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HERBARIUM BOGORIENSE, BOTANY DIVISION,
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Kongkanda Chayamarit, Queen Sirikit Botanic Garden, P.O. Box 7, Mae Rim, Chiang Mai, Thailand
AN ASSESSMENT OF PRESENT PLANT DIVERSITY ON THE NATEWA PENINSULA, VANUA LEvu, FIJI

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ANDREW POWLING
School of Biological Sciences, University of Portsmouth, King Henry I Street, Portsmouth, PO1 2DY, UK.
Email: andrew.powling@port.ac.uk; apowling01@btinternet.com

ABSTRACT
POWLING, A. 2018. An assessment of present plant diversity on the Natewa Peninsula, Vanua Levu, Fiji. Reinwardtia 17(2): 125–132. — The Natewa Peninsula, part of the Fijian island of Vanua Levu, is naturally afforested but the forests have been extensively logged in the last 50 years. It is now planned to protect some of the forests from further logging by incorporating them into a National Park. A survey of plant species in the regenerating forests and surrounding land on the Peninsula was performed to assess the taxonomic and ecological diversity of the trees and shrubs, including figs and palms, and also the orchids presently to be found on the Peninsula. The degree of invasion by introduced plant species was also assessed. Of 67 tree and shrub species it was found that 17 were endemic to the Fijian islands, 40 others were indigenous and ten were introduced. The normal habitats of these species included dense, open and secondary forest, showing that trees with a range of ecological characteristics were still present. Endemic and indigenous species of both figs and palms were found, and also terrestrial and epiphytic orchids. No severe infestations of introduced species were observed. It is concluded that the forests of the Peninsula are of sufficient conservation value to justify National Park status.

Key words: conservation, trees, Fiji, figs, orchids, palms.

INTRODUCTION
The Fijian archipelago in the tropical south-west Pacific consists of about 320 islands, of which the two largest are Viti Levu and Vanua Levu. The Natewa Peninsula makes up the south-easterly part of Vanua Levu. The Peninsula is 60 km long and is linked at its south-westerly end to the rest of Vanua Levu by an isthmus 2 km wide (Geological Survey of Fiji, 1965). To the north-west the Peninsula is separated from the bulk of Vanua Levu by Natewa Bay. The villages of Natewa, Vusaratu and Dawa lie on the north-west coast of the Peninsula, overlooking Natewa Bay.

The oldest rocks in Fiji are volcanics of late Eocene age (about 40–35 million years ago) and it is thought that plate tectonic activity has resulted in a series of more or less short-lived volcanic islands being formed in the area since then (Neall & Trewick, 2008). It is thought that the Fijian flora was able to establish and survive on these volcanic islands (Heads, 2006). Many plant species which are endemic to the Fijian Archipelago have evolved and persist but estimates of the numbers and proportions of endemic species have varied. For instance, Ash (1992) states that ‘about 25%’ of the native vascular plant species are endemic whilst Smith (vol. 6, 1996) gives figures of 1318 indigenous flowering plant species of which 812 (61.6%) are endemic. These figures differ in part because there are debates about how many species should be recognised and which ones should be defined as indigenous (Heads, 2006).

The landscape of the Natewa Peninsula is rugged, with a maximum altitude of approximately 800 m. The rocks consist of volcanic andesites of
RESULTS AND DISCUSSION

The survey concentrated on forest trees and shrubs, which are reported on first, but other plants were also identified. The fig (*Ficus*), palm and orchid species that were found are dealt with separately, since fig species are very important for the wider ecology of the forest and some endemic palm and orchid species are of great conservation interest. Introduced species are likewise treated separately because of their relevance to the conservation status of the Peninsula.

**Forest trees and shrubs**

Table 1 lists 67 tree and shrub species (excluding *Ficus* species and palms) identified in the survey area, that were found outside cultivation in natural habitats where they appeared not to have been planted. They are arranged in alphabetical order of the 33 families to which they belong. Fifty-seven of the species occur naturally on Fiji, 17 being endemic to the Fijian islands and 40 being indigenous but also occurring elsewhere. Ten species have been introduced to Fiji, all of them existing naturally in the area, outside cultivation.

| Tree and shrub species | Ficus species | Palm species | Orchid species |
|------------------------|--------------|-------------|---------------|
| 37 tree and shrub species | 50 | 17 | 40 |

The Natewa Peninsula was presumably the home of much plant diversity before logging took place, since it has high rainfall and diverse topography. There is no list of plant species which grew in the survey area before the logging, so no assessment of plant diversity loss due to logging can be made; but statements about present diversity are now possible. Table 1 shows 41 native species which grow in areas away from the...
Table 1. Trees and shrubs identified on the Natewa Peninsula, arranged alphabetically by Family.

| Species                              | Family            | Forest type          | Status     |
|--------------------------------------|-------------------|----------------------|------------|
| Dracontomelon vitiense Engl.         | Anacardiaceae     | Coastal              | Indigenous |
| Rhus simarubifolia A.Gray            | Anacardiaceae     | Open                 | Indigenous |
| Cananga odorata (Lam.) Hook. f. & Thoms. | Annonaceae       | Coastal              | Indigenous |
| Alstonia costata (G.Forst.) R.Br.    | Apocynaceae       | Secondary            | Indigenous |
| Alstonia macrophylla Wall. ex G.Don  | Apocynaceae       | (Secondary)          | Introduced |
| Alstonia vitiensis Seem.             | Apocynaceae       | Open, Dense          | Endemic    |
| Cerbera manghas L                    | Apocynaceae       | Open, Dense          | Indigenous |
| Agathis macrophylla (Lindl.) Mast.   | Araucariaceae     | Secondary, Dense     | Indigenous |
| Spathodea campanulata Beav.          | Bignoniaceae      | Secondary, Open, Dense | Introduced |
| Cordia subcordata Lam.               | Boraginaceae      | Coastal              | Indigenous |
| Casuarina equisetifolia J.R. & G.Forst. | Casuarinaceae  | Coastal              | Indigenous |
| Gymnostoma vitiense L.A.S.Johnson    | Casuarinaceae     | Open, Dense          | Indigenous |
| Atuna racemosa Raf.                  | Chrysobalanaceae  | Open, Dense          | Indigenous |
| Parinari insularum A.Gray            | Chrysobalanaceae  | Open, Dense          | Indigenous |
| Terminalia litoralis Seem.           | Combretaceae      | Coastal              | Indigenous |
| Geissois ternata A.Gray              | Cunoniaceae       | Open, Dense          | Indigenous |
| Cyathea lunulata (G.Forst.) Copel.   | Cyatheaceae       | (Open, Dense)        | Indigenous |
| Endospermum robbieanum A.C.Sm.       | Euphorbiaceae     | Open                 | Endemic    |
| Macaranga harveyana (Müll.Arg.) Müll.Arg. | Euphorbiaceae  | Secondary, Open, Dense | Indigenous |
| Macaranga magna Turrill              | Euphorbiaceae     | Open, Dense          | Indigenous |
| Macaranga seemannii (Müll.Arg.) Müll.Arg. | Euphorbiaceae | Open, Dense          | Indigenous |
| Fagraea gracilipes A.Gray            | Gentianaceae      | Open, Dense          | Endemic    |
| Scaevola sericata Vahl               | Goodeniaceae      | Coastal              | Indigenous |
| Calophyllum cerasiferum Vesque       | Guttiferae        | Secondary, Dense     | Endemic    |
| Calophyllum inophyllum L.             | Guttiferae        | Coastal              | Indigenous |
| Calophyllum vitiense Turrill         | Guttiferae        | Open, Dense          | Endemic    |
| Hernandia nymphiifolia (J.Presl) Kubitzki | Hernandiaceae    | Coastal              | Indigenous |
| Gmelina vitiensis (Seem.) A.C.Sm.    | Labiatae          | Dense                | Endemic    |
| Cinnamomum verum J.Presl             | Lauraceae         | (Dense)              | Introduced |
| Barringtonia asiatica (L.) Kurz      | Lecythidaceae     | Coastal              | Indigenous |
| Barringtonia edulis Seem.            | Lecythidaceae     | Open, Dense          | Indigenous |
| Inocarpus fagifer (Parkinson) Fosberg | Leguminosae      | Coastal              | Indigenous |
| Intsia bijuga (Colebr.) Kuntze       | Leguminosae       | Coastal              | Indigenous |
| Maniltoa grandiflora (A.Gray) Scheffer | Leguminosae      | Open, Dense          | Indigenous |
| Species                                | Family              | Forest type          | Status      |
|----------------------------------------|---------------------|----------------------|-------------|
| Millettia pinnata (L.) Panigrahi       | Leguminosae         | Coastal              | Indigenous  |
| Serianthes melanesica Fosberg          | Leguminosae         | Dense                | Indigenous  |
| Grewia crenata (J.R. & G.Forst.) Schinz & Guillaumin | Malvaceae          | Secondary, Open, Dense | Indigenous  |
| Hibiscus tiliaeus L.                   | Malvaceae           | Coastal              | Indigenous  |
| Kleinovia hospita L.                   | Malvaceae           | Coastal              | Indigenous  |
| Thespesia populnea (L.) Solander ex Correa | Malvaceae        | Coastal              | Indigenous  |
| Dysoxylum lenticellare Gillespie       | Meliaceae           | Secondary, Open, Dense | Endemic    |
| Swietenia macrophylla King             | Meliaceae           | (Secondary, Open)    | Introduced  |
| Swietenia mahagani (L.) Jacq.          | Meliaceae           | (Secondary, Open)    | Introduced  |
| Myristica grandifolia A.DC.            | Myristicaceae       | Secondary, Dense     | Endemic     |
| Decaspermum vitiense (A.Gray) Niedenzu | Myrtaceae           | Open                 | Endemic     |
| Metrosiders collina A.C.Sm. var. collina | Myrtaceae         | Dense                | Indigenous  |
| Syzygium malaccense (L.) Merr. & Perry | Myrtaceae           | Open, Dense          | Introduced  |
| Syzygium neurocalyx (A.Gray) Christophersen | Myrtaceae       | Dense                | Indigenous  |
| Syzygium wolffii (Gillespie) Merr. & Perry | Myrtaceae         | Secondary, Open, Dense | Endemic    |
| Bischofia javanica Blume               | Phyllanthaceae      | Open, Dense          | Indigenous  |
| Glochidion cf. amentuligerum (Müll. Arg.) Croizat | Phyllanthaceae  | Secondary, Open, Dense | Endemic    |
| Glochidion seemannii Müll. Arg.        | Phyllanthaceae      | Secondary, Open, Dense | Endemic    |
| Pinus caribaea Morelet                 | Pinaceae            | (Secondary)          | Introduced  |
| Piper aduncum L.                       | Piperaceae          | Secondary            | Introduced  |
| Dacrydium nidulum de Laubenfels       | Podocarpaceae       | Open, Dense          | Indigenous  |
| Podocarpus neriifolius D.Don           | Podocarpaceae       | Open, Dense          | Indigenous  |
| Retrophyllum vitiense (Seem.) C.N.Page | Podocarpaceae       | Dense                | Indigenous  |
| Columbrina asiatica (L.) Brongn.       | Rhamnaceae          | Coastal              | Indigenous  |
| Guettarda speciosa L.                  | Rubiaceae           | Coastal              | Indigenous  |
| Morinda citrifolia L.                  | Rubiaceae           | Coastal              | Introduced  |
| Mussaenda raiateensis J.W.Moore        | Rubiaceae           | Secondary, Open, Dense | Indigenous  |
| Neonauclea forsteri (Seem. ex Haviil.) Merr. | Rubiaceae         | Open, Dense          | Indigenous  |
| Pometia pinnata J.R. & G.Forst.        | Sapindaceae         | Open                 | Indigenous  |
| Burckella fijiensis (Hems.) A.C.Sm. & S.Darwin | Sapotaceae       | Open, Dense          | Endemic     |
| Palaquium hornei (Hartog ex Baker) Dubard | Sapotaceae         | Dense                | Endemic     |
| Palaquium porphyreum A.C.Sm. & S.Darwin | Sapotaceae         | Dense                | Endemic     |
| Dendrocnide harveyi (Seem.) Chew       | Urticaceae          | Dense                | Indigenous  |

Note: Information on Family, Forest type and Status taken from Smith (1979−1996), Keppel & Ghazanfar (2011) and Mabberley (2008). Forest types in parentheses are the result of observations made during the present study.
coast, of which 17 (41.5%) are endemic to Fiji. Of the 100 rainforest tree species described by Keppel & Ghazanfar (2011), 38 were found in the survey (a total that includes two Ficus species listed in Table 2). A further 24 indigenous and endemic species not fully described by Keppel & Ghazanfar (2011) were also found. These figures show that the area proposed for the National Park still hosts a considerable diversity of woody plants, including many endemic species that should be conserved.

Table 1 includes 18 species, listed with the forest type ‘Coastal’, which grew in forest immediately behind the beach at Tuicau Point, within the proposed National Park. Most of these species belong to the coastal strand-line vegetation, specifically the Barringtonia formation (Whitten et al., 2002). This vegetation consists of species which are common on coastlines throughout the Indo-Pacific region, due to their ability to disperse from island to island by fruits and seeds that can float and survive in seawater. As a result, none of these species is endemic to Fiji.

**Fig (Ficus) species**

In total eight species of Ficus (figs), family Moraceae, were found in forests, roadsides and riversides (Table 2). Two species are introduced (F. benjamina and F. elastica), whilst the other six are native (Smith, 1979–1996). It is quite possible that other Ficus species exist on the Peninsula but were not found during the survey. The Table also shows the subgenera and sections to which the species belong (van Noort & Rasplus, 2018).

Ficus proved to be the most species-rich genus of native plants found on the Natewa Peninsula. Harrison (2005) has previously observed that Ficus is usually among the most species-rich genera in tropical lowland forests. He suggested it is because fig species have been able to diversify into a wide range of ecological niches. They have effective long-distance seed dispersal due to birds and bats eating the ‘fruits’ (syconia), then excreting the intact seeds. Fig plants also have a very specific pollination system involving species of fig wasps which are specific to particular fig species and can transfer pollen long distances from fig to fig (Cook & Rasplus, 2003). The result is that fig species have been able to colonise new habitats, then evolve and form new species adapted to small and rare niches, but are still able to cross-pollinate despite individuals being few and far between (Harrison, 2005).

Another consequence of the Ficus pollination system involving fig wasps is that within a forest the individual fig plants making up a population must produce ripe syconia asynchronously, so that at all times there are figs ready to receive fig wasps. This allows the fig wasps to complete their life cycle and maintain their local population. As a result, ripe figs are always present in the forest and supply food for animal species. Indeed, Ficus species have been described as ‘keystone’ species in tropical forests (Kinniard et al., 1999), since they provide a reliable, year-round, food supply to many forest animals. Birds and fruit bats are among the species particularly reliant on them (Ryan, 2000). A requirement for the maintenance of fig species in a forest is that the conserved area should be large enough to hold viable populations of the species and their pollinating fig wasps. This should be considered when setting the boundaries of a future National Park.

Ficus species are used as ‘framework’ species in efforts to regenerate tropical rainforests, since some of them can be planted in open situations and will then attract foraging birds and fruit bats to the area (Elliott et al., 2013). The incoming frugivores will bring seeds of other tree species in...
their guts and deposit them at the site of the regenerating forest. The presence of naturally occurring Ficus species in the Natewa Peninsula must aid the regeneration of the forest after logging.

An interesting aspect of Table 2 is that it shows the presence of three Ficus species in the subgenus Sycidium, section Sycidium: F. fulvo-pilosa, F. greenwoodii and F. masonii. Four other Ficus species in the same subgenus and section are known in Fiji: F. bambusifolia Seem., F. barclayana (Miq.) Summerhayes, F. scabra G.Forst. and F. storckii Seem. (Smith, 1979–1996). All except two of these seven species are endemic to Fiji; the two exceptions being F. scabra and F. storckii which also occur on other islands in the south west Pacific. Therefore, it appears that there has been an adaptive radiation on Fiji of Ficus species in subgenus Sycidium, section Sycidium. Such a radiation would imply a corresponding radiation of pollinating fig wasp species (Cook & Rasplus, 2003).

#### Palms (Palmae)

Four endemic species of palms were found during the survey (Table 3). Of these, Balaka seemannii is only known from Vanua Levu and the neighbouring island of Taveuni but is widespread on these islands (Hodel, 2010). The other species of Balaka, B. macrocarpa, is only known from three sites on Vanua Levu, which include the Natewa Peninsula (Hodel, 2010). It is classified as Endangered by the IUCN (2017). The species was found to be common in secondary forests in the survey area, with many individuals bearing developing fruit, but the general rarity of the species is one of the prime reasons for conserving vegetation on the Natewa Peninsula. A further species, Veitchia filifera, was found in, and on the edges of, forest and is one of the commonest forest tree species. It is endemic to Vanua Levu and Taveuni (Watling, 2005). Its congeneric relative, V. joannis, was found in forest near the coast but not in the main survey area.

Other palm species were found in cultivation or were escaping from cultivation (Table 3). Notable in this regard was Elaeis guineensis, the oil palm. Some large specimens were found on open ground near a road; they were the remnants of a failed trial to see if the species could be grown commercially (T. Raicoi, pers. comm.). Interestingly, young individuals were found in the nearby secondary forest, so maybe the species will become naturalised in the area.

#### Orchids (Orchidaceae)

A list of orchid species found is presented in Table 4. These species were identified from photographs by Andre Schuiteman of the Royal Botanic Gardens, Kew. By far the most common species was Spathoglottis pacifica, a terrestrial orchid able to grow in high light intensities and in apparently poor and nutrient deficient soils. It was found in forest clearings but more often at roadsides and other open places with disturbed and bare ground. A terrestrial orchid which was only found in forests in low light intensities was Calanthe hololeuca, which flowered in the month of June. A further terrestrial orchid of the forest was Peristylus maculifer. Five species of epiphytic orchid were found. One species, Liparis elegans, grew in closed and dark forest; the remaining four species were capable of growth on trees in more open situations.

The existence of terrestrial and epiphytic orchids in the forest is encouraging. It suggests that destruction of the forest by loggers was not
complete since the various species of orchid have either survived the logging or have found the regenerating forest suitable for their re-establishment.

**Introduced species**

The list of trees and shrubs (Table 1) includes ten introduced species. Of these, only two, *Spathodea campanulata* and *Syzygium malaccense*, appear to be extensively naturalised in the forest. Fortunately, the former species does not occur as frequently on the Natewa Peninsula as it does in northern Vanua Levu. The other eight species persist mostly at roadsides and on forest edges. *Swietenia macrophylla* has been established in plantations in some places and it remains to be seen how far it can spread naturally. Unfortunately, the tannin-rich leaves and the ground water that runs from *S. macrophylla* plantations suppress the growth of other trees, so these plantations hinder the natural regeneration of surrounding forests (T. Raicoi, pers. comm; Cernansky, 2018).

Disturbed forest and forest edges are often extensively overgrown by the indigenous scrambler *Merremia peltata* (L.) Merr. (Convolvulaceae), which must retard successional processes in many places. A species that can dominate in open situations in the tropics is the scrambler *Mikania micrantha* Kunth (Compositae); this has been introduced to Fiji and is often a problem due to its rampant growth, but on the Natewa Peninsula it appears to be only a minor part of the vegetation in disturbed places. Another introduced species which is a problem elsewhere due to rapid growth and bird dispersal is *Lantana camara* L. (Verbenaceae). This is present on the Natewa Peninsula but does not appear to be common, growing on waste ground near human habitation.

Two non-native species found near forest edges and showing some penetration into disturbed forest are *Piper aduncum* L. (Piperaceae) and *Clidemia hirta* (L.) D.Don (Melastomataceae). Indigenous species usually dominate in forest clearings, with the fern *Dicranopteris linearis* (Burm. f.) Underw. (Gleicheniaceae) and the club-moss *Lycopodium cernuum* L. (Lycopodiaceae) often being prominent ground-layer plants.

Three grass species (Graminae) are very common beside roads and tracks. Two of these are native: *Imperata conferta* (J.Presl) Ohwi and *Miscanthus floridulus* (Labill.) W arb., but the other is the introduced *Arundo donax* L. The *Arundo* has been widely planted to stabilise road verges and now is common and spreading along roadsides.

**CONCLUSIONS**

The forested area studied has been severely disturbed by logging in the recent past but is now regenerating. Table 1 shows that species of secondary forests occur in the area but that many species of mature forest, both open and dense, are present as well. The species show taxonomic diversity as well as habitat diversity, and many endemic species, which have high conservation value, grow in the regenerating forest. At least six native *Ficus* species are present and the figs they produce attract birds and fruit bats which bring with them the seeds of other forest trees. The forest still contains rare endemic palm species, together with terrestrial and epiphytic orchids, further adding to its conservation value. These observations suggest that the forest is, at present, worth conserving and should increase in conservation value if it is protected from further logging by incorporation into a National Park.
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