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Species diversity, composition and the regeneration potential of native plants at the Wainiveiota Mahogany Plantation, Viti Levu, Fiji Islands

Senilolia H. Tuiwawa[1,2] and Gunnar Keppel[1,3]

[1]*School of Biological and Chemical Sciences, Faculty of Science, Technology and Environment, The University of the South Pacific, Private Mail Bag, Suva, Fiji.*
[2]*Institute of Applied Science, Faculty of Science, Technology and Environment, The University of the South Pacific, Private Mail Bag, Suva, Fiji.*
[3]*School of Natural and Built Environments and Barbara Hardy Institute, University of South Australia, Mawson Lakes Campus, GPO Box 2471, Adelaide, South Australia 5001.*

Abstract

*Mahogany (*Swietenia macrophylla *King) plantations cover a considerable area on the south-eastern parts of Viti Levu, Fiji. The understorey of these plantations often comprise a diverse, but undocumented, assemblage of native plant species. This study investigates the diversity, composition and regeneration potential of native plant species in the Wainiveiota mahogany plantation 40-50 years after establishment. Ten 10 m x 10 m plots were alternately placed at 10 m intervals perpendicular to a 200 m line transect. A total of 491 individual plants with dbh ≥ 1 cm, comprising 69 species, 51 genera and 34 families, were sampled. In addition to the exotic mahogany, there were 68 native (39 endemic, 24 indigenous and 5 identified to genus only) species recorded.* Girronniera celtidifolia *Gaud.,* Dillenia biflora *(A.Gray) Martelli ex Dur. & Jacks and* Barringtonia edulis *Seem. had the highest recruitment and* Endospermum macrophyllum *(Muell.Arg.) Pax & Hoffm. was the dominant native species.* Syzygium *Gaertn. (Myrtaceae) was the most diverse genus and Myrtaceae the most diverse family. With 98% of the sapling recruitment consisting of native species, there is potential for re-establishment of a lowland rainforest dominated by native species over time.*

Keywords*:* Swietenia macrophylla*, mahogany plantation, native plants, regeneration*

1. Introduction

Plantations of commercially valuable timber species are a common feature of tropical landscapes (Varmola and Carle, 2002; Lugo, 1999). Such plantations may provide considerable financial revenue to landowners and reduce pressure on remaining native forests (Perfecto *et al*., 1996). Often plantations comprise a single, exotic species, displacing native forest. However, a variety of native species may colonise after plantation establishment, providing considerable biodiversity value (Barlow *et al*., 2007; Lozada *et al*., 2007; Lugo, 1999).

Swietenia macrophylla King (mahogany, large-leaved mahogany or Honduras mahogany) is one of the primary exotic timber species cultivated in Fiji. The species' native distribution range is in the tropics of Central and South America. It is characterised by its pinkish to pale brown heartwood with reddish streaks and light pink to yellowish brown sapwood (Singh, 1978). A naturally fast growing hardwood, this timber species thrives in disturbed areas and is commercially matured and ready for harvest within 30 years of establishment (Gullison *et al*., 1996; Smith, 1979-91).

Fiji's mahogany plantations were established at the expense of native lowland rainforest (Tuiwawa, 1998) and cover a total of about 30,000 ha (Varmola and Carle, 2002). Currently there are fourteen mahogany plantations ranging in size between 2,500 ha to 12,200 ha (FHCL, 2002) spread across Fiji's two largest islands, Viti Levu and Vanua Levu. Clear-fell logging of native lowland rainforest for plantation establishment would have resulted in the disruption and compacting of soil, destruction of the humus layers, and changes to the soil seed bank. Such changes would have benefitted mahogany, but been detrimental to most native species (Ash, 1992; Singh, 1978). The largest plantations occur in Naboutini, Nadarivatu and Galoa on Viti Levu and are managed by Fiji Hardwood Co-operation Limited (FHCL, 2002).

Wainiveiota mahogany plantation, established in 1960, is part of the Colo-i-Suva Forest Reserve, which is one of the fourteen plantation sites in Fiji (FHCL, 2002). Administered by the Department of Forestry, this plantation has not been logged since establishment and now supports a broad range of native species at various growth stages in the understorey. In this study we quantitatively assess the species diversity, composition and regeneration potential of native species and mahogany in the Wainiveiota plantation. The results are used to make inferences about the abundance and representativeness of regeneration by native species and mahogany in a mahogany plantation.

2. Materials and Methodology

2.1 Study Area

Located about 7 km from Suva, the Wainiveiota mahogany plantation occurs at an elevation of about 130 m in Colo-i-Suva, Naitasiri province, Viti Levu, receives an average annual rainfall of about 424 cm,

with November to March being the wettest months and May to August the driest. The area has a mean annual temperature of 24°C (Southern, 1986; Berry & Howard, 1973) and is administered by the Department of Forestry. The oldest rocks at the site are Tawavatu tuff with Vago outliers including basalt, pillow lava and some andesites, members of the Medrausucu andesitic group, and are about 5.3 million years old. Other rock types are the Veisari sandstone and Suva marl (Rodda, 1976; Ladd, 1934).

2.2 Sampling

During a reconnaissance survey, a representative area was identified in the homogenous mahogany forest and representative topographic areas that included gentle and steep slopes, ridges, relatively flat land and dried creeks (Table 1). In this area a 200 m long transect line was laid and ten 10 m × 10 m plots were established 5 m from and perpendicular to the line transect on alternate sides at 10 m intervals. For each plot, percentage cover was estimated using a densitometer and the diameter at breast height (dbh) and identity of each individual with a dbh ≥ 1 cm determined. The plot size of 10 m × 10 m was considered adequate for assessing regeneration in rainforest (Tuiwawa, 1999; Mueller-Dombois and Ellenberg, 1974). Samples that could not be identified in the field were verified at the South Pacific Regional Herbarium (SUVA) using Smith (1979-91).

3. Data Analysis

The species-area curve was used to determine the minimal area of sampling. This method has been used in lowland rainforest studies on Viti Levu and allows estimating the number of species within a study area. Species-area curves typically plateau after a minimal area has been attained, indicating that chances of recording any new species would be low (Mueller-Dombois and Ellenberg, 1974; Tuiwawa, 1999). Botanical diversity and composition was assessed by determining the most abundant and dominant taxa. Information obtained was then used to construct the class-size graphs from which the potential regeneration of native species was assessed.

4. Results

The species-area curve plateaus after 7 plots (Figure 1), suggesting that a minimum of 7 plots are required to obtained a floristically representative sample of the area (Tuiwawa, 1999; Mueller-Dombois and Ellenberg, 1974). Plots covered a variety of topographic habitats with 18-26 (mean = 24) species per plot and an average canopy cover of c. 65% (Table 1).

A total of 68 native plant species were recorded in addition to the exotic mahogany. The most common species were *Gironniera celtidifolia* Gaud. with 55 individuals, followed by mahogany with 39, *Dillenia biflora* (A. Gray) Martelli ex Dur. & Jacks with 29, and *Barringtonia edulis* Seem. with 28 individuals. Of the native species about 57% (39 species) were endemic species, 36% (24 species) were indigenous species (including endemics) and 12% (5 species) could only be identified to the genus level. Apart from *S. macrophylla* with an average dbh = 17.9 cm, *Endospermum macrophyllum* (Muell.Arg.) Pax & Hoffm. was the dominant native species, dbh = 17.3 cm. The dominant families (Table 2) comprised 57% of the flora with Meliaceae having the largest number of genera (4) and Myrtaceae as the most diverse family (5 species).

Table 1. Site description, percentage % canopy cover, number of plants and number of species for ten 10 × 10 m study plots in the Wainiveiota mahogany plantation.

Plot #	Site description	% canopy cover	no. of plants	no. of species
1	Relatively flat slope	80	90	28
2	Gentle slope	80	60	29
3	Dry creek	80	54	25
4	Gentle slope	70	33	22
5	Gentle slope	70	32	18
6	Rising slope	70	33	24
7	Rising slope	60	52	25
8	Fairly steep slope	40	43	24
9	Relatively flat slope	50	49	21
10	Relatively flat slope	50	45	23
	Average	**65**	**49**	**24**
	Total	**650**	**491**	**69**

The class-size distribution of individuals with dbh ≥ 1 cm differed considerably between native species and mahogany, as 98% of all native plants combined had a dbh < 10 cm and about 54% of all mahogany plants had a dbh ≥ 10 cm (Table 3). Mahogany displayed a u-shaped class size distribution, indicating an abundance of mature individuals and saplings, but a lack of trees at the intermediate categories (Figure 2).

5. Discussion

The abundant recruitment of saplings of a variety native species demonstrates the capacity of mahogany plantations to support high plant diversity, and suggests potential for native lowland rainforest to re-establish after the harvesting period (30 years) of mahogany. The diversity and composition of this plantation forest exhibit elements of a lowland rainforest. In fact, the number of species recorded in this study, represent more than 50% of the diversity commonly recorded per hectare in lowland rainforests of south-east Viti Levu (Keppel *et al*., 2010, 2011). Many of the native species recorded, such as *Balaka*

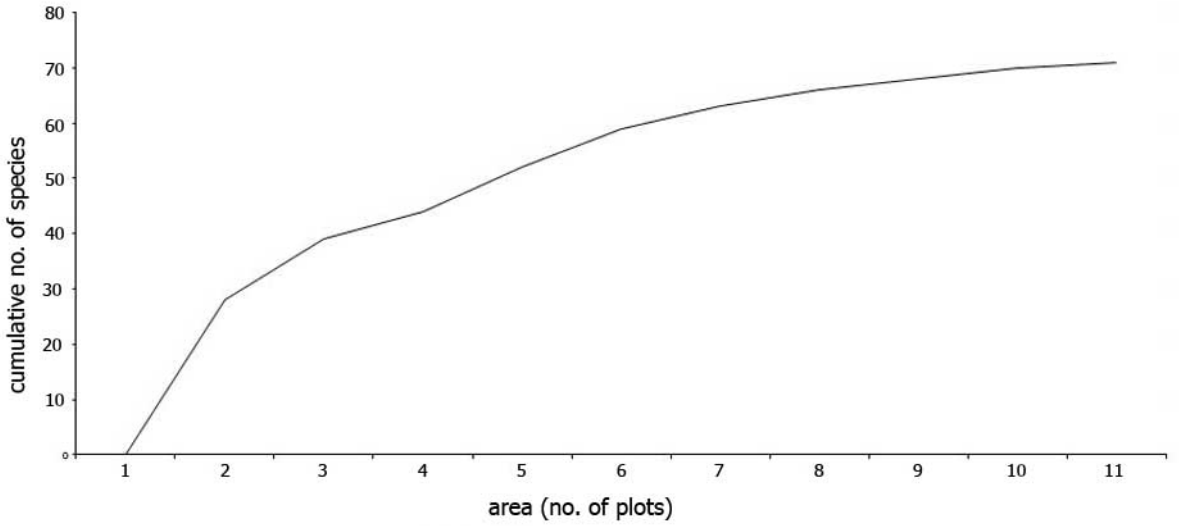

Figure 1. Species-area curve of cumulative species richness in ten 10 × 10 m plots along a 200 m transect in the Wainiveiota mahogany plantation.

Table 2. Plant families with 3 or more species in ten 10 m × 10 m study plots in the Wainiveiota mahogany plantation.

Family	Genera	Species	% of flora
Meliaceae	4	4	6
Caesalpiniaceae	3	3	4
Rubiaceae	3	3	4
Annonaceae	3	3	4
Myrtaceae	2	5	7
Lauraceae	2	4	6
Clusiaceae	2	3	4
Moraceae	1	4	4
Myristicaceae	1	4	4
Sapotaceae	1	3	4
Araliaceae	1	3	4
Total	**23**	**39**	**48**

Table 3. Girth distribution of mahogany and native plants (all species combined) at the ten 10 m × 10 m plots in the Wainiveiota mahogany plantation.

Class interval (cm)	No. of mahogany plants	Mo. of native plants
1-3	10	312
4-6	6	110
7-9	2	21
10-12	0	5
13-15	1	3
16-18	1	0
19-21	1	0
22-24	0	0
25-28	0	0
28-30	1	0
> 30	17	1
Total	**39**	**452**

microcarpa Burret, *Aglaia* sp., *Myristica casteneifolia* A.Gray, *M. gillespieana* A.C.Smith, *Calophyllum vitiensis* Turrill, species of *Syzygium* Gaertn., *Palaquium porphyreum* A.C.Smith & S.Darwin and *P. vitilevuense* Gilly ex van Royen, are often observed in primary lowland rainforest. (Keppel *et al*., 2010, 2011; Tuiwawa, 1999; Smith, 1979-1991).

This good representation of native rainforest taxa and the observed abundance of seedlings and saplings, suggest efficient regeneration of native species (Pascal and Pelissier, 1996; Kirkpatrick and Hassal, 1985). Whilst this demonstrates the potential for re-establishing native lowland rainforest, the scenario would primarily depend on the ability of the majority of native species to thrive under the closed mahogany canopy and the ability of the matured native cohort to outcompete mahogany in a secondary forest system.

Saplings of mahogany have been observed in the understory of primary forests along the peripherals of mahogany plantations throughout south-east Viti Levu (Keppel *et al*., 2005; Keppel and Watling, 2011). Whilst this is also evident in the outskirts of the plantation it is suggestive that mahogany could persist in its current location however likely at a lower density that it presently does.

6. Conclusion

This study documents abundant recruitment by a wide diversity of native species and mahogany in the understory of a mahogany plantation. Because native species are a common component of a lowland rainforest, there is potential for the re-establishment of native rainforest by way of perhaps the active removal and management of mahogany saplings. This study provides an important baseline for the diversity and composition to expect in mahogany plantations

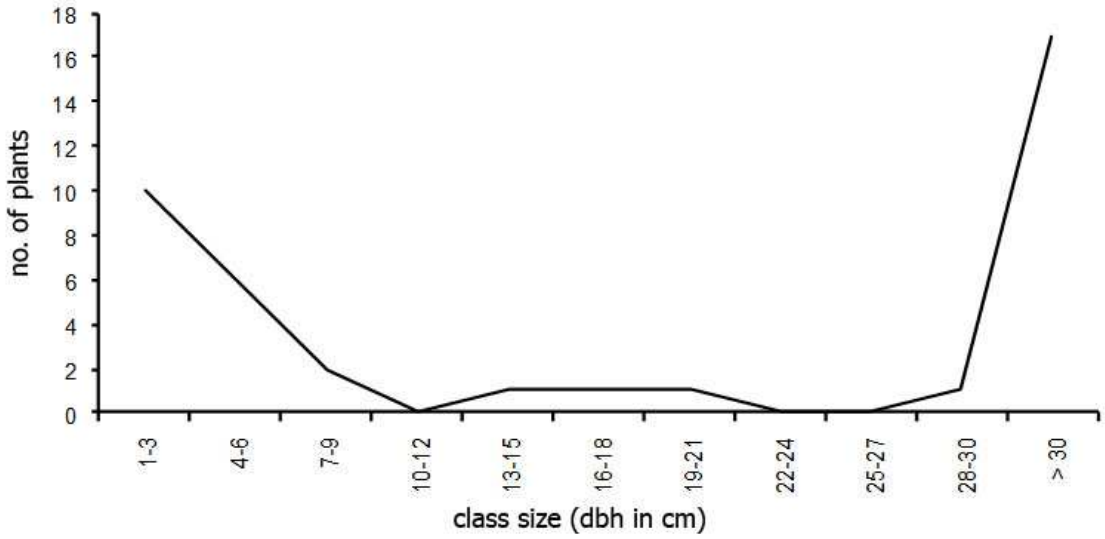

Figure 2. Class-size distribution of mahogany, *S. macrophylla* King, in ten 10 m x 10 m plots at the Wainiveiota mahogany plantation.

on the south eastern parts of Viti Levu. Most importantly, this preliminary study highlights the need to understand the long-term dynamics of mahogany plantations under different management scenarios, as their capacity to support plant species, other than *S. macrophylla*, is unknown and undocumented.

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Correspondence to: Senilolia H. Tuiwawa or Gunnar Keppel
E-mail: senilolia.heilala@yahoo.com or Gunnar.Keppel@unisa.edu.au

Appendix A. Preliminary Plant Checklist to the Wainiveiota Plantation at the Colo-i-Suva Forest Reserve.

Species Name	**Family**	**Origin**
Aglaia sp.	Meliaceae	Ind/End
Alstonia pacifica (Seem.) A.C.Sm.	Apocynaceae	Indigenous
Amaroria soulameoides A.Gray	Simaroubaceae	Endemic
Anacolosa lutea Gillespie	Olaceae	Indigenous
Atuna racemosa Raf.	Chrysobalanaceae	Indigenous
Balaka microcarpa Burret	Araceae	Endemic
Barringtonia edulis Seem.	Lecythidaceae	Endemic
Barringtonia sp. nova	Lecythidaceae	Endemic
Calophyllum vitiensis Turrill	Clusiaceae	Endemic
Canarium harveyi Seem.	Burseraceae	Indigenous
Cerbera manghas L.	Apocynaceae	Indigenous
Cordyline terminalis (L.) Kunth	Agavaceae	Indigenous
Crossostylis seemanii (A.Gray) Schimper	Rhizophoraceae	Endemic
Cryptocarya constricta Allen	Lauraceae	Endemic
Cyathea lunulata Copel.	Cyatheaeceae	Indigenous

Cyathocalyx insularis A.C.Sm.	Annonaceae	Endemic
Cynometra insularis A.C.Sm.	Caesalpiniaceae	Endemic
Decaspermum vitiense (A.Gray) Nied.	Myrtaceae	Endemic
Dillenia biflora Martelli	Dilleniaceae	Indigenous
Diospyros spp.	Ebenaceae	Ind/End
Dolicholobium spp.	Rubiaceae	Indigenous
Dysoxylum richii (A.Gray) C.DC.	Meliaceae	Endemic
Dysoxylum spp.	Meliaceae	Ind/End
Elaeocarpus chelonimorphus Gillespie	Elaeocarpaceae	Endemic
Endiandra elaeocarpa Gillespie	Lauraceae	Indigenous
Endiandra gillespiei A.C.Sm.	Lauraceae	Endemic
Endiandra spp.	Lauraceae	Ind/End
Endospermum macrophyllum (Müll.Arg.) Pax & Hoffm.	Euphorbiaceae	Endemic
Ficus barclayana (Miq.) Summerhayes	Moraceae	Endemic
Ficus fulvo-pilosa Summerhayes	Moraceae	Endemic
Ficus storckii Seem.	Moraceae	Indigenous
Ficus theophrastoides Seem.	Moraceae	Indigenous
Garcinia myrtifolia A.C.Sm.	Clusiaceae	Indigenous
Garcinia pseudoguttifera Seem.	Clusiaceae	Indigenous
Gironniera celtidifolia Gaudich.	Ulmaceae	Indigenous
Gnetum gnemon L.	Gnetaceae	Indigenous
Gonystylus punctatus A.C.Sm.	Gonystylaceae	Endemic
Haplolobus floribundus (K.Schum.) H.J.Lam	Burseraceae	Indigenous
Hernandia olivaceae Gillespie	Hernandiaceae	Endemic
Ixora spp. L.	Rubiaceae	Endemic
Kingiodendron platycarpum B.L.Burtt	Caesalpiniaceae	Endemic
Maniltoa grandiflora (A.Gray) Scheff.	Caesalpiniaceae	Indigenous
Melicope cuculata (Gillespie) A.C.Sm.	Rutaceae	Endemic
Myristica castaneifolia A.Gray	Myristicaceae	Endemic
Myristica chartaceae Gillespie	Myristicaceae	Endemic
Myristica gillespieana A.C.Sm.	Myristicaceae	Endemic
Myristica grandifolia A.DC.	Myristicaceae	Endemic
Neuburgia corynocarpa (A.Gray) Leenh.	Loganiaceae	Indigenous
Omalanthus nutans (G.Forst.) Guillemin	Euphorbiaceae	Indigenous
Palaquim horneii (Hartog ex Baker) Dubard	Sapotaceae	Endemic
Palaquim porphyreum A.C.Sm. & S.P.Darwin	Sapotaceae	Endemic
Palaquim vitilevuense Gilly ex P.Royen	Sapotaceae	Endemic
Parinari insularum A.Gray	Chrysobalanaceae	Indigenous
Pleiogynium timoriense (DC.) Leenh.	Anacardiaceae	Endemic
Plerandra insolita A.C.Sm.	Araliaceae	Endemic

Plerandra spp.	Araliaceae	Endemic
Plerandra vitiensis (Seem.) Baill.	Araliaceae	Endemic
Polyalthia loriformis Gillespie	Annonaceae	Endemic
Psychotria spp.	Rubiaceae	Endemic
Santalum yasi Seem.	Santalaceae	Indigenous
Semecarpus vitiensis (A.Gray) Engl.	Anacardiaceae	Indigenous
Swietenia macrophylla King	Meliaceae	Introduced
Syzygium fijiensis L.M.Perry	Myrtaceae	Endemic
Syzygium gracilipes (A.Gray) Merr. & L.M.Perry	Myrtaceae	Endemic
Syzygium grayii (Seem.) Merr. & L.M.Perry	Myrtaceae	Endemic
Syzygium spp.	Myrtaceae	Ind/End
Termanalia spp.	Combretaceae	Endemic
Vavaea amicorum Benth.	Meliaceae	Indigenous
Xylopia pacifica A.C.Sm.	Annonaceae	Endemic