)
-'Ana Fekau- IIB Coordinator(Department of Environment)

2.1 Schedule

22nd -23rd July- Meetings with survey team at the main office of Department of Environment
24th July – Flights to 'Eua Island. Briefing with Fosita Masi, Acting Government Representative of 'Eua
25th July- Meeting with Town Officers and Town Districts of 'Eua Island
26th July- Visit the 'Eua National Park and plot the first plot(Plot 14) lead by local expert Sitiveni Hamani
27th July – Team planning on plotting the second plot (Plot 13). 29th July- Measured and plot Plot 13.
30th July- Measured and plot Plot 12 and 10
31st July- Community Consultation(two sessions in the morning) 1st-3rd August – No surveyed due to bad weather
5th August – Measured and plot Plot 7 and 4
6th August- Last Consultation with Government Representative, Town officers and Town districts, 7th August- Return to Nuku'alofa by boat

2.2 Methodology

Surveys of 'Eua National Park consisted of two elements:

1. Plot 15 at the southern end of the National Park was located using the GPS and the compass was then used to locate the other six plots which are located at the northern side with the same bearing (360 degree). Each plot was located and then established 4 sub plots, one at the north, south, west and east 80 metres from the centre point. In each sub plot it was also divided into unit and sub unit and each subplot is 10 x 100 metres and trees with dbh of ≥ 10 cm were recorded in the field form. After the plot was set up, data was collected and recorded under each subplot.

2.3 Preliminary Map Production

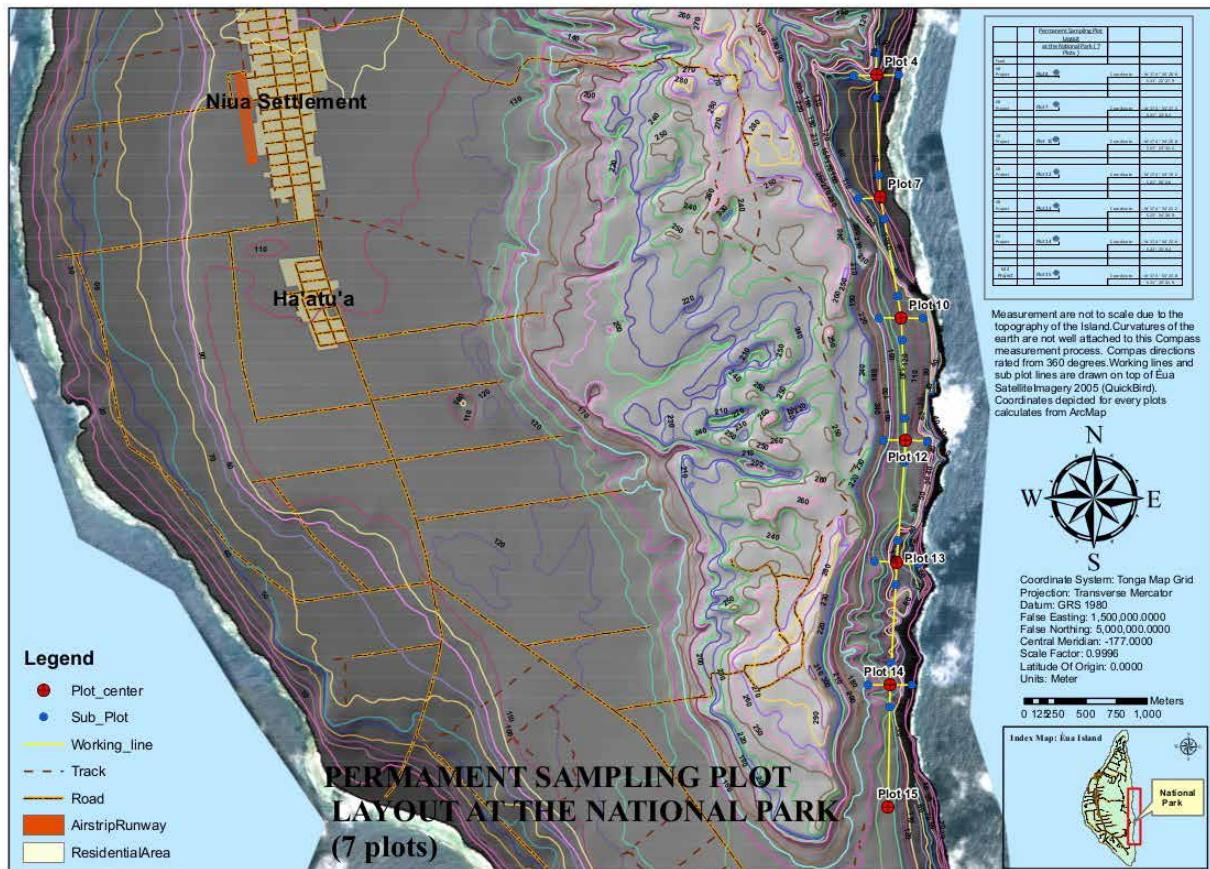
Satellite images with high resolutions baseline on 2004 have been used as the remotely sensed data source for 'Eua National Park. For the purpose of this report, a map unit refers to the predefined delineation of vegetation communities visualised from interpretive material. It is important to note that mapping of vegetation within the 'Eua National Park imposes boundaries on a transition or continuum; often temporal as well as spatial. It attempts to capture, within the 'Eua National Park area, boundaries that are not always distinctly definable in nature. Vegetation maps are produced assuming communities are established in a manner that can be visualised through interpretation of remote sensing data such as satellite imagery at a point in time.

2.4 Data Use and Collection

Before the on-the-ground survey was conducted at the 'Eua National Park, vegetation and forest types were identified using the latest satellite images of 2004 and the GIS mapping technique. The main purpose of the analysis is to produce a forest classification, identification of species located within the national park.

2.5 Map Scale

The 'Eua National Park map was drawn using metre units (map 2). The amount detail that shown on this map is mostly a function of scale. The information on this small scale map is usually more generalised than on a large scale map.



Map 2: Map of permanent sampling plots layout of 'Eua National Park in metres;

Source: GIS Unit, MLECCNR, 2013

2.6 Consultation with Key Stakeholders and Communities

There were consultations hosted by the Ministry of Lands, Environment, Climate Change & Natural Resources in 'Ohonua, 'Eua to raise awareness on the importance of consistently monitoring the work that has been done on the 'Eua national Park. Before conducting the consultations and awareness programs, a separate meeting was called on the first day of our arrival on the island to introduce the team to the government representative, town districts and town officers. During the meeting with town officers and town districts, they initially asked questions about why the government is so concerned with the national park, how are they going to assist with the long-term conservation of the national park? Were there funds provided by the government to monitor works that has done to the national park? These questions were discussed and elaborated to avoid misunderstanding between key stakeholders and the works that implemented by the government ministries.

During the first day of consultation with government representative, town officers and town districts, were given an overview of the vegetation plot survey to be held at the 'Eua National Park which known to all of Tonga that is the oldest national park in Tonga and donors are still supported the government of Tonga with funds to implement priority activities and to conserve the native species within the park. On the last day of consultations results from completed vegetation plots were reported back to key stakeholders and communities.

All issues raised during consultation with key stakeholders and communities were individually analysed, and recorded. Two categories of issues emerged, first, is based on monitoring of vegetation plots after the completion of the IIB project on December 2015 and the strategies to protect and conserve important rare plant species in the national Park. However, there was a concerned with the issues of monitoring and quality survey of vegetation plots.

3. RESULTS AND DISCUSSIONS

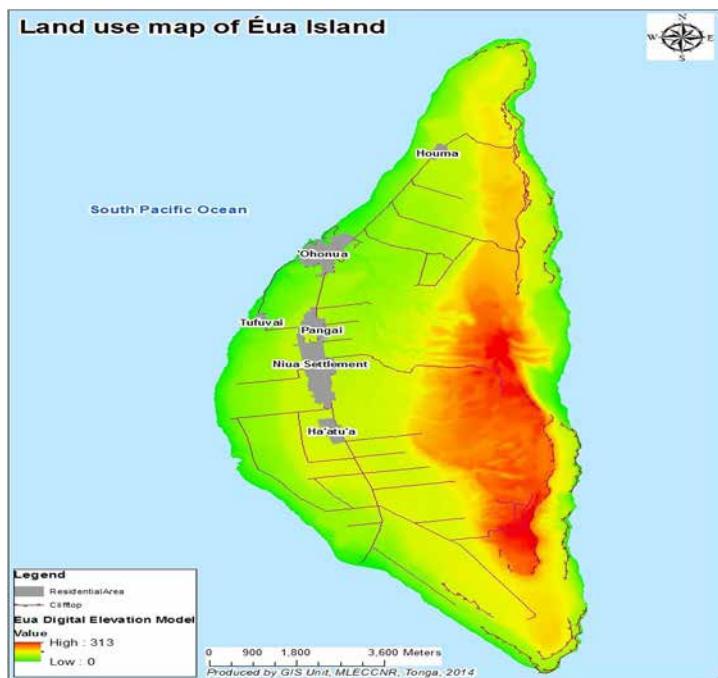
As discussed in the introduction, a survey was conducted on 'Eua National Park between 25th July – 5th August, 2014 using experts who were government officers from two government agencies (Ministry of Lands, Environment, Climate Change and Natural Resources, and Ministry of Agriculture, Food, Forestry and Fisheries). The results from survey is fully analysed and described.

3.1 Description of Permanent Plots

The A permanent plot was plotted at the southern end of the National Park and located with a GPS. A compass was then used to locate the other six plots which are located at the northern side with the same bearing (360 degree). Each plot was located and then established 4 sub plots, one at the north, south, west and east 80 metres from the centre point. In each sub plot it was also divided into unit and sub unit 10 by 100 metres and trees with dbh of $\geq 10\text{cm}$ were recorded in the field form.

3.2 Field Data Collection and Analysis

Field data collection were completed to classify, and fully describe all vegetation type across national parks that located between plot 4 and plot 14. Different vegetation types were delineated through the interpretation of landuse map photography across the pilot study area of 'Eua National Park (map 3) The field work was stratified to find the location(bearings) of plot 15 that was established by the GIZ project in 2010 in order to continue with finding the location of plot 4, plot 7, plot 10, plot 12, plot 13 and plot 14. Field teams were cutting through paths for each plot starting from plot 4 where each plot were established 4 subplots (north, south, west and east)- photo 5 and 6.



Map 3: Land use map of 'Eua island showing digital elevation of 'Eua National Park
Source: GIS Unit, MLECCNR, 2014

3.3 Review Meeting

Before conducting the survey on 'Eua National Park, a meeting was held at the Government representative office in 'Ohonua village for the introduction of the survey team to key stakeholders and the purpose of the team from the Ministry of Lands, Environment, Climate Change & Natural Resources of coming to 'Eua island. The participants during the first meeting were included the Government representative, town districts and town officers. This meeting was different when we are hosting two meetings with local communities.

The results of vegetation plot at the national park, the selection of the 'Eua national park, field methodologies were presented during consultation with stakeholders and communities. The list of vegetation types that encountered through the field work and survey were also presented with key findings to the audience for discussions.

Specific feedback requested from participants to refine the list of classification units and to develop the descriptions of vegetation types, and the key environmental factors. There were to be a concerted attempt to identify any gaps in the pilot study in terms of its environments, vegetation types and additional features that should be mapped. Hence, the list of vegetation types, were recorded on each plot for comparison.

3.4 Collection and Review of Existing Information

To ensure the full application of existing data and other information on the 'Eua national park, information on the national park's resources will be reviewed and fully evaluated for their quality and utility to the Integrated Island Biodiversity Project. An attempt will be made to identify and contact all individuals who have expertise concerning the long-term monitoring of the national park. The availability of adequate data will have some effect on the ability to develop the sampling protocols for 'Eua national park.



Photo 5 & 6: Survey team making a path from centre point, 'Eua National Park; Source: Photo taken by 'Ana Fekau

Table 1: Shows details on Plot 4

Species	DPH	Mode	Perc_mode	Log_Height	Tree_Top
<i>Myristica hypargyraea</i>	1528.4	40	49.38271605	647	1240
<i>Macaranga harveyana</i>	55.1	2	2.469135802	20	73
<i>Bischofia javanica</i>	326.1	7	8.641975309	83	242
<i>Cocos nucifera</i>	319.5	11	13.58024691	297	399
<i>Inocarpus fangifera</i>	39.8	1	1.234567901	18	35
<i>Artocarpus altilis</i>	105.63	4	4.938271605	52	108
<i>Dendrocnide harveyi</i>	313.2	5	6.172839506	75	163
<i>Calophyllum inoplyllum</i>	51.5	1	1.234567901	10	14
<i>Thespesia populnea</i>	98.7	3	3.703703704	27	99
<i>Terminalia catappa</i>	54.3	2	2.469135802	37	69
<i>Garcinia myrtifolia</i>	23.3	2	2.469135802	0	0
<i>Neisosperma oppositifolium</i>	51.7	2	2.469135802	27	43
<i>Dysoxylum tongense</i>	18.8	1	1.234567901	0	0

Table 1 outline the raw information compiled to decide the appropriate analytical proposal and graphs that follow. Each column apart from the 'Species' column indicates the:

Total DPH, Log Height and Tree_top with the following formula:

= a particular plant species like *Myristica*

$$\sum DPH \text{ of } x's \text{ where } x$$

hypargyraea only. DPH can be substitute with either Log_Height or Tree_Top.

- Mode (count):

$$\sum x$$

- Perc_mode:

$$\left(\frac{\sum x}{\sum n} \right) \times 6((\text{ where } n = \text{ number of all plant species (13).})$$

Example:

:(40 *Myristica hypargyraea* , 81 species all

$$\left(\frac{\sum x}{\sum n} \right) \times 6((=)F R 3 \text{ sig fig 5}$$

together)

Fig. 3.1: Percentage mode of species in Plot 4

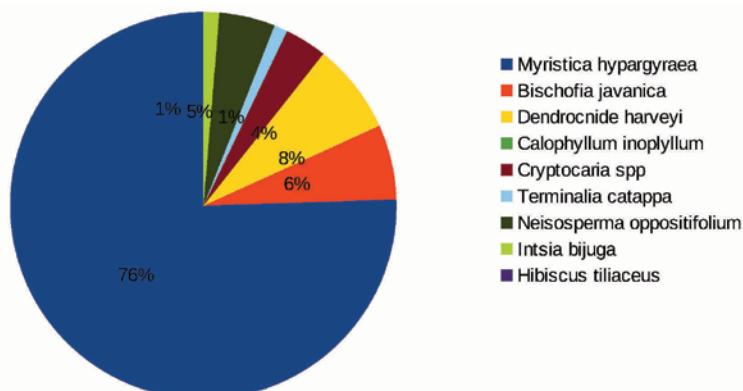
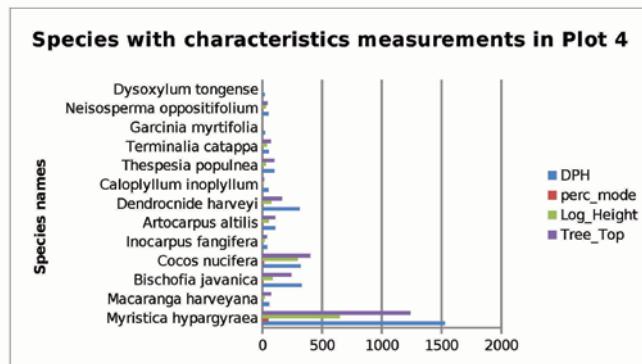


Fig. 3.2: Species with characteristics measurements in Plot 4



As seen on figure. 3.1, Kotone *Myristica hypargyraea* has the highest percentage of 49%, thus dominates the plant species within plot 4. Niu *Cocos nucifera* comes second with 14% whereas the other remaining 37% are unequally shared by the other species out of a total of 13 plant species.

With this result we can note that the Kotone *Myristica hypargyraea* will have the greatest DPH, Log height and Tree top distantly followed by the Niu *Cocos nucifera*, Koka *Bischofia javanica* and Salato *Dendrocnide harveyi* all in meters measuring unit. Kotone *Myristica hypargyraea* as seen in figure.3.2 has the most suitable characteristics for logging and we can predict an increase in its growth in the next 5 to 10 years time as well as advising that plot 4 is an excellent habitat for Kotone *Myristica hypargyraea* species. However by observing the other species there is relatively few percentage number of them which may due to logging activity as most of these plants were found “unloggable” which is either yet to be fully grown or had already been slashed. Another reasoning for few of these species is, either it is an edible plant (Telie *Terminalia catappa* , Niu *Cocos nucifera*, Ifi *Inocarpus fangifera*, Mei *Artocarpus altilis*) or is being used for medicinal purposes like Milo *Thespesia populnea* and Loupata *Macaranga harveyana*.

Table 2: Plant species within Plot 7

Species	DPH	Log Height	Tree Top	Mode	Perc_mode
<i>Myristica hypargyraea</i>	1706.90	678.00	1327.00	44	68.75
<i>Bischofia javanica</i>	212.70	50.00	110.00	5	7.81
<i>Dendrocnide harveyi</i>	250.90	58.00	133.00	5	7.81
<i>Calophyllum inoplyllum</i>	14.20	14.20	0	1	1.56
<i>Cryptocaria spp</i>	26.10	28	62	3	4.69
<i>Terminalia catappa</i>	39.80	5	20	1	1.56
<i>Neisosperma oppositifolium</i>	144.80	16	82.00	3	4.69
<i>Intsia bijuga</i>	38.00	4	23	1	1.56
<i>Hibiscus tiliaceus</i>	23.30	0	0	1	1.56

Figure 3.3: Measurements of characteristics of Species in Plot 7

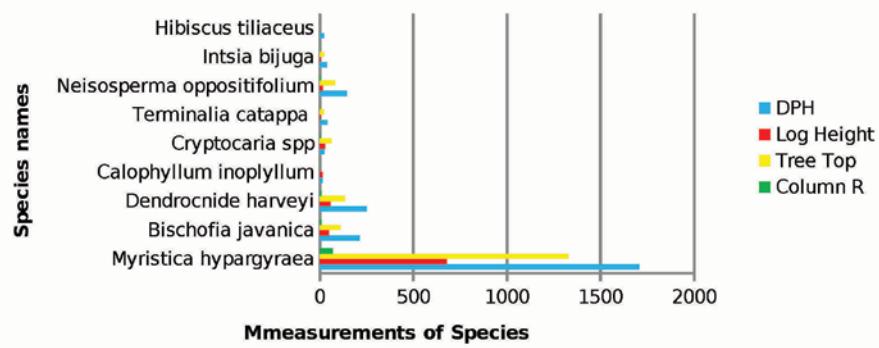
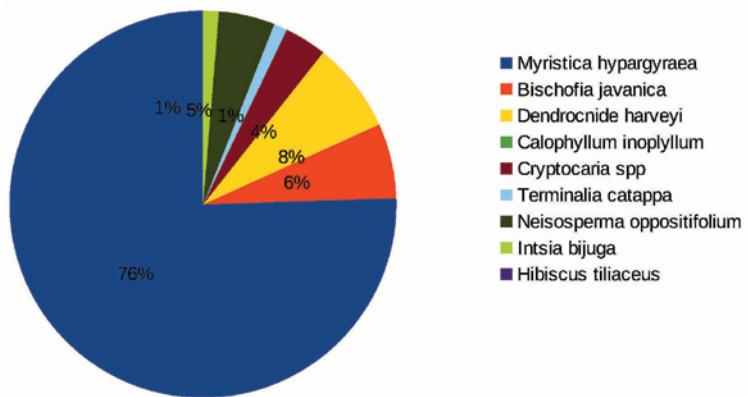


Figure 3.4: Percentage of Species specified in Plot 7



Regarding to figure.3.3 and figure.3.4, these graphs shows similar trend as that to figure 3.1 and figure 3.2, indicating that Kotone *Myristica hypargyraea* is the most occurrence plant species in plot 7. The domination of the Kotone *Myristica hypargyraea* species proves its greatest measurement for DPH, Log_Height and Tree_Top. In contrast to figure 1.2 Kotone *Myristica hypargyraea* has an increase of numbers by 20% (69%) as well as only 9 plant species occupy plot 7 with Koka *Bischofia javanica* and Salato *Dendrocnide harveyi* both having 8% to being the second most occurrence plant species. As seen in figure.3.1 Telie *Terminalia catappa*, Fehi *Afzelia bijuga* and Fau *Hibiscus tiliaceus* has no log height bar graph indicating that such plant are "unloggable" other then being slashed or it is still a young plant, these plants have crooked twirling branches not suitable which is not suitable for a proper log height. This can also affect their tree top causing their tree top measurement to be low which is also seen for Tamanu *Calophyllum inophyllum* species. Also the tree top of the Kotone *Myristica hypargyraea* tends to cover the upper level in the forestry that it reduces the amount of sunlight that might have enabled the growth of most of the other plant species. Fau *Hibiscus tiliaceus* plant species has only one existing bar graph for figure 3.3 yet there is 2% of Fau *Hibiscus tiliaceus* in plot 7, the most usage of this plant is for handicraft making like taóvala (kiekie), weaving of mats, fans and so forth. Hence majority of women population in Éua relies on handicrafts that can lead to its cause of slashed.

Table 3: Measurement taken for Plot 10

Species	DPH	Mode	Log Height	Tree top	Perc_mode
<i>Cryptocaria hornei</i>	333.00	13	66.00	158.00	18.31
<i>Dendrocnide harveyi</i>	764.10	12	121.00	367.00	16.90
<i>Afzelia bijuga.</i>	83.30	2	56.00	86.00	2.82
<i>Bischofia javanica</i>	164.60	2	37.00	75.00	2.82
<i>Dysoxylum tongense</i>	199.30	3	39.00	97.00	4.23
<i>Garcinia myrtifolia</i>	201.80	5	98.00	169.00	7.04
<i>Canarium indicum</i>	336.60	7	89.00	234.00	9.86
<i>Ellatostachys falcate</i>	281.60	4	89.00	159.00	5.63
<i>Calphyllum inophyllum</i>	725.40	17	216.00	482.00	23.94
<i>Myristica hypargyraea</i>	139.90	3	28.00	62.00	4.23
<i>Hibiscus tiliaceus</i>	47.80	3	0.00	-	4.23

Table 3 shows the measurements taken for plot 10 with a total of 11 plant species altogether. All calculation of equation is referred to formula under Table 1.

Figure 3.5: Measurements of species characteristics in Plot 10.

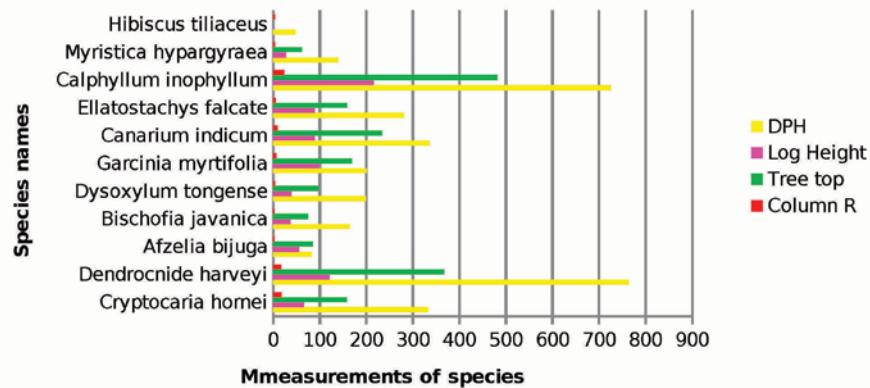
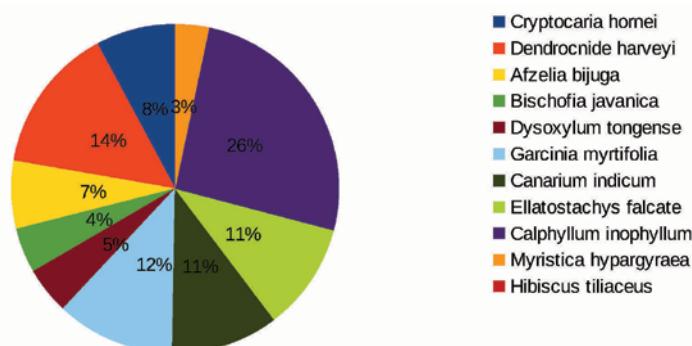


Figure 3.6: Percentage of Species in Plot 10



According to figure.3.5 and figure.3.6, there is a wide difference between plot 10 and the previous discussed plots. There is a relatively spread of plants as well as the number of the species within plot 10. Tamanu *Calophyllum inophyllum* has the most dominant species with Motou *Cryptocaria hornei* and Salato *Dendrocnide harveyi* closely behind. The highest DPH is 764 meters whereas in the previous plots the DPH was 1706 meters. Also there's 3% for the least species which has an increased of 2% compared to plot 4 and 7. A distribution of the DPH, log height and tree top are clearly seen which amount to the idea that plot 10 is a very good representation of plant distribution and growth is stabilized. We can also say that plot 10 has good wood volume, various species is found and a good commercial foundation in the future hence plot 10 still needs good protection because it promises a lush forest in 5 to 10 years time.

Table 4: Species measurements recorded in Plot 12

Species	Mode	DPH	Log_Heights	Tree_Top	Percentage_mode
<i>Canarium indicum</i>	6	276.40	75.00	190.00	10.17
<i>Myristica hypargyraea</i>	6	331.60	86.00	233.00	10.17
<i>Cryptocaria hornei</i>	13	252.30	58.00	116.00	22.03
<i>Dendrocnide harveyi</i>	13	1055.10	228.00	510.00	22.03
<i>Dysoxylum tongense</i>	3	109.80	38.00	113.00	5.08
<i>Grewia crenata</i>	1	27.40	8.00	21.00	1.69
<i>Garcinia myrtifolia</i>	5	120.60	67.00	128.00	8.47
<i>Ficus obliqua</i>	4	112.00	29.00	161.00	6.78
<i>Bischofia javanica</i>	2	54.90	22.00	88.00	3.39
<i>Afzelia bijuga</i>	1	32.30	12.00	14.00	1.69
<i>Disoxylum forsteri</i>	2	94.60	20.00	63.00	3.39
<i>Calophyllum inophyllum</i>	3	42.80	12.00	37.00	5.08

Table 4 shows the measurements taken for plot 12. All calculation is referred to formula under Table 1.

Figure 3.7: Plant species with characteristics measurements in Plot 12

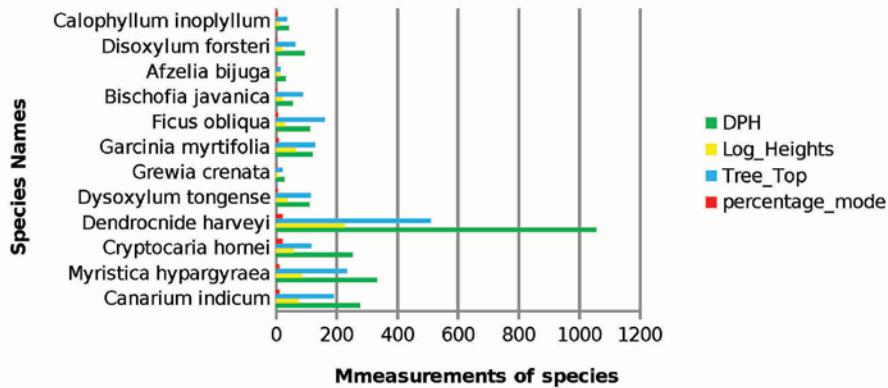
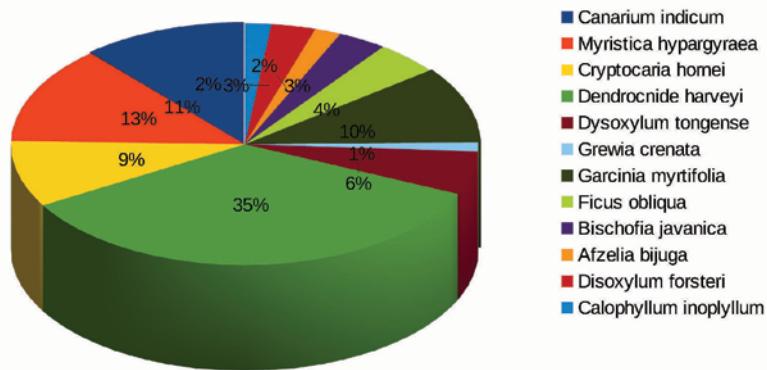


Figure 3.8: Percentage of species in Plot 12



Plot 12 has 12 total numbers of species with Salato *Dendrocnide harveyi* and Motou *Cryptocaria hornei* as the most dominant species (figure. 3.8) and 56% assign to the other 10 species. The high occurrences for Salato *Dendrocnide harveyi* may be due to its poisonous feature adaptation that encourages its growth and dispersion from humans. The interesting aspect shown by plot 12, there is no Kotone *Myristica hypargyraea* exist here compared to the three last discussed plots. However new plant is seen such as Ficus and Foúi which contributes to the diverse species found within the studied plot. This can show that in the more distant future these plants may also be found within plots that these two plants did not exist through bird or wind carrier. Although Salato *Dendrocnide harveyi* and Motou were the dominant species according to figure.3.7 Salato *Dendrocnide harveyi* has the highest DPH and Tree top unlike the Motou, because Motou is under the shrub level category.

Table 5: Shows measurements taken for Plot 13

Species	Mode	Per_mode	DPH	Log_Height	Tree_Top
<i>Myristica hypargyraea</i>	14	26.42	382.10	97.00	446.00
<i>Dysoxylum tongense</i>	4	7.55	108.20	34.00	76.00
<i>Afzelia bijuga</i>	5	9.43	126.70	26.00	59.00
<i>Canarium indicum</i>	10	18.87	289.20	72.00	176.00
<i>Dendrocnide harveyi</i>	10	18.87	618.10	147.00	331.00
<i>Calophyllum inoplyllum</i>	2	3.77	47.20	9.00	37.00
<i>Ficus obliqua</i>	4	7.55	96.60	10.00	49.00
<i>Aleurites moluccana</i>	1	1.89	70.30	16.00	45.00
<i>Bischofia javanica</i>	1	1.89	47.70	10.00	47.00
<i>Hibiscus tiliaceus</i>	2	3.77	33.00		

Table 5 shows the measurements taken for plot 13. All calculation of equation is referred to formula under Table 1.

Figure 3.9: Measurements of species characteristics in Plot 13

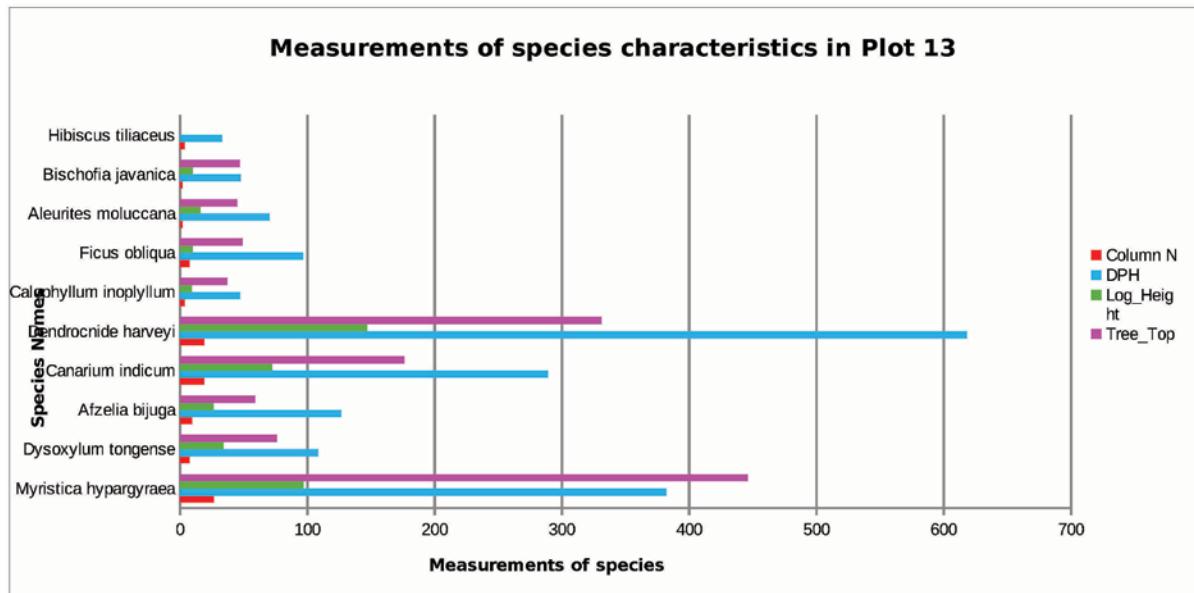


Figure 3.10: Percentage of Species in Plot 13

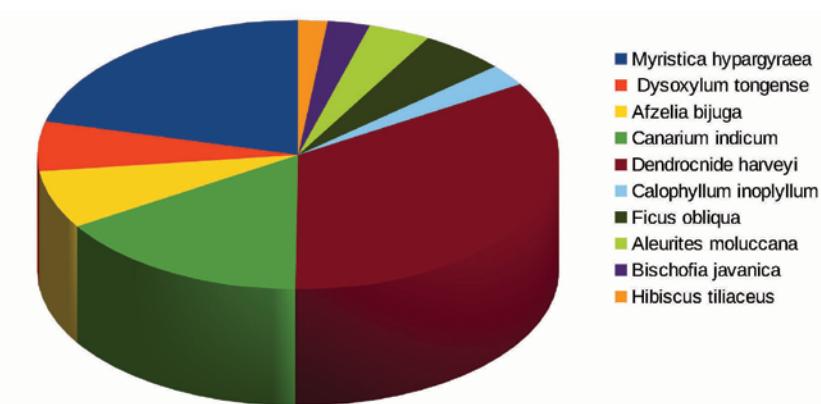


Figure 3.10 shows 10 plant species within plot 13; Kotone *Myristica hypargyraea* as the most leading plant with 26% Salato *Dendrocnide harveyi* and Ái *Syzguyn nakaccense* following up. Another new plant the Tuitui *Aleurites moluccana* appears, yet Salato *Dendrocnide harveyi* tend to have the highest DPH indicating good wood volume similarly to the Kotone *Myristica hypargyraea*. The remaining 7 plant species are closely levelled compared to figure. 3.9 yet the species characteristics measurement are less compared to all previous plot analysed. The theory behind this analysis, the greater the number of the most occurrence plant species in plot 13, this species will act as an outlier by skewing all data that are in proximal spatial distance. Tuitui *Aleurites moluccana* is a medicinal plant is first sighted here therefore indicate its dispersion either by travellers or wind and birds.

Table 6: Details measurement of Plot 14

Species	Mode	Per_mode	DPH	Log_Height	Tree_Top
<i>Myristica hypargyraea</i>	10	18.51852	466.7	163	379
<i>Cyathea dealbata</i>	3	5.555556	104.4	29	118
<i>Canarium indicum</i>	6	11.11111	222.5	73	251
<i>Grewia Crenata</i>	1	1.851852	33.9	20	45
<i>Dendrocnide harveyi</i>	11	20.37037	505.3	183	401
<i>Calophyllum inophyllum</i>	4	7.407407	148.3	72	131
<i>Macaranga harveyana</i>	4	7.407407	114.9	69	173
<i>Dysoxylum tongaense</i>	2	3.703704	59.3	23	43
<i>Rhus taitensis Guillemin</i>	1	1.851852	52.5	15	42
<i>Alphitonia zizyphoides</i>	1	1.851852	47	13	38
<i>Garcinia myrtifolia</i>	1	1.851852	33.3	12	42
<i>Ficus obliqua</i>	2	3.703704	58.6	30	79
<i>Dysoxylum tongense</i>	1	1.851852	52.5	25	48
<i>Glochidion cuspidatum</i>	1	1.851852	39.8	2	21
<i>Afzelia byjuga</i>	2	3.703704	44.1	5	28
<i>Ficus oblique</i>	1	1.851852	73.8	10	30
<i>Crytocaria hornei</i>	1	1.851852	23.3	0	0
<i>Xylosma obbiculatum</i>	1	1.851852	18.9	0	0
<i>Ellatostachys falcate</i>	1	1.851852	13.5	0	0

Table 6 shows the measurements taken for plot 14. All calculation of equation is referred to formula under Table 1.

Figure 3.11: Species with characteristics measurements in Plot 14

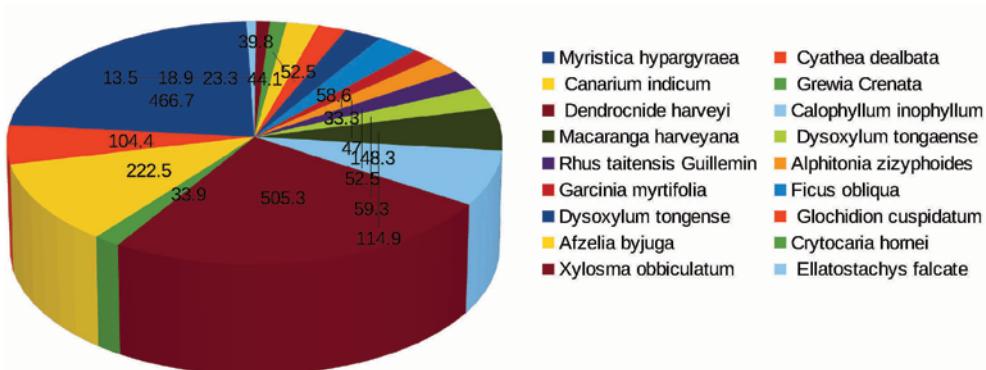
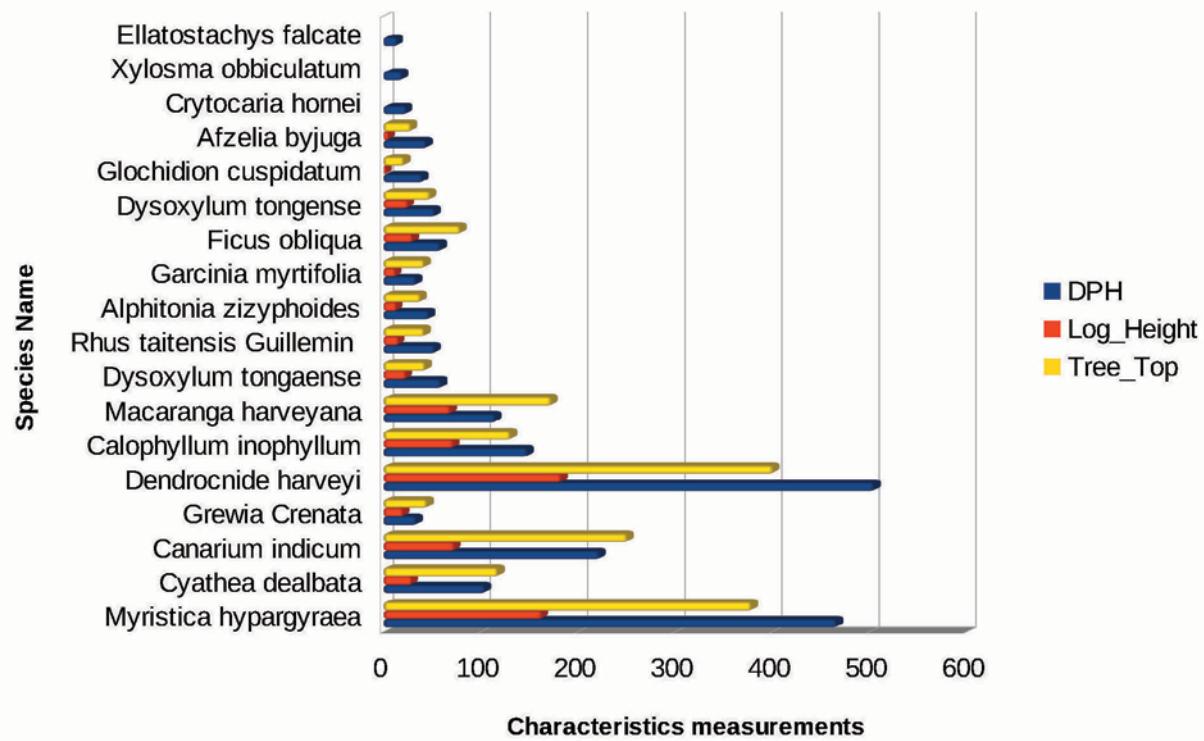


Figure 3.12: Species with percentage mode for Plot 14



Finally, plot 14 tallies to 18 total number of plant species, Salato *Dendrocnide harveyi* as the most dominant species. Reference to figure. 3.12, the DPH, tree top and log height found here is less than the measured characteristics found in plot 4 and 7. This may due to the total number of plant found in each plot that may cause the data to be skewed also the number of dominant species otherwise known statistically as outliers also affect the average approximation of the information analysed.

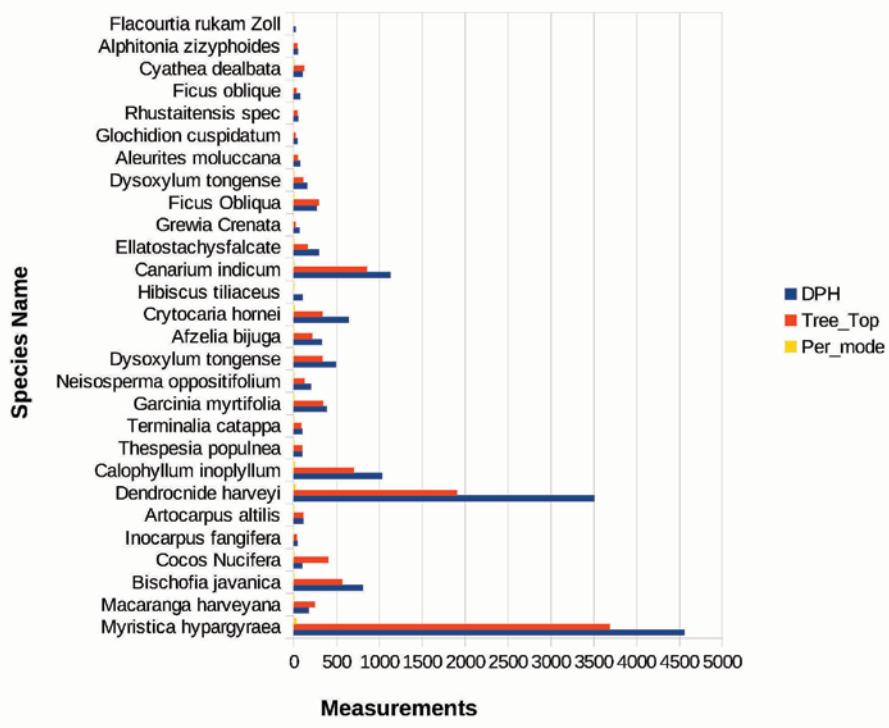
However the average DPH, log height and tree top is also sums up when all the plots were analysed, that the average DPH would be approximate to 600 meters, log height is 200 meters and tree top equals 200 - 300 meters.

Table 7: Compilation of Data from Plot 4, Plot 7, Plot 10, Plot 12, Plot 13 and Plot 14.

Species	Mode	Log_Height	DPH	Tree_Top	Per_mode
<i>Myristica hypargyraea</i>	117	1699	4555.6	3687	32.59
<i>Macaranga harveyana</i>	6	89	170	246	1.67
<i>Bischofia javanica</i>	17	202	806	562	4.74
<i>Cocos Nucifera</i>	11	297	98.7	399	3.06
<i>Inocarpus fangifera</i>	1	18	39.8	35	0.28
<i>Artocarpus altilis</i>	4	52	105.63	108	1.11
<i>Dendrocnide harveyi</i>	56	812	3506.7	1905	15.60
<i>Calophyllum inoplyllum</i>	28	333.2	1029.4	701	7.80
<i>Thespesia populnea</i>	3	27	98.7	99	0.84
<i>Terminalia catappa</i>	3	42	94.1	89	0.84
<i>Garcinia myrtifolia</i>	13	177	379	339	3.62
<i>Neisosperma oppositifolium</i>	5	43	196.5	125	1.39
<i>Dysoxylum tongense</i>	12	136	488.6	334	3.34
<i>Afzelia bijuga</i>	11	103	324.4	210	3.06
<i>Crytocaria hornei</i>	30	152	634.7	336	8.36
<i>Hibiscus tiliaceus</i>	6		104.1		1.67
<i>Canarium indicum</i>	6	309	1124.7	851	1.67
<i>Ellatostachysfalcate</i>	5	89	295.1	159	1.39
<i>Grewia Crenata</i>	2	28	61.3	21	0.56
<i>Ficus Obliqua</i>	10	69	267.2	289	2.79
<i>Dysoxylum tongense</i>	4	43	153.9	106	1.11
<i>Aleurites moluccana</i>	1	16	70.3	45	0.28
<i>Glochidion cuspidatum</i>	1	2	39.8	21	0.28
<i>Rhurstaitensis spec</i>	1	15	52.5	42	0.28
<i>Ficus oblique</i>	1	10	73.8	30	0.28
<i>Cyathea dealbata</i>	3	29	104.4	118	0.84
<i>Alphitonia zizyphoides</i>	1	13	47	38	0.28
<i>Flacourtie rukam Zoll</i>	1	0	18.9	0	0.28

Table 7 compiles all the plant species found in all 6 plots with their measurements. All of these measurements were done using the same method (equation) below Table 1.

Figure 3:13: Species with all measurements at 'Eua National Park



The above figure 3.13 indicates the generalized data of all plant species found from recent survey on six plots set up. Only 10 species are shown on Table 7 out of 28 species altogether. The remaining 18 species occurred only once which was excluded from figure 3.13 to avoid skewing of information. As suspected and proven true, Kotone *Myristica hypargyraea* is the most dominant species overall, has the maximum DPH, log height and tree top measurement. Next to Kotone *Myristica hypargyraea* is Salato *Dendrocnide harveyi*, Tamanu *Calophyllum inoplyllum* and so forth.

With reference to Map 2 (below), the location of the plots makes them unique in a way that it is not accessible by travellers and locals in terms of its proximity towards the cliff site, height and distance from residential areas. The area covered by the plot sites is 'Eua National park which has been declared as a Protected Site ('Eua Management Plan, 2010), However it only occupies a total of 28 plant species which is quite less and a total of 370 species altogether. There is need for greater amnesty of less grown species such as Malolo *Glochidion cuspidatum*, Tavahi *Rhurstaitensis spec*, Fau *Hibiscus tiliaceus*, Toi *Alphitonia zizyphoides* and so forth as their role in local medicinal purposes, handicrafts and recreational uses are very important as well as sustaining rare flora such as Milo *Thespesia populnea*. Each plot site in Map 2 can be evaluated further with each graph titled accordingly.

Overall, the best plot to observe is plot 10 as seen throughout the information from the data, plot 4 and 7 shows the domination of Kotone *Myristica hypargyraea* indicates good wood volume for commercial activities whilst plot 12, 13, and 14 shows little similarity trend in terms of height, width and coverage whereas Salato *Dendrocnide harveyi* and Kotone *Myristica hypargyraea* competes. Plot 10 data shows varied distribution of plants DPH, Log height and Tree top.

Therefore, these plot requires amnesty in order for future growth as seen in plot 4 and 7, there is only a few edible and medicinal plants compared to plot 12, 13 and 14.

Replanting scheme should be encouraged as well to speed up the process of natural dispersion of seeds and growth. Such action plan should aim to reach a specific number of species in the next 5 – 10 years in order to keep track, promote and sustain growth.

CONCLUSION

It is important to recognise that 'Eua national park is vital nationally and globally because of its flora and fauna species. Improving the management objectives that has been identified under the 'Eua National Park Management Plan will assist the Ministry in management, protection and sustainable development of the National Park for long-term vision. The national park is a government estate which is under the Ministry of Lands, Environment, Climate Change and Natural Resources. To manage and protect 'Eua national park is not just the responsibility of the MLECCNR. It requires the commitment from local communities in 'Eua island to work together with MLECCNR and Department of Forestry based in 'Eua to manage and protect flora and fauna ecosystems on 'Eua national park.

'Eua National Park is extremely important in terms of its primary vegetation and richness in biodiversity. Over the past years, Vegetation plots were likely to be complicated and took more than a month to plot a single plot in the national park. With good weather, we were able to complete the whole six plots within one month. One of the key findings of vegetation is completion of these plots. It is important to take into consideration the value of 'Eua National Park locally, regional and international and how its plant species are highly classified to be very important to all Tongans.

It is critically concerned that the one month survey provided a snapshot of plant species and important information on 'Eua National Park but it is still highly required further work to record other species which can assist the Ministry to establish good picture on aiding the management of protected area.

During the establishment of vegetation plot by GIZ project funded by Germany in 2009, there has been a widespread loss of important cultural plants in 'Eua National Park which evidently declined the population of other species. However, the one month survey did not cover other species rather than focusing on plant species on each six plots yet it is encouraging to note that the management plan that established in 2009 was concerned and agreed according to existing legislations and Government obligations to international agreements on protection and conservation of forests and trees resources in Tonga. The key management goals set for the protection and conservation of 'Eua National Park (ENP) which we are highly required to take into consideration these important lists:-

- Maintain biological diversity and geographical features in 'Eua National Park Area as natural reserve;
- Base on the ecological values and forests potentials in the adjacent 'Eua Forest Plantation, maintain socio-economic provisions from forests in perpetuity and;
- Develop an environmental sustainable ecotourism and maintain historical sites.

RECOMMENDATIONS

Planning to protect the areas within the 'Eua national park from being visited and deforestation from happening, we strongly recommended to:

- Visit ENP yearly to monitor the six permanent plots established by the Island Biodiversity Project.
- Enforce the existing Parks and Reserves Acts regulations
- Prohibit any form of agricultural farming near the permanent plots
- Maintain species population by enrichment planting and natural regeneration
- Prohibit improper harvesting technique (complete cutting) and propagate and promote planting of trees on private lands
- Encourage regular field patrol and conduct field monitoring based of visitors comments and field observation
- To provide training of local staffs for data analysis techniques
- Closely monitor suspicious visitors to national park
- Develop a strong relationship between relevant stakeholders to ensure successful monitoring of permanent vegetation plots at the ENP
- Propose follow up surveys to include areas of vegetation plot (plot 15) and area that has not been surveyed in the past to maximize data collection so we can plan possible conservation and monitoring actions.
- To provide training for local villages and permanent staffs of the Ministry of Lands, Environment, Climate Change and Natural Resources to help improve knowledge on conservation issues of plant species at the ENP and to develop strategies to aid protection of key resources(plant) that are crucial to biodiversity of 'Eua and all of Tonga.

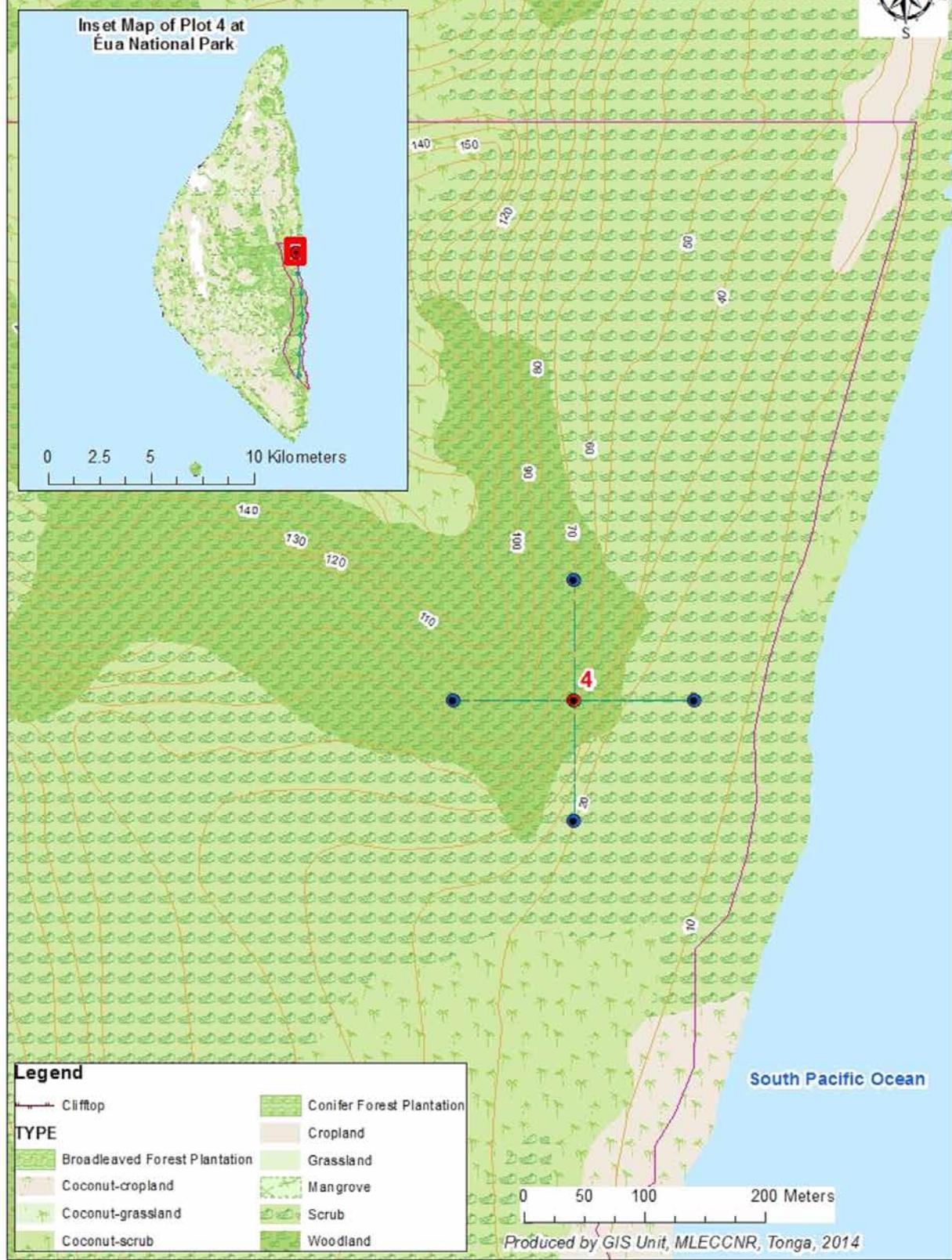
A multiple use management of the adjacent areas to buffer the national park is essential for the protection of the ENP. Harvesting of traditional and cultural trees and plants in the adjacent area will be regulated to promote natural regeneration. Designation of areas with unique ecological and conservation values as 'Special Protected Area' will be made and strictly controlled. The MLECCNR is encouraged to conduct education and future research for the ongoing monitoring of the permanent vegetation plots at the Eua National Park(ENP) and to train staffs to carry out the monitoring not only the ENP but the other parks in Tonga which is under the Department of Environment and Climate Change.

APPENDIX

Appendix 1: Land use map of 'Eua national park with six permanent plots



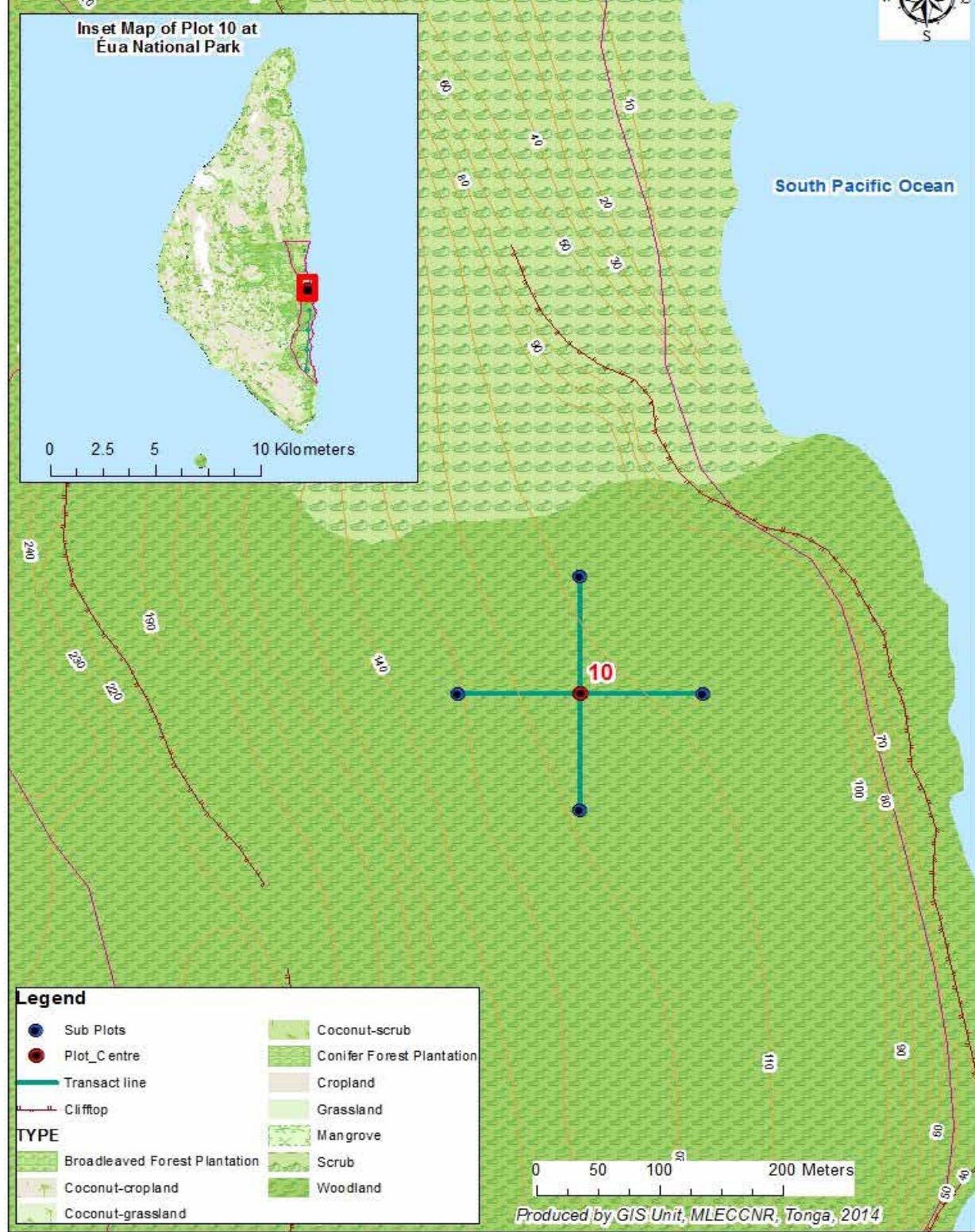
Land use map of Plot 4 at Éua Island



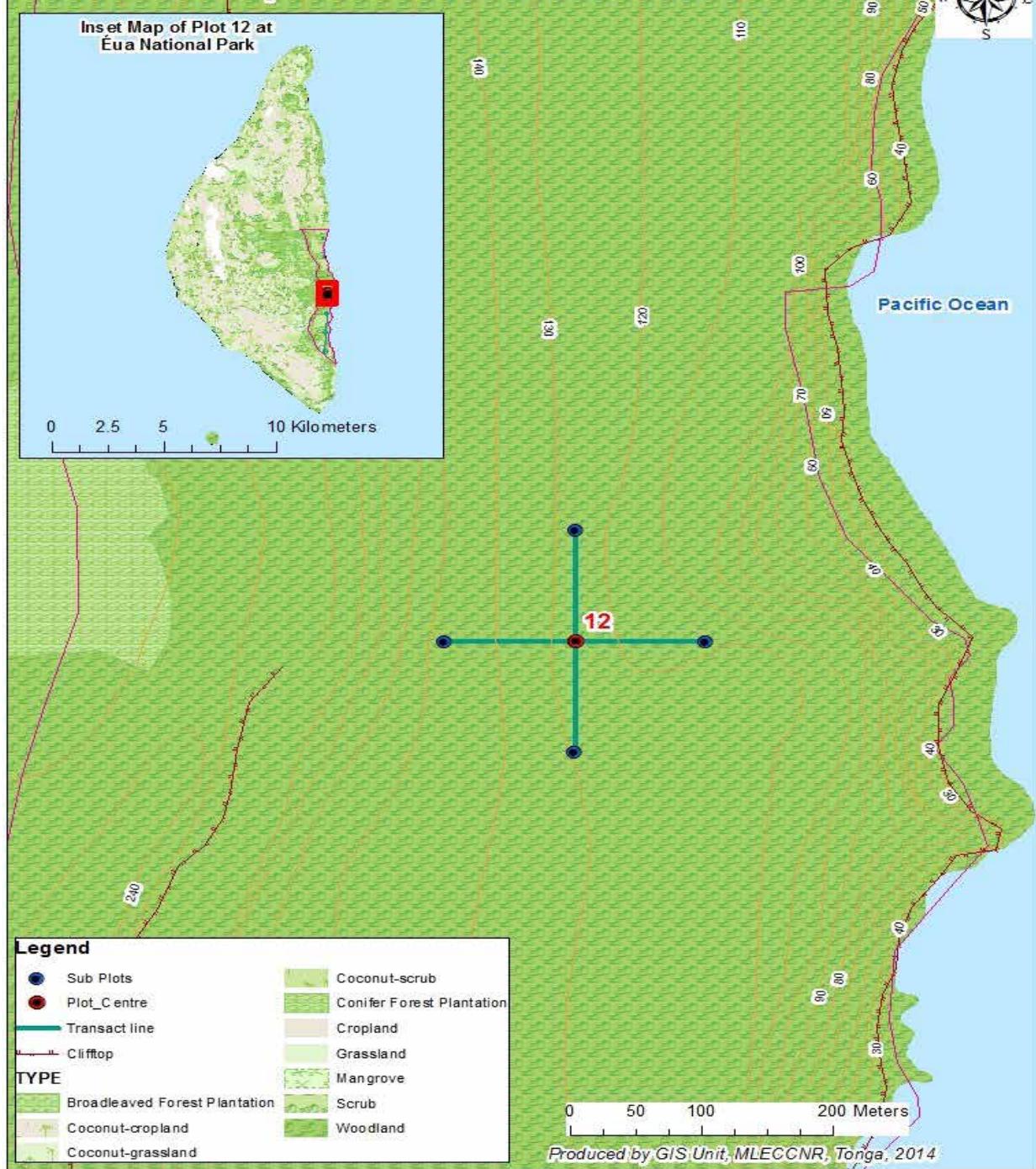
Land use map of Plot 7 at Éua Island

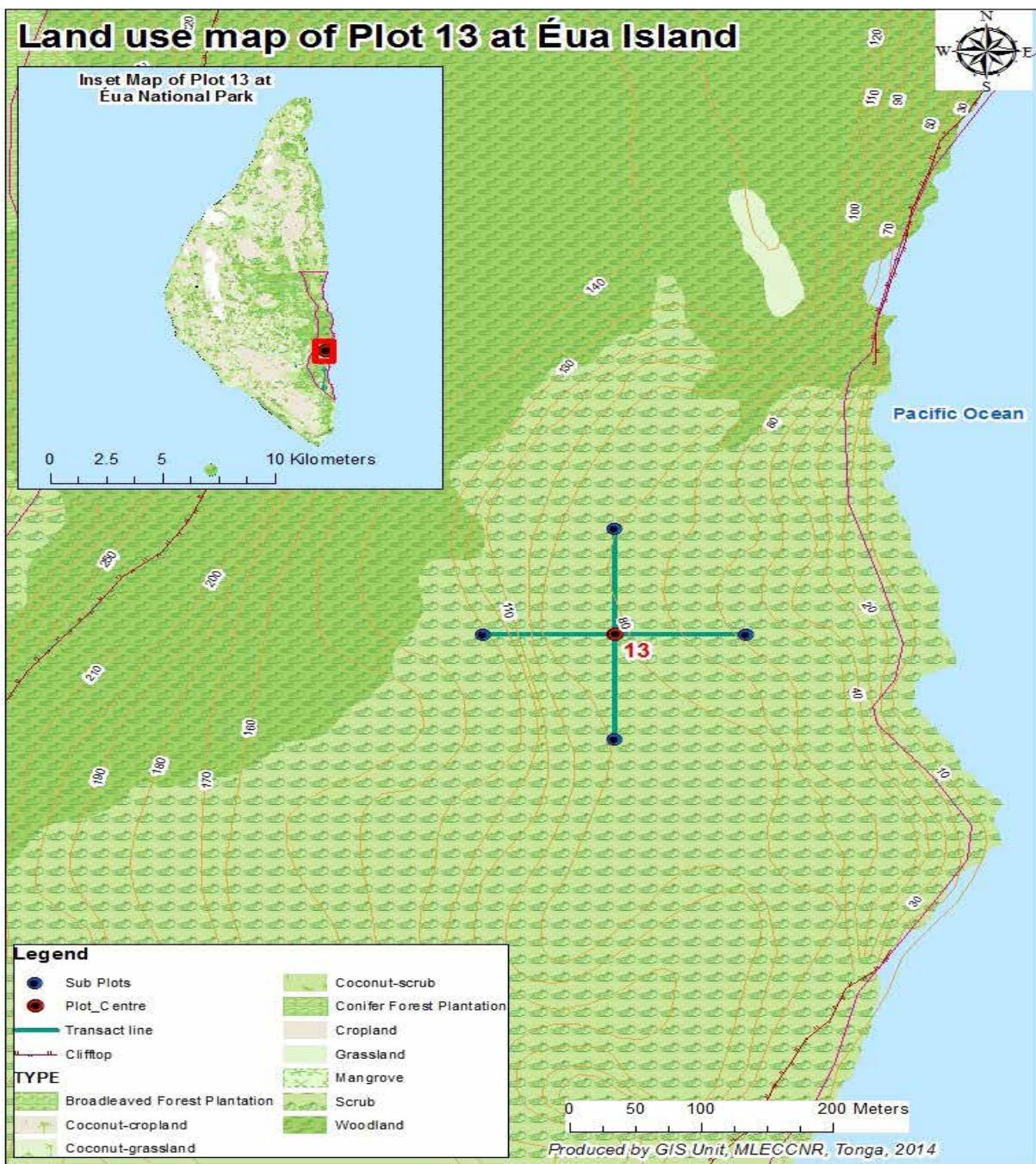


Land use map of Plot 10 at Éua Island

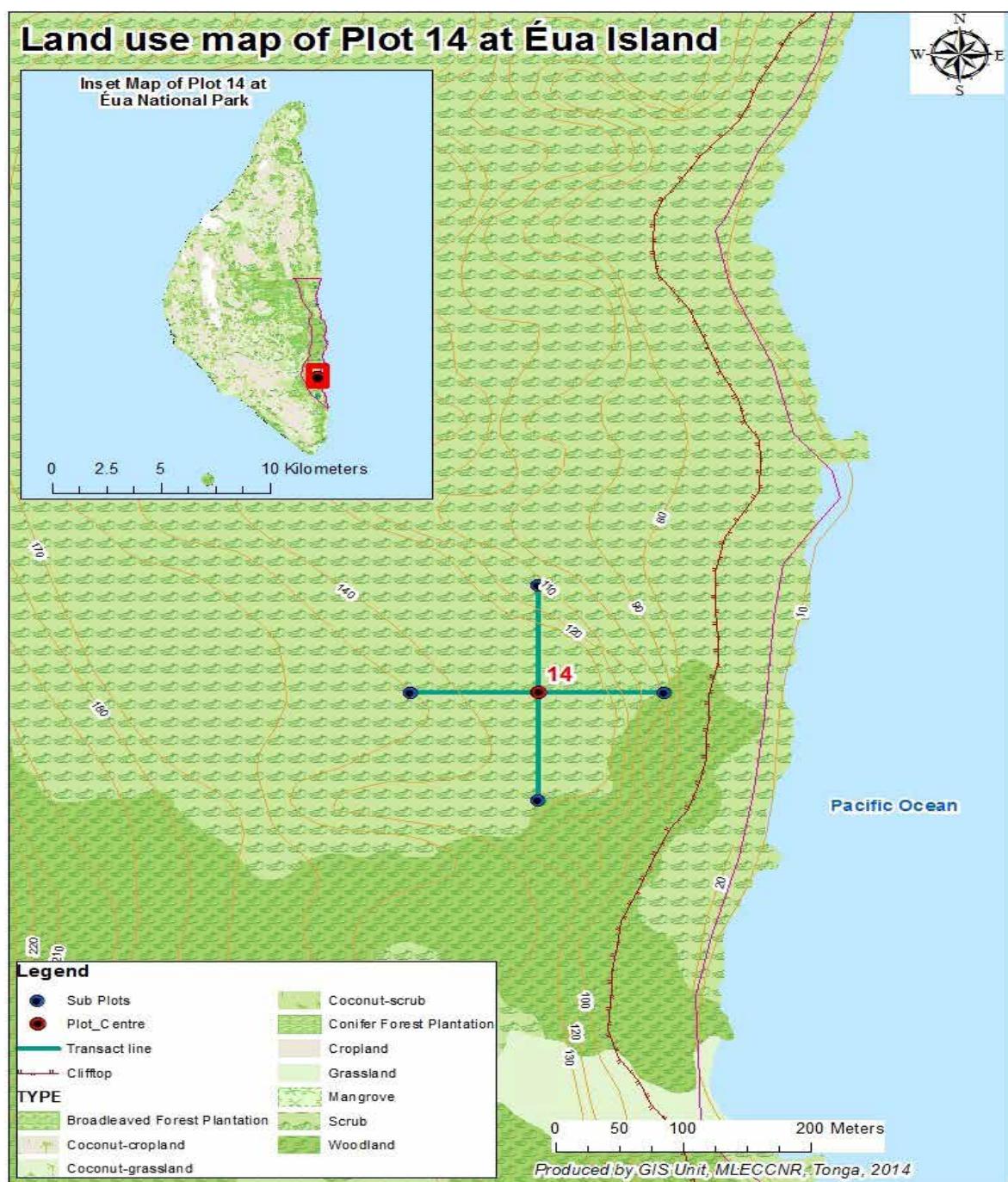


Land use map of Plot 12 at Éua Island





Land use map of Plot 14 at Éua Island



Appendix 7: Survey data sheet

MAR-Fieldform

