Flora and Vegetation Survey of the Nakorotubu Range, Ra and Tailevu Provinces, Viti Levu, Fiji.

Authors: Tuiwawa, Marika, and Whistler, Arthur

Source: A Rapid Biodiversity Assessment of the Nakorotubu Range, Ra and Tailevu Provinces, Fiji: 1

Published By: Conservation International

URL: https://doi.org/10.1896/054.059.0102

Chapter 1

Flora and Vegetation Survey of the Nakorotubu Range, Ra and Tailevu Provinces, Viti Levu, Fiji.

Marika Tuiwawa and Arthur Whistler

Team members: *Sukulu Cavu and Ilimo Tulevu (Fiji Department of Forests), Isaac Rounds (Conservation International (Fiji), Seremaia Namanuloa (Matuku Village), Senilolia Heilala Tuiwawa and Manoa Maiwaqa (SPRH).*

SUMMARY

A series of eight 1000m^2 plots were used in selected forest types to assess the vegetation and flora of the Nakorotubu Range. Two principle vegetation types based on Mueller-Dombois & Fosberg (1998) description were observed in the study area. They are the Lowland Vegetation Type and the Upland Vegetation Type. Within these vegetation types four main plant communities or forest types were distinguished—(1) Secondary Forest, (2) Primary Forest, (3) Freshwater Swampland and (4) Karst or Limestone Forest. Only the secondary and primary forest types were quantitatively assessed and the other two briefly described qualitatively.

The flora of the Nakorotubu Range is described from a rapid biodiversity assessment survey. A total of 425 plant taxa (including 32 undetermined species) were recorded representing 118 families. This comprises 75 dicot families, 19 monocots, 2 gymnosperms and 21 fern and fern allies families. Two of the largest families include Orchidaceae with 20 genera and 26 species; followed by Poaceae with 19 genera and 20 species.

Of the 393 species identified 78% (307 species) are native with 35% (132) endemic species. The 307 native species comprise about 17% of the entire native flora for Fiji. The Angiosperms and Gymnosperms recorded during the survey added up to 337 species. Of these, 75% (251) are native species and of this native species, 53% (132 species) are endemic. A total of 64 exotic plant species were recorded during the survey of which six species are internationally recognized invasive species.

Two species of conservation interest include the Critically Endangered gymnosperm *Acmopyle sahniana* and the endemic palm *Calamus vitiensis* considered Least Concern in the IUCN Red list. The presence of *A. sahniana* in the study area has resulted in its range extensión to a third province of Ra in Fiji. The palm is known to occur in only two locations (small populations) on Viti levu- Wailekutu (within the vicinity of Nasaua village) and interior of Namosi, but common on Taveuni.

The findings are discussed in a conservation framework that highlights the taxonomic and/or ecosystem value of notable plant species and vegetation types.

INTRODUCTION

This botanical survey is part of a Rapid Assessment Program (RAP) conducted in the Nakorotubu Range, on the northeast portion of Viti Levu, the largest island of the Fiji group. The elevation of the study area ranges from about 100 m to 560 m on the highest peaks. Much of the mountainous interior area is covered with primary forest, but the vegetation of many other areas comprises secondary forest, agroforest, and village land. The primary or native forest is not homogeneous, because elevation, topography, and substrate all contribute to differences in species composition, density and distribution. The two principle vegetation types (Mueller-Dombois and Fosberg 1998) observed for the area includes the Low Land Rainforest and the Upland Vegetation. Hardly any botanical collecting has been done in this area, hence a reason for its selection as a RAP site.

A research team conducted a biological survey of the area from 30 November to 12 December 2009 with the results of the botanical survey included here. The botanical team was

headed by Marika Tuiwawa, Curator of the South Pacific Regional Herbarium (SPRH), University of the South Pacific (USP) assisted by Dr. Art Whistler – botanist from the University of Hawai'i, Botany Department; Senilolia Tuiwawa and Manoa Maiwaqa also from IAS/USP and Isaac Rounds – Conservation International (Fiji). Other scientists not specifically part of the botanical team also helped with some aspects of the field work, i.e., bringing in interesting specimens and assisting with the quantitative work in the plots.

The expedition

The expedition commenced when the team, about 30 strong, left Suva for Matuku (a settlement that is part of Soa Village), where they set up headquarters in the village meeting house. The team hiked north from the village to a site where Base camp 1 (S 17.59; E 178.36) was established on a flood plain next to a tributary of the Uloa Stream at about 162 m elevation. Reconnaissance trips were made from Base camp 1 into the surrounding forests during the rest of the arrival day and over the next two days, during which time plant specimens were collected, vegetation was sampled, and notes were taken. After three nights at this site, the research team hiked back to Matuku, where they spent the night. The next morning they hiked into the mountains east of Matuku and established Base camp 2 at S 17°35'53.4" ; E 178°23'02.4" next to Nalalau Stream at approximately 550 m elevation. Collecting trips were made from Base camp 2 into the surrounding forest, and the vegetation and flora surveys were conducted as they were at the first base camp.

After three nights at the second site, the research team members hiked back to Matuku, where they packed up and moved south to Nasau Village during the same afternoon. Because of the arduous work and hiking conditions over the previous three days, the team spent the next day doing short biological excursions around Nasau Village. The following day, the team hiked east into the mountains and set up Base camp 3 at S 17.72, E 178.42 for the following three nights near the Walotua River at approximately 50 m elevation. After doing their biological surveys, the team hiked back to Nasau Village, packed up, and returned to Suva on the 12th of December, ending the two-week excursion.

METHODOLOGY

The botanical survey comprised two main parts, flora and vegetation. All plants identified during the hikes and vegetation sampling were compiled into an annotated checklist (see Appendix 1). Plants that were fertile (bearing fruits and/or flowers) and those that were not able to be identified in the field were collected. The vouchers were labeled and trimmed or arranged to the requisite size and placed in a sheet of newspaper. Each was then given a collection number. The newspaper-bound specimens were then transported back to the village headquarters in Matuku for drying. At the end of the field survey the specimens were further processed at the South Pacific Regional Herbarium at the University of the South Pacific.

The vegetation was studied by taking samples of trees found in eight 1000 m^2 plots. Each plot measured 100 x 10m. Four plots were sampled in the Matuku area (Appendix 2: Tables 2A.1-A.4); two in the Nalidi area east of Matuku (Appendix 2: Tables 2A.5 and A.6); and two in the Nasau area (Appendix 2: Tables 2A.7 and A.8). These plots were placed in representative vegetation generally lacking recent disturbance. To facilitate the sampling, ten 10 x 10 m subplots were marked off within the plot with sticks placed in their corners as boundary markers. These subplots were usually in a straight line, but because it was sometimes difficult to find a suitable 100 m long patch of homogeneous vegetation, the subplots were sometimes arranged in a different pattern (depending upon the topography).

Once the plot boundaries were laid out, the field crew went through and measured every tree with a dbh (diameter at breast height) greater then or equal to 5 cm. This was done by means of a "dbh tape" wrapped around the trunk at breast height (1.3 m). These measurements and the identities of the sampled trees were recorded in a field book. Trees that could not be recognized immediately had their flowers, fruits, and/or leaves collected by means of a long pole or by someone climbing the trunk (when feasible). Non-tree species [epiphytes (orchids and ferns), lianas, vines, shrubs and herbs] were also recorded in each of the plots.

The tree data for the eight plots sampled is shown in Appendix 2. The determination of which tree or trees were "dominant" was based on biomass, using the parameter of stem cross-sectional area (basal area). This produced the column headed by "Basal Area." The species were arranged in order based on this parameter, from highest total basal area to the lowest. The column after the species name, headed by "No. Trees" (number of trees) is the total number of individuals of each species found in the plot. This is an indicator of frequency, but the trees may be small and have a low overall dominance because of a relatively small dbh. The third column, headed by "No. Trees >15 cm," is an indicator of typical tree size. If all of the trees of a species are under 15 cm dbh, it is likely that the species is small and not a canopy species (or all of the trees are young, an indicator of recent disturbance). The last column, headed by "Relative Dominance," is an important parameter for determining "dominance," i.e., which species has the greatest biomass in the sampled area. It is obtained by dividing the basal area of each species by the total basal area of all trees in the plot. The total basal area of all trees in the plot is found in the lower right-hand corner of the table. High numbers here (e.g., over 60,000 cm^2) usually indicate a lot of relatively large trees present.

RESULTS

Vegetation

The vegetation of the study area can be divided into several entities based upon elevation, topography, species composition and distribution, and density the life form of

the species that dominate (e.g., trees, grasses, etc.).

Two principle vegetation types based on Mueller-Dombois & Fosberg's (1998) description were observed in the study area. They are the Lowland Vegetation Type and the Upland Vegetation Type. Within this vegetation types four main plant communities or forest types were distinguished - (1) Secondary Forest, (2) Primary Forest, (3) Freshwater Swampland and (4) Karst or Limestone Forest. Only the secondary and primary forest types were quantitatively assessed and the other two briefly described qualitatively.

(1) Secondary Forest – Lowland vegetation, Base camp 1, north of Matuku settlement.

The first four plots sampled (see Appendix 2, Tables 2A.1-A.4 for details), around Base camp 1 had a forest type that was classified as Secondary Forest. Table 1.1 shows a summary compilation of the data from the four plots. The plots were placed in areas with elevations ranging from 120-320m.

The most common species in these plots was *Gironniera celtidifolia* (sisisi). In the four plots, a total of 140 individuals of this species were measured, which is roughly equal to the total for the next four most common species combined. It is a subcanopy or medium-sized tree, with only about a quarter of the measured individuals being larger than 15 cm dbh. Because of its relatively small size, it ranked only third in relative dominance. Other medium-sized Secondary Forest trees in Table 1.1 are *Dillenia biflora* (kuluva), *Pagiantha thurstonii* (tadano), *Litsea magnifolia* (lidi), and *Cupaniopsis concolor* (no common Fijian name). These species totaled 113 individuals, only 51 of which were 15 cm dbh or greater in diameter.

The overall dominant tree in the four plots was *Myristica castaneifolia* (kaudamu), which in primary forests is a canopy tree species. Its dominance often indicates that the forest has been logged for the large canopy species, allowing kaudamu to dominate the depleted canopy. The fact that few valuable timber species, especially conifers, such as *Agathis macrophyllum* (dakua) were present, suggest occurrence of logging at sometime in the past or perhaps extensive agriculture.

Table 1.1: Matuku Combined Secondary Forest Tree Composition (4 Plots).

Species	No. of Trees	No. > 15 cm	Basal Area	Rel. Dom.	Frequency
Myristica castaneifolia	40	18	28978	13%	4/4
Bischofia javanica	16	16	21980	10%	3/4
Gironniera celtidifolia	140	34	17989	8%	4/4
Trichospermum calyculatum	9	8	17447	8%	2/4
Burckella sp.	7	4	14314	7%	2/4
Endospermum macrophyllum	4	4	11313	5%	3/4
Dillenia biflora	37	18	10374	5%	4/4
Pagiatha thurstonii	37	18	10274	5%	4/4
Parinari insularum	15	9	9341	5%	2/4
Viticipremna vitilevuensis	1	1	8258	4%	1/4
Litsea magnifolia	23	7	7721	4%	4/4
Cupaniopsis concolor	16	8	5519	2%	3/4
Dysoxylum sp.	18	9	4156	2%	4/4
Haplolobus floribundus	10	7	4083	2%	4/4
Terminalia cf. capitanea	5	3	3114	2%	4/4
Syzygium sp.	12	2	3080	1%	2/4
Elaeocarpus sp.	5	2	2921	1%	4/4

The second most dominant tree in the four combined plots was *Bischofia javanica* (koka), which is a canopy tree. All sixteen measured individuals were over 15 cm dbh.

The average number of tree species above 5 cm dbh was 35 per 1000 m2 plot (ranging from 29 to 42) in these areas of Secondary Forest. This is a measure of tree biodiversity of a forest. The average number of individuals per 1000 m^2 plot was 155 (ranging from 122 to 190). This is a measure of the density of trees in the forest. In both of these categories, the Secondary Forest ranks below the primary forests discussed in the next two sections.

The presence in relatively high numbers of the tree species *Bischofia javanica, Trichospermum calyculatum, Dillenia biflora* and *Gironniera celtidifolia* but to a lesser extent *Vietchia joanis* is indicative of a secondary forest. This is especially true for the presence of *B. javanica, G. celtidifolia* and *V. joannis* as they are also associated with old village and garden sites.

Endospermum macrophyllum (kauvula) and *Trichospermum calyculatum* (mako) were represented in the four plots by 13 individuals, all but one of which was over 15 cm dbh. Given enough time, the dominant canopy tree species for the area sampled by the four plots would be expected to be primary forest dominated by trees such as *Planchonella* sp. (sarosaro), *Burckella* sp.(bau), *Syzygium* spp.(yasiyasi), and *Terminalia capitanea* (tivi).

Overall, the immediate area surrounding Base camp 1 is secondary forest infested with feral cattles and pigs which are abundant and the impacts of these animals on the environment is very evident i.e hoofprints, uprooted plants and dug up soil.

(2) Primary Forest – Upland Vegetation, Base camp 2, north of Nalidi village.

Upland Forest is a variation of rainforest that occurs on rugged topography between lowland and cloud forest, and in the study area was found around 500 m elevation. The two plots sampled around Base camp 2 north of Nalidi are best classified as Upland Rainforest vegetation because of the overall stature of the forest (generally stunted), high density of species and the mid-elevation mountainous topography. Table 1.2 shows a compilation of the data from the two plots (see Appendix 2, Tables 2A.5 and 2A.6 for details). The most common species in these plots were *Garcinia myrtifolia* (laubu, 90 individuals), *Canarium harveyi* (kaunicina, 57), *Calophyllum cerasiferum* (damanu dilo, 37), *Myristica castaneifolia* (kaudamu, 37), *Alstonia pacifica* (sorua, 36), and the tree fern *Cyathea hornei* (balabala, 32). *Gironniera celtidifolia* (sisisi), which is so characteristic of Secondary Forest, was virtually absent.

Table 1.2: Nalidi Combined Primary Forest Tree Composition (2Plots).

Species	No. of Trees	No. > 15 cm	Basal Area	Rel. Dom.	Frequency
Garcinia myrtifolia	90	14	9463	12%	2/2
Agathis macrophylla	4	4	5900	8%	1/2
Canarium harveyi	57	9	5652	7%	2/2
Myristica castaneifolia	37	9	5611	7%	2/2
Hernandia olivacea	25	7	4541	6%	2/2
Dacrydium nidulum	1	1	4416	6%	1/2
Syzygium sp.	23	8	3134	4%	2/2
Calophyllum cerasiferum	37	3	2312	3%	2/2
Retrophyllum vitiensis	8	3	2220	3%	2/2
Calophyllum neo-ebudicum	20	6	2163	3%	2/2
Parinari insularum	9	5	2140	3%	2/2
Garcinia pseudoguttifera	13	4	1760	2%	2/2
Alstonia pacifica	36	1	1715	2%	2/2
Myristica chartacea	15	3	1617	2%	2/2
Unknown	7	2	1574	2%	2/2
Hedycarya dorstenioides	14	3	1554	2%	1/2
Cyathea hornei	32	1	1368	2%	2/2

This forest is dominated (in basal area) by a combination of species. The first of these in the two sampled plots was *G. myrtifolia*, which had only 12% relative dominance. This tree is more of an understory species (only 14 of the 90 individuals in the two plots were over 15 cm in dbh) in lowland rainforest. The high number of individuals (averaging 45 per 1000 m^2 plot) of this medium-sized tree species, which gave it its prominence, is probably related to the dissected topography (ridges and steep slopes) of the two plots. The second dominant in Table 1.2, with 8% average dominance, was *Agathis macrophylla*. Two other conifer trees were shown in Table 1.2, *Retrophyllum vitiensis* (dakua salusalu, 3% in 8 individuals) and *Dacrydium nidulum* (yaka, 6% in a single tree). Two additional, smaller gymnosperm trees were also recorded in the plots, but both had a negligible relative dominance—*Podocarpus neriiformis* (kuasi, 22 trees) and *Gnetum gnemon* (sukau, 14 trees). Other canopy species include *Canarium harveyi* (kaunicina, 7% relative dominance), *Hernandia olivacea* (no Fijian name, 6%), *Syzygium* sp. (4%), *C. cerasiferum* (3%), and *C. neo-ebudicum* (damanu, 3%). As in the Secondary Forest, *M. castaneifolia* is both common and a co-dominant as a subcanopy tree.

The average number of tree species above 5 cm dbh was 55 per 1000 m^2 plot (ranging from 53 to 59). This is a measure of tree biodiversity in the primary ridge forests around Nalidi forests, and is relatively high (Plate 1) compared to the average of 35 species for the first four plots in Secondary Forest near Matuku. The average number of individuals per 1000 m^2 plot was 352 (ranging from 290 to 414). This is a measure of the tree density (number of individuals per area) in the forest, and compares to an average of 155 in the Secondary Forest plots - less than half. This indicates the greater density of trees in this type of ridge forest compared to secondary and lowland rainforest, probably caused by the steep dissected topography and higher elevation.

(3) Primary Forest - Lowland Vegetation, Base camp 3, northwest of Nasau village.

Lowland Rainforest is a variation of rainforest that occurs on flatland and gentle slopes in Fiji, ranging from near sea level up to about 600 m elevation. The two plots sampled northwest of Nasau are best classified as Lowland Rainforest based upon the dominant species and population structure. Table 1.3 shows a compilation of the data from the two plots. The most common species in these plots were *Canarium harveyi* (kaunicina, 62 individuals), *Gnetum gnemon* (sukau, 59), *Calophyllum vitiense* (damanu, 38), *Myristica castaneifolia* (kaudamu, 37) making up more than 50% of trees assessed. As in the Upland Rainforest, *Gironniera celtidifolia* (sisisi), which is so characteristic of Secondary Forest, was virtually absent.

This forest is dominated by a combination of species. The first of these in the two plots sampled was *C. vitiense*, which had 15% relative dominance. Other significant species with at least 4% relative dominance were *Gonostylus punctatus* (mavota, 13%), *M. castaneifolia* (10%), *Parinari insularum* (sea, 8%), *Canarium harveyi* (kaunicina, 7%), and *Endospermum macrophyllum* (kauvula, 7%). These six tree species made up 60% of the relatively dominant trees in the two plots.

The *C. vitiense, G. punctatus, P. insularum, E. macrophyllum, Agathis macrophylla*, and possibly *Syzygium* sp are all typical Fijian Lowland Rainforest canopy trees. Only two gymnosperm species were found in the plots, the 59 small individuals of the understory species *G. gnemon*, and the one large *A. macrophylla*. As in the Upland and Secondary Forests, the canopy tree *M. castaneifolia* was both common and a co-dominant in this forest (third in dominance, fourth in the number of individuals).

Table 1.3: Nasau Lowland Rainforest Tree Composition (2 Plots).

Species	No. of Trees	No. > 15 cm	Basal Area	Rel. Dom.	Frequency
Garcinia myrtifolia	90	14	9463	12%	2/2
Agathis macrophylla	4	4	5900	8%	1/2
Canarium harveyi	57	9	5652	7%	2/2
Myristica castaneifolia	37	9	5611	7%	2/2
Hernandia olivacea	25	7	4541	6%	2/2
Dacrydium nidulum	1	1	4416	6%	1/2
Syzygium sp.	23	8	3134	4%	2/2
Calophyllum cerasiferum	37	3	2312	3%	2/2
Retrophyllum vitiensis	8	3	2220	3%	2/2
Calophyllum neo-ebudicum	20	6	2163	3%	2/2

(Cont'd - Table 1.3)

Species	No. of Trees	No. > 15 cm	Basal Area	Rel. Dom.	Frequency
Parinari insularum	9	5	2140	3%	2/2
Garcinia pseudoguttifera	13	4	1760	2%	2/2
Alstonia pacifica	36	1	1715	2%	2/2
Myristica chartacea	15	3	1617	2%	2/2
Unknown	7	2	1574	2%	2/2
Hedycarya dorstenioides	14	3	1554	2%	1/2
Cyathea hornei	32	1	1368	2%	2/2

The average number of tree species above 5 cm dbh was 52 per 1000 m^2 plot (ranging from 42 to 60). This is a measure of tree diversity in the Lowland Rainforest around Nasau, and is relatively high (Plate 2) compared to the average of 35 for the first four plots in Secondary Forest near Matuku, and a little less than that found in the Upland Rainforest. The average number of individuals per 1000 m^2 plot was 243 (ranging from 160 to 326). This is a measure of the tree density (number of individuals per area) in the forest, and compares to an average of 155 in the Secondary Forest plots (less than half), but considerably less than in the dense Upland Rainforest.

(4) Freshwater Swampland, Upland Rainforest, Base camp 2, north of Nalidi village.

Due to time constraints a brief qualitative assessment was carried out for this uncommon vegetation type. The Freshwater Swampland is part of a system of "landlocked" body of water found amongst the undulating hills (Plate 3) that form the headwaters of the Nalalau River. Water that streams out of this swamps is slow moving. Similar high altitude wetland systems are found in the highlands of Taveuni (Lake Tagimoucia), Viti Levu (Nadrau swamps), and Vanua Levu (Bua and Macuata).

In the study area the swampland is dominated by the endemic pinescrew tree *Pandanus vitiensis*. Other common species observed included the tree *Macaranga* spp.,*Hedycarya* sp., *Dillenia biflora, Gnetum gnemon*, the sedges *Hypolytrum nemorum* and *Mapania parvibracteata*, the liana *Faradaya* sp. and *Freycinetia* spp. and the aboriginal introduced *Bambusa vulgaris*.

Vegetation along the fringes of the swamp is thick and comprise mostly of shrubs and vines. The shrubs include *Dolicholobium* sp., *Fagraea beteroana*, *Neuburgia* sp., *Geniostoma* sp., *Astronidium* spp. and *Syzygium* spp. The vines include *Geitonoplesium cymosum*, *Smillax vitiense*, *Piper* sp., *Lygodium* sp., *Freycinetia* spp. and *Epipremnum pinnata*. The epiphyte flora is diverse with ferns and orchids being the most common.

(5) Karst Forest or Limestone Forest, Base camp 3, outskirts of Nasau village.

Due to fatigue and time constraints a brief qualitative assessment was carried out for this unique forest type. For the Nakorotubu Range this forest type is restricted to the immediate surrounding of Nasau Village. Most of the limestone outcrops encountered had intact forest cover (Plate 4) except for those systems near roads and villages.

Overall the dominant native trees in terms of biomass are *Pometia pinnata*, *Dysoxylum richii*, *Calophyllum vitiensis*, *Myristica chartacea* and *Palaquium vitilevuense*. These tree species on average have dbhs that are ca. 45 cm and form the bulk of the trees in the canopy layer. In sections of the forest that are least disturbed the forest has a closed canopy with an occasional emergent like Endospermum macrophyllum. Native tree species that form the subcanopy layer are *Alangium vitiense*, *Garcinia pseudoguttifera*, *Dendrocnide vitiense*, *Dillenia biflora*, *Gironniera celtidifolia*, *Dolicholobium latifolium* and saplings of most of the canopy trees.

In sections of the forest where it is relatively intact and the canopy is closed, there is very little ground cover except for a thin layer of leaf litter and terrestrial orchids like *Calanthe triplicata*, *Peristylus aliformis*, *Corymborkis veratrifolia*; the ferns *Tectaria latifolia*, *Trichomanes boryanum*, *Selaginella breynioides*. Some of the more common creeping plants and lianas include *Calamus vitiense*, *Entada phaseoloides*, *Connarus pickeringii*, *Derris malaccensis* and *Freycinetia* spp.

Common epiphytes observed included the ferns *Asplenium nidus*, *Epipremnum pinnatum*, *Pyrrosia adnascens*, *Ophioglossum pendulum*, *Rhaphidophora spuria* and *Davallia solida*. Other terrestrial species include *Phymatosorus scolopendria*, *Tectaria* sp. and *Nephrolepis biserrata*.

Flora

The flora of an area comprises all the plants that are found there. Based on the specimens collected (see Appendix 3 for a list of voucher specimens) and visual identification by the field team, 425 vascular plant species were recorded (see Appendix 1) including 32 undetermined species. This can be broken down into 270 dicots, 91 monocots, 7

gymnosperms, and 57 ferns and fern allies. A total of 223 voucher specimens were collected (see Appendix 3) during the field work.

There were 108 families identified during the survey. This comprised of 75 dicot families, 19 monocots, 2 gymnosperms and 21 fern and fern allies families. There were 317 genera recorded comprising 197 dicots, 77 monocots, 7 gymnosperms and 36 fern and fern allies.

The four largest families were Orchidaceae with 20 genera and 26 species; followed by Poaceae with 19 genera and 20 species; Rubiacea with 15 genera and 23 species and Euphorbiacea with 11 genera and 17 species.

For the 393 species identified 78% (307 species) are native with 35% (131) endemic species. The 307 native species comprise about 17% of the entire native flora for Fiji. With more time to collect in this area and more plots, no doubt the number of native plant species recorded in the area would significantly increase.

The Angiosperms and Gymnosperms recorded during the survey added up to 337 species. Of these, 75% (251) are native species and of this native species, 53% (132 species) are endemic. Endemism for Fiji ranges from 35% in lowland rainforest to 60% in the rich upland and cloud forest (Watkin 1995) especially in southeast Viti Levu. This is similar to plant species endemism for low land forest systems in Fiji

The most significant species in a flora are threatened or endangered species. Although there are no officially listed Threatened or Endangered Species by the government of Fiji, the IUCN has a "Red List" of plants of concern in the Pacific. However, the list is quite out of date and full of errors. There are many species that are rare in Fiji (some known from only a single collection) (Tuiwawa 1999) and others are probably extinct (although the IUCN list notes only one species being officially classified as "extinct"). Although some of the voucher specimens collected during this survey could not be identified by the time this report was written, none of the species recorded could be identified as "Threatened" or "Endangered, except the Critically Endangered gymnosperm *Acmopyle sahniana* and the endemic palm *Calamus vitiensis* considered Least Concern in the IUCN Red list. The palm is known to occur in only two locations (small populations) on Viti Levu, Wailekutu (including vicinity of Nasaua village) and interior of Namosi but common on Taveuni.

Invasive plants

A total of 64 exotic plant species were recorded during the survey. The first six are internationally recognized invasive species (see web search on the Global Species Database or http//www.issg.org/database/species/search.asp/st=100ss) and the last thirteen species are known to show invasive characteristics (Table 1.4) and have the tendency to grow or encroach into forest beyond where they were originally introduced. This was not only observed in the surveyed area but elsewhere in Fiji.

Table 1.4: List of recognized invasive species and potential invasives in the areas surveyed. A brief description of where they are found and local abundance/distribution is also provided.

Family	Botanical Name	Local name	locality	Abundance
Melastomataceae	*Clidemia hirta*	Qatima, koster's curse	All forest and vegetation types	Widespread & very common
Asteraceae	*Mikania macrantha*	Mile a minute	All forest and vegetation types	Widespread & common
Poaceae	*Arundo donax*	Gasau ni vavalagi	Along roadside, villages and river flats.	Uncommon
Verbenaceae	*Lantana camara*	Lantana	Roadsides, paddocks and other degraded vegetation types,	Uncommon
Bignoniaceae	*Spathodea campanulata*	African tulip tree	Secondary forest, fallowed land, near gardens & settlements.	Widespread & very common
Asteraceae	*Sphagneticola trilobata*	Wedelia	Near villages, settlements & roadsides.	Locally common
Convolvulaceae	*Merremia peltata*	wa bula, merremia	Widespread forest opening and degraded vegetation.	Widespread and common

(Cont'd - Table 1.4)

Family	Botanical Name	Local name	locality	Abundance
Zingiberácea	*Hedychium coronarium*	cevuga vula	Disturbed stream/ river flats & village outskirts.	Locally common
Passifloraceae	*Passiflora foetida*	loli mei rakalavo	Secondary forest and forest openings.	Locally common
Piperaceae	*Piper aduncum*	Onalulu, yaqoyaqona	River and creek embankment.	Locally common
Zingiberaceae	*Zingiber zerumbet*	Cagolaya	Secondary forest.	Common
Asteraceae	*Ageratum conyzoides*	Botebotekoro	Secodary forest, village outskirts, river flats.	Very common and widespread
Musaceae	*Musa velutina*	Ornamental banana	Outskirts of villages a& roadsides	Common
Fabaceae	*Derris malaccensis*	duva ni niuqini	River and creek embankment.	Locally common
Verbenaceae	*Gmelina aborea*		Pastures and village outskirts.	Uncommon
Solanaceae	*Solanum torvum*	Prickly solanum	Secondary forest, creek, river flats.	Common
Meliaceae	*Swietenia macrophylla*	Mahogany	Near villages & plantations.	Locally common
Zingiberaceae	*Costus speciosus*		Roadsides, along tracks to gardens.	Common
Zingiberaceae	*Alpinia purpurata*		Roadside, outskirts of villages & settlement.	Common

DISCUSSION

The study area north of Matuku settlement is secondary forest characterized by species such as *Bischofia javanica* (koka), *Gironniera celtidifolia* (sisisi), *Dillenia biflora* (kuluva), *Trichospermum calculatum* and *Schizostachyum glaucifolium* (bitu dina). The description of this forest being disturbed is reinforced by the number of anthropogenic trees, such as *Artocarpus altilis* (breadfruit), *Vietchia joannis*, and *Citrus* spp., which are present in more exposed "sunny" places in this study area. No conifers were found in any of these plots but with the presence of *S. glaucifolium* this usually suggests some kind of logging or similar development has probably occurred there in the past. Despite the disturbance, which does not appear to be very recent, only a single tree, *Spathodea campanulata* (African tulip-tree), is an alien species among the 619 trees measured. Alien or exotic herbaceous species like *Clidemia hirta*, *Hedychium* sp., *Zingiber zerumbet* and *Crassocephalum crepidioides* and shrubs like *Solanum torvum*, *Leucaena leucocephala* and *Piper aduncum* are the more common species in the area, especially along stream flats. Overall, the disturbed forest in the area surveyed does not have any significant alien tree invaders whilst elsewhere in Secondary Forest in Fiji, the African tulip-tree is a serious native forest invader.

The Upland Rainforest in the area north of Nalidi village is characterized by high species diversity, high tree density, and relatively low growing (stunted?) trees. The dominant species, *Garcinia myrtifolia* (laubu), is typically a sub canopy species, but the conditions on ridges favor its growth over the canopy species of nearby lowland forest. The top six tree species that make up about 50% relative dominance for the two plots sampled included typical dominant canopy and emergent tree species that would be observed in similar forest types in Fiji. These included *Agathis macrophylla*, *Hernandia* sp., *Canarium* sp. and *Myristica* sp. Ten other tree species had at least 3% relative dominance in the two plots sampled. *Gironniera celtidifolia* (sisisi), which is characteristic of Secondary Forest, was virtually absent (only 6 individuals with negligible relative dominance were measured in this forest). The average size of the trees is relatively small, with only 15% of the individuals measuring over 15 cm dbh. This compares to the Secondary Forest, which had 40%, and Lowland Rainforest, which had 24%. Because of this and the dissected topography, this native forest is not of much commercial interest, but is of great biodiversity inter-

est. Not a single tree measured was an alien species, which shows how good this forest is in terms of its intactness and biodiversity. Overall in the area assessed the only alien plant species observed was a few *Clidemia hirta*, an invasive species naturalized in Fiji's forests. All tree species documented are native and those that would be typically found in a primary forest. The high diversity of gymnosperms (seven species out of the nine species known for Fiji) augurs well for the pristine state of the forest in the area.

The forest sampled north of Nasau village is primary Lowland Rainforest. It has high species diversity like the Upland Rainforest north of Nalidi village. The dominant species in the plots was *Calophyllum vitiense*, with a relative dominance of 15%. Most of the other large trees species are typical Lowland Rainforest canopy species like Gonystylus sp., *Myristica* sp., and *Parinari* sp., with no monodominant species. These four trees make up more than 50% relative dominance of all trees sampled in the two plots. No secondary species were present including *Gironniera celtidifolia* were recorded in the plots. Also, the general lack of alien tree species except for a few naturalized invasive species of *Clidemia hirta* and *Mikania macrantha* found in the plots showed how pristine this forest is.

When compared with other similar forest systems in Fiji (especially Sovi Basin, Nakauvadra) the Nakorotubu forests are relatively pristine, judging by the form of the vegetation (closed canopy forest) as well as the general absence of most alien weeds. Only a few naturalised alien weedy species were found during the survey (restricted to forest gaps and exposed "sunny" areas on flood plains along streams), which included *Crassocephalum crepidioides* (thick head), *Mikania micrantha* (mile-a-minute vine), *Clidemia hirta* (Koster's curse), and *Piper aduncum*.

In summary, the Nakorotubu Range is home to large areas of native forest, both Primary and Secondary Rainforest. It is rich in species, and most of it is virtually free of invasive tree species. Every effort should be made to work with the local villagers to preserve these forests.

CONCLUSIONS AND CONSERVATION RECOMMENDATIONS

Future surveys

The following recommendations are made:

1. More collections are needed. The checklist of vascular species present is only preliminary, since all the fieldwork was done over only thirteen days. The list probably includes only 60 to 75% of the species present. The orchids and ferns are much underrepresented, since many of the species are restricted to the tops of trees, where they were not observed. (Fiji has about 150 native species of orchid and ca. 300 species of ferns). The most difficult groups during the present work included the genera *Psychotria* (76 native species in Fiji), *Syzygium* (28 species), and Gesneriaceae (37 species), and the Lauraceae family (34 species).
2. The forests on limestone areas around Nasau village should also be explored in more detail, since this is an entirely different substrate than most of the other forests in the area. With current developments (road works, agriculture) in progress nearby this should be treated as a priority.
3. A thorough assessment of the relatively intact freshwater swampland that is the source and headwater of most of the major rivers originating from this mountain range should be undertaken as soon as possible. Such a system is rare for Fiji and all the currently known high altitude swamps (two - Nadrau Swamp, Lake Tagimoucia) are very much threatened and already impacted by development.

Conservation recommendations

1. The Nakorotubu mountain range area should be included and nominated as a key or important biodiversity area for Fiji and efforts to list it as a "protected area" for Fiji should be pursued.
2. Awareness regarding the ecological and botanical importance of the area to the landowners should take place as soon as possible for the purpose of protecting the area. Currently logging operations are underway on the northern part of the mountain range.

REFERENCES

Brownlie, G. 1977. The Pteridophyte flora of Fiji. In: Cramer, J. (ed.) Beihefte zur Nova Hedwigia, Vol. 55. A. R. Gantner verlag KG, Germany.

IUCN. 2010a. Pacific Red List for Plants. Available at http://www.redlist.org

IUCN. 2010b. Summary of species on the 2008 IUCN Red List. Available at http://www.redlist.org

Morrison, C. (ed) A Rapid Biodiversity Assessment of the Nakauvadra Range, Ra Province, Fiji. Conservation International. Arlington, VA.

Mueller-Dombois and Fosberg (1998). Vegetation of the Tropical Pacific Islands. Springer-Verlag, New York.

Smith, A. C. 1936. Fijian plant studies. Bishop Mus. Bull. 141: 1-166.

Smith, A.C. 1977. Flora Vitiensis Nova. Pacific Tropical Botanical Gardens. Lawai, Kauai, Hawaii. 1:34-84.

_____.1979. Flora Vitiensis Nova - A new flora of Fiji (Spermatophytes only). Vol. 1. Pacific Tropical Botanical Garden, Lawai, Kauai, Hawaii.

_____. 1981. Flora Vitiensis Nova - A new flora of Fiji (Spermatophytes only). Vol. 2. Pacific Tropical Botanical Garden, Lawai, Kauai, Hawaii.

_____. 1985. Flora Vitiensis Nova - A new flora of Fiji (Spermatophytes only). Vol. 3. Pacific Tropical Botanical Garden, Lawai, Kauai, Hawaii.

_____. 1988. Flora Vitiensis Nova - A new flora of Fiji (Spermatophytes only). Vol. 4. Pacific Tropical Botanical Garden, Lawai, Kauai, Hawaii.

_____. 1991. Flora Vitiensis Nova - A new flora of Fiji

(Spermatophytes only). Vol. 5. Pacific Tropical Botanical Garden, Lawai, Kauai, Hawaii.

Watkins, A. J. 1994. A biogeographic database for seed plants of Fiji: A preliminary communication. S. Pac. J. Nat. Sci. 14: 75-96.