Composition and diversity of the rain forest in Central Guyana

An addendum to
'Soils of the rainforest
in Central Guyana'

Hans ter Steege, Ramesh Lilwah, Renske Ek, Peter van der Hout, Raquel Thomas, Jessica van Essen, Victor Jetten

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CONTENTS

1 Introduction

In 1990 a project was initiated to describe the soil types and vegetation a selected area in central Guyana, to provide baseline data for other projects carried out within the framework of the Tropenbos-Guyana Programme. Both the completion of the soil map and vegetation map were severely delayed. The soil map was published in 1996 (van Kekem et al. 1996) but logistical problems prohibited the production of a vegetation map of the area. With the new computerisation of previous inventory data of the "Great Falls Inventory" (Welch & Bell 1971) and a new inventory of the Forest Reserve Mabura Hill sufficient data was available to add a vegetation legend to the soil map of 1996. Further studies into the plant diversity added several hectare plots (Ek 1997) and botanical collections to the knowledge base of the area and allow us to discuss the diversity of several forest types and their conservation value for Guyana.

The area discussed is approximately 2187 km^2 and is located on the Essequibo-Demerara watershed between longitude 58°26'W and 58°54'W. In the north the area is bound by a line east to west from the Great Falls on the Demerara river to the Essequibo river (5°20'N) and in the south by a line close to Kurupukari (4°40'N) (Figures 1, 2). The area is part of a timber concession of Demerara Timbers Ltd., known as TSA 91/1. In the following the area will be referred to as the Mabura Concession. A further description of the area can be found in ter Steege et al. (1995) and van Kekem et al. (1996).

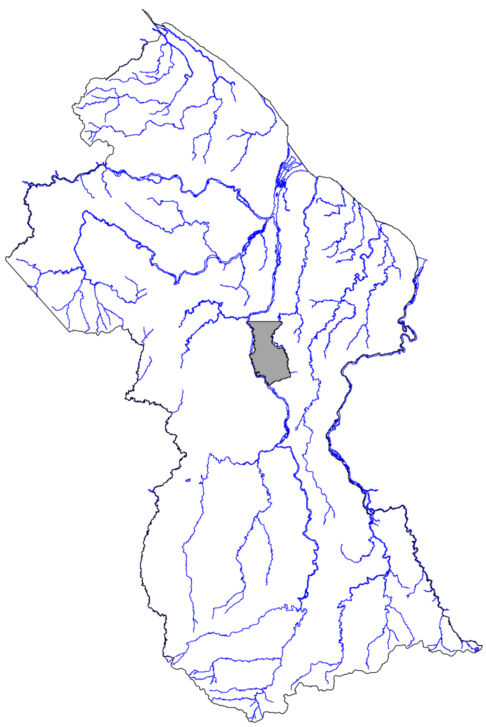


Figure 1. Location of the Mabura Hill concession

The forest of the Mabura Hill Concession Area (MHCA) is part of the central wet forests of Guyana (sensu ter Steege 1998) and has potential high conservation and commercial value (ter Steege 1998, ter Steege et al. 1999). Previous descriptions of the forest types in the area can be found in Fanshawe (1952), Welch & Bell (1971), and ter Steege et al. (1993). General collecting has been carried out in the area since the 1800's but recently due to the start of the Tropenbos-Guyana Programme on this site has the number of botanical collections risen quite sharply (ter Steege et al. 1995, Ek & ter Steege 1998). At present 3093 collections have been made comprising 1479 taxa, of which 90% have been identified to the species level (Ek 1997, Ek & ter Steege 1998).

Individuals of a number of endemic species are abundant, and even locally dominant, in the area (ter Steege 1998). Such species include Potaro kakaralli (*Eschweilera potaroensis*), Sarebebeballi (*Vouacapoua macropetala*), Wamara (*Swartzia leiocalycina*), Greenheart (*Chlorocardium rodiei*), Clump wallaba (*Dicymbe altsonii*), and Sand baromalli (*Catostemma altsonii*). Several species, endemic to the 3 Guianas are also characteristic of the forests of the area: Mora (*Mora* *excelsa*), Morabukea (*M. gonggrijpii*), Soft wallaba (*Eperua falcata*), Ituri wallaba (*E. grandiflora*), Dakama (*Dimorphandra conjugata*), and others. Individuals of endemic species may account for over 50% of all individuals of the forest stands over relatively large areas (ter Steege 1998). Within families, thought to be characteristic for lowland rainforest of the Guianas, a high percentage of endemic species occurs in the forest of the Berbice formation, of which the area is a part (ter Steege 1998, ter Steege *et al*. 1999).

In this report a new legend is added to the soil map of the area (van Kekem et al 1996). The legend description give floristic composition, diversity, and biomass and carbon store for all major forest units found. The legend has been added to the Arcview databases of the soil map. For more information contact the Tropenbos-Guyana Office.

Vernacular names used in the forest inventories have been translated into scientific names using the list of names in Ek (1997). In these studies most species have been collected and identified in the Utrecht Herbarium.

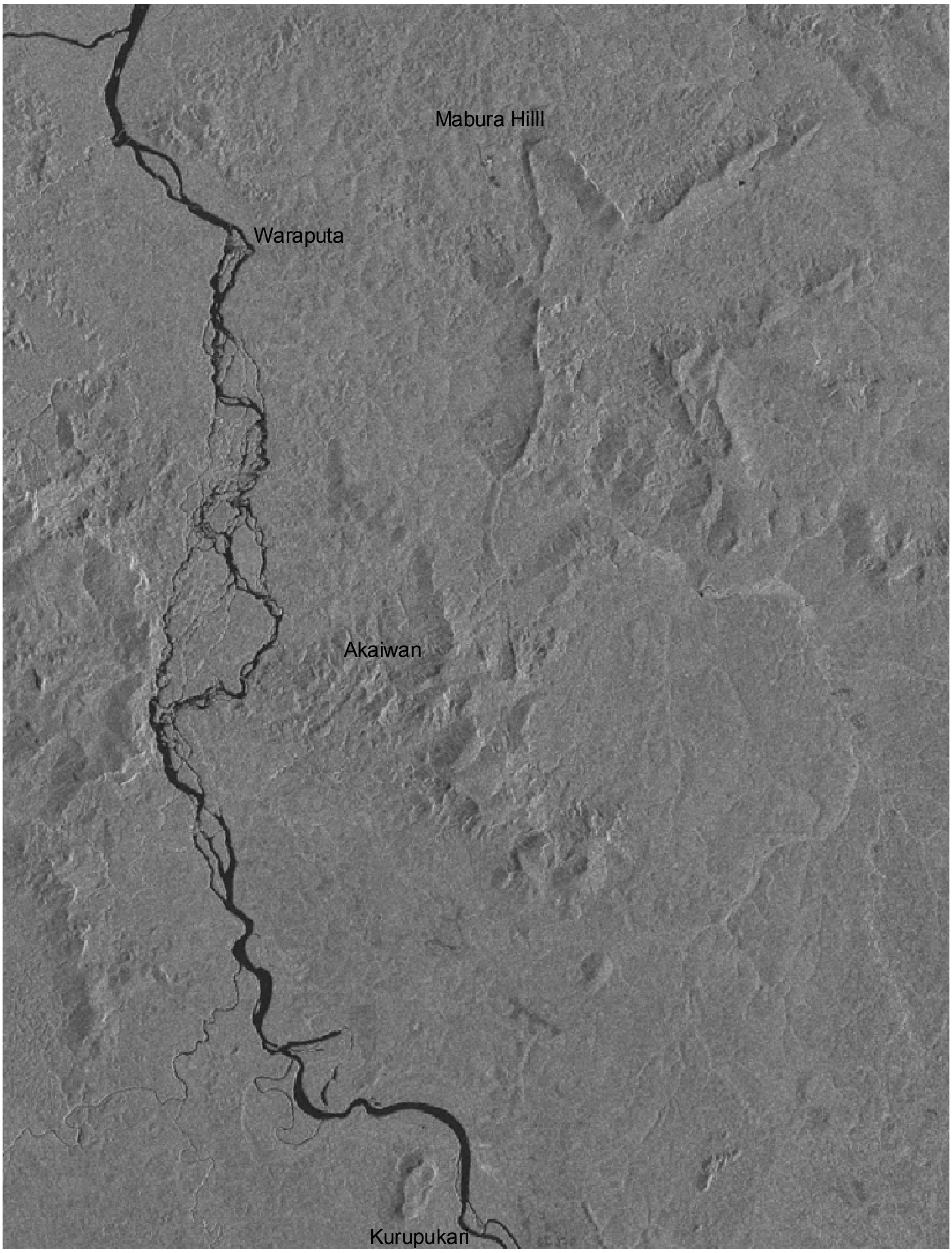


Figure 2. Major features of the Mabura Concession area. Based on radar data from NASDA-JERS.

2 Brief description of the data sources and their methods

The MHCA has been the focus of a large set of inventories and ecological studies. Timber inventories that have have been carried out in the area are:

1. Davis (1935) – an area from Ekuk creek to Great Falls
2. Vink 1956 – an area close to Waraputa Falls
3. King 1959 – and area south of Great Falls
4. Forest Industries Development Surveys (de Milde & de Groot 1970) – The National Forest Inventory, a few plots of which fall in the area under consideration
5. Great Falls Inventory (Welch & Bell 1971), covering the complete area under consideration

In addition to that, two more extensive botanical inventories were carried out:

6. Waraputa Watershed (ter Steege 1993), covering 480 ha.
7. Forest Reserve Mabura Hill (this report), covering 900 ha

And finally a number of small plot (1-2 ha) studies were executed:

8. Pibiri, 15 plots in mixed forest on brown sands (Ek 1997, van der Hout 1999)
9. Waraputa, 3 plots in mixed forest on brown sands (Ek 1997)
10. Forest Reserve Mabura Hill, 3 plots in mixed forest on brown sands (Ek 1997)
11. Forest Reserve Mabura Hill, plots in Wallaba forest on white sand, in mixed forests on brown sand, clay, and laterite (Thomas 1999)
12. Forest Reserve Mabura Hill, plots in mixed forests on laterite (van Essen 1999)
13. Camoudi Compartment, in mixed forest on brown sands (Thomas 1999)
14. 2Km, 3 plots in mixed forest on brown sands (Ek 1997)

The Forest Industries Development Surveys

The FIDS, Guyana's National Forest Inventory, was carried out over a four year period (de Milde & de Groot 1970). Over a thousand plots were established nation-wide and a number of plots of the FIDS are situated in the MHCA. The data of this inventory were computerised during the course of this study. Because of the low intensity of this inventory the data is not very useful in describing the forest types of the region in great detail. For information on this survey see de Milde & de Groot (1970) and ter Steege (1998).

The Great Falls Inventory

In 1971 an inventory was carried out covering the full MHCA. The primary block unit was 2 square miles, subdivided into 2 sub-blocks of 1 square mile. Two lines were randomly chosen out of 16 possible for each sub-block. A maximum of 40 1/10th acre plots was equally spaced out along the sample lines. All trees over 12" DBH (Diameter at Breast Height) were sampled. In total 23 blocks were established in the field (Figure 3), with an average of approximately 150 plots per block. A total of 12,349 trees were measured on these plots. Soil type and forest type were recorded on the field-forms. For more information on the inventory design see Welch & Bell (1971)

Waraputa Compartment Inventory

Following a timber inventory of DTL a more complete botanical inventory was carried out in the Waraputa Compartment (480 ha). On 29 cut-lines, a total of 252 circular plots of 0.05 ha were established. All trees over 20 cm dbh were recorded. A total of 2952 trees was found. Soil types were noted in the field and more elaborate soil measurements were made on 87 of the plots (Jetten 1994). For more information see ter Steege (1993), ter Steege *et al*. (1993), or Jetten (1994).

Forest Reserve Mabura Hill Inventory
Within the Forest Reserve Mabura Hill, all trees over 7 cm DBH (20 cm GBH, Girth at Breast Height) that occurred within 5 metres of all the major trails in the Reserve were inventoried. Plots were defined as being portions along these trails of 25 (x 10) m. This provided us with a total of 883 plots and 18,121 trees. The results of this inventory will be discussed in a separate chapter.

Botanical inventories using hectare plots
Most of the smaller scale plot inventories used fixed plots of 1 to 2 ha. All trees above 10 cm DBH were measured. In the case of van der Hout (1999) and Ek (1997), trees of over 20 cm DBH were measured in the full ha area, while trees between 10 and 20 cm were measured in 25% subsamples. Smaller plants (shrubs, herbs, epiphytes) were sampled in even smaller sub-samples (Ek 1997).

Locations of the more important research sites are given in Figure 3.

To describe the forests in the area we make use of data sets 4-7, while for more specific biodiversity measurement we also make use of the plots 8-13, Davis & Richards (1934), and Johnston & Gillman (1995). Data and reports of 1-3 were not available during the course of the study.

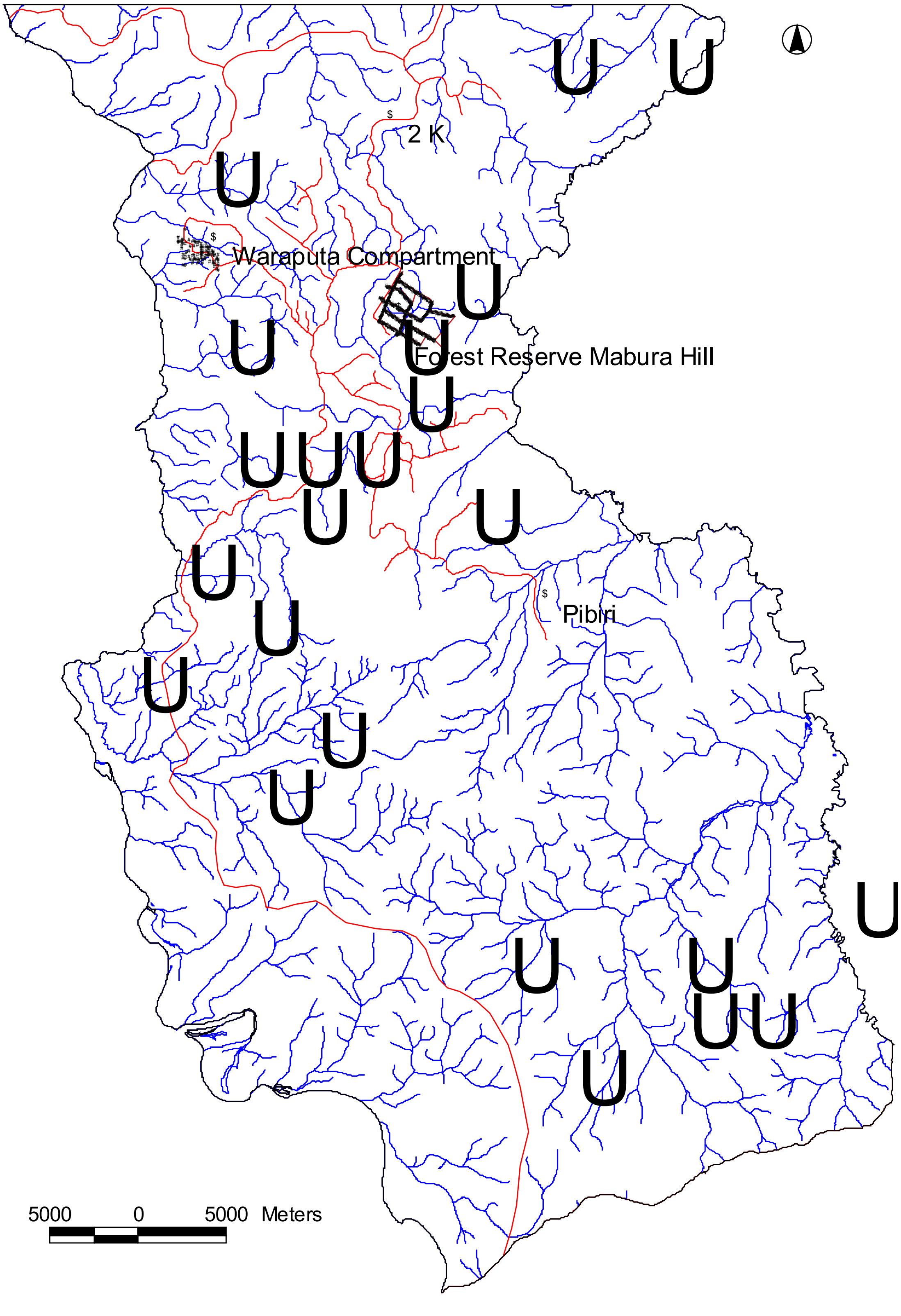


Figure 3. Location of research plots. The individual plots in the FRMH and the Waraputa Compartment are shown. The large squares are the primary blocks of the Great Falls Inventory. Base map from van Kekem *et al*. (1996)

3 Flora of the area

The flora of the MHCA is typical for the lowland Guianas wit relatively high species richness in tree families such as Chrysobalanaceae, Lecythidaceae, and Leguminosae. At present over 1400 species have been collected (Ek 1997). Leguminosae s.l. accounts for a total of 132 species (Table 1), which are divided over its three subfamilies as: Caesalpiniaceae 39, Fabaceae 65, and Mimosaceae 28. Other tree families with high species richness are Annonaceae (38 species), Chrysobalanaceae (37), Lauraceae, and Sapotaceae (29). Orchidaceae are the largest non-woody family with 125 species, partly because epiphytes have been a focal study object in the area (ter Steege & Cornelissen 1989, Biesmeijer & Bley 1990, Ek et al 1997).

Table 1. Major plant families with at least 10 species in the Mabura Hill Concesion.

Family	#species	Family	#species
Orchidaceae	125	Graminae	21
Rubiaceae	69	Menispermaceae	21
Fabaceae	65	Bromeliaceae	20
Pteridophyta	62	Compositae	18
Melastomataceae	49	Lecythidaceae	18
Bignoniaceae	41	Hippocrateaceae	17
Caesalpiniaceae	39	Moraceae	15
Annonaceae	38	Solanaceae	15
Chrysobalanaceae	37	Connaraceae	14
Euphorbiaceae	31	Cucurbitaceae	14
Sapindaceae	31	Palmae	14
Apocynaceae	30	Convolvulaceae	13
Lauraceae	30	Loganiaceae	13
Guttiferae	29	Flacourtiaceae	12
Sapotaceae	29	Gentianaceae	12
Araceae	28	Passifloraceae	12
Mimosaceae	28	Boraginaceae	11
Malpighiaceae	27	Dilleniaceae	11
Cyperaceae	26	Gesneriaceae	11
Myrtaceae	25	Burseraceae	10
Piperaceae	22		

There are many tree genera among the larger genera in the area such as *Licania* (incl. Kauta's, Kautaballi's, Marishiballi's, Konoko), *Pouteria* (incl. Asepoko, Asepokoballi, Kokoritiballi), *Swartzia* (incl. Wamara, Banya, Itikiboroballi's, Parakusan's, Serebedan), *Inga* (whitie's), *Ocotea* (incl. Silverballi's, Kereti), and *Eschweilera* (Kakaralli's) is the genus with the largest number of species. Other large genera are found in the Orchidaceae, Rubiaceae, and Melastomataceae. These genera are commonly found in many of the forests of the Neotropics.

Table 2. Major plant genera with at least 10 species in the Mabura Hill Concesion.

Genus	# species	Genus	# species
Licania (Chrysobalanaceae)	25	*Inga* (Mimosaceae)	11
Pleurothallis (Orchidaceae)	19	*Passiflora* (Passifloraceae)	11
Pouteria (Sapotaceae)	19	*Philodendron* (Araceae)	11
Miconia (Melastomataceae)	18	*Solanum* (Solanaceae)	10
Psychotria (Rubiaceae)	17	*Trichomanes* (Hymenophylaceae)	10
Maxillaria (Orchidaceae)	15	*Abuta* (Euphorbiaceae)	10
Ocotea (Lauraceae)	15	*Clusia* (Guttiferae)	10
Swartzia (Fabaceae)	15	Eschweilera (Lecythidaceae)	10
Epidendrum (Orchidaceae)	14	*Peperomia* (Piperaceae)	10
Piper (Piperaceae)	12	Strychnos (Loganiaceae)	10

4 Forest type map of the Mabura Hill Concession Area

Three major landforms are found in the MHCA (Table 3). In accordance with the FAO inventories (de Milde & de Groot 1970) the forest types are divided in three main forest groups:

1. Mixed forests (either on sediment plateaus or hill systems)
2. Wallaba and Dakama forests (on white sands)
3. Swamp and Marsh forests (in alluvial plains)

Each forest type group has a number of forest types based on the landform, physiognomy, or composition.

In the MHCA 13 combinations of soils and forest type are being recognised (Figure 4). The names of these type follow the FAO classification (de Milde & de Groot 1970). At smaller scales finer subdivision exist, as will be show in chapter 5 on the Forest Reserve Mabura Hill.

Presence, total number of individuals/ha and basal area/ha are given for all species and all forest types in Appendix 1.

In the following the legend to the forest type map will be expanded. Per forest type we will present a map with its distribution, data on its composition, tree diversity, basal area, biomass, and carbon store (all (except mentioned otherwise) based on data from the GFI).

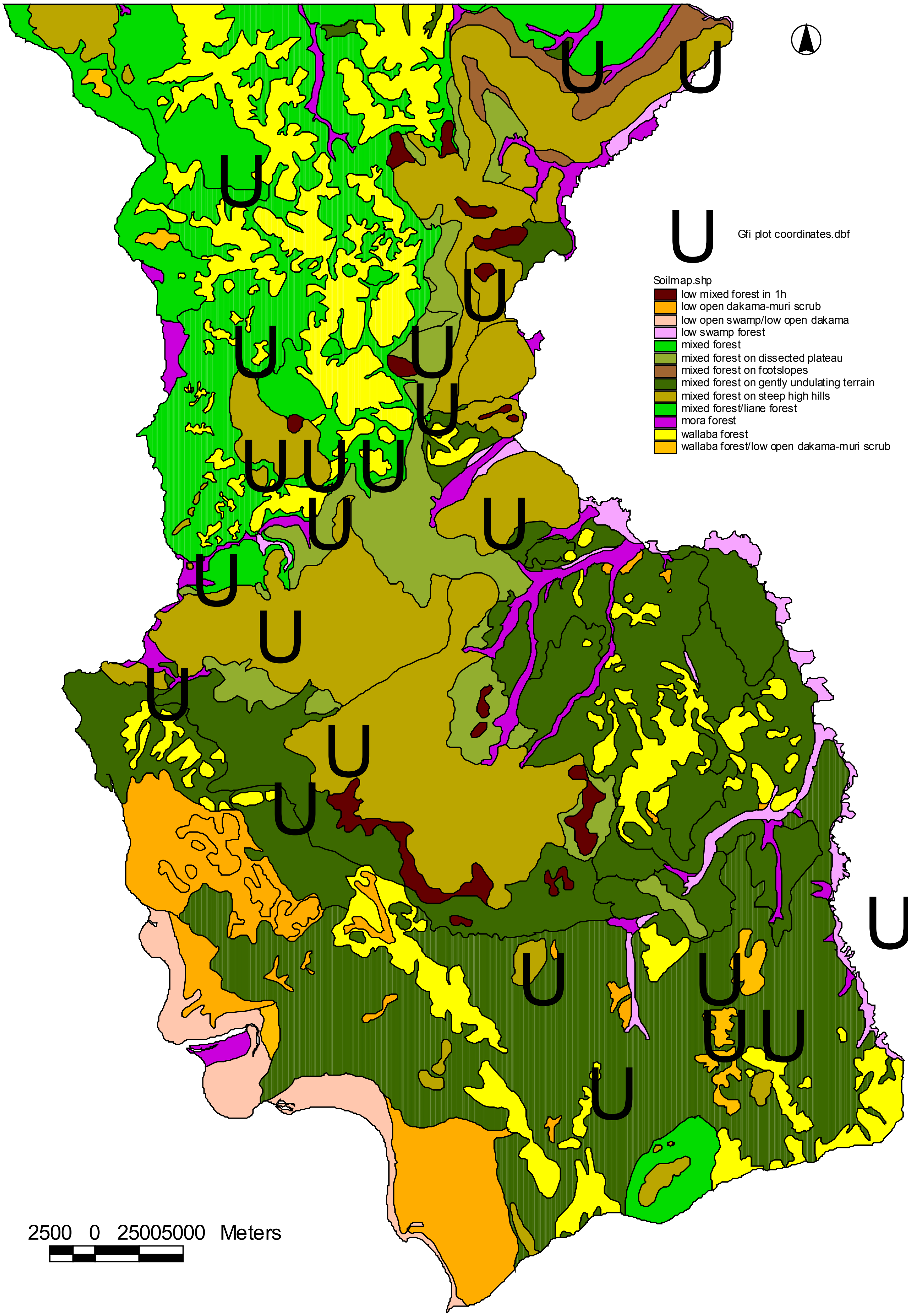
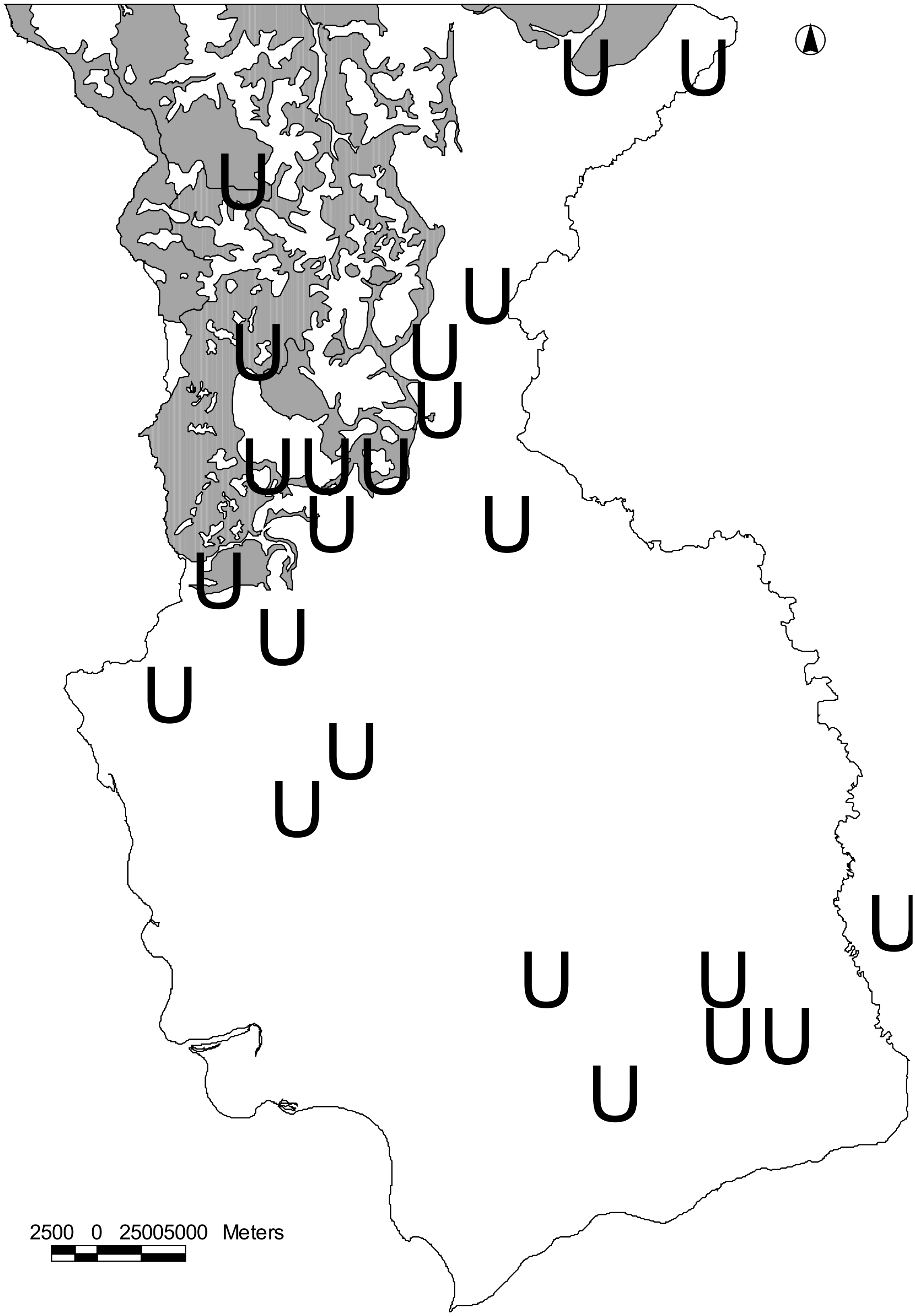

Gfi plot coordinates.dbf
Soilmap.shp
low mixed forest in 1h
low open dakama-muri scrub
low open swamp/low open dakama
low swamp forest
mixed forest
mixed forest on dissected plateau
mixed forest on footslopes
mixed forest on gently undulating terrain
mixed forest on steep high hills
mixed forest/liane forest
mora forest
wallaba forest
wallaba forest/low open dakama-muri scrub
2500 0 25005000 Meters

Table 3. Soil types and major forest types of the Mabura Hill region.

FAO Series	Guyana Series	Local Name	Forest types
on hills, footslopes and dissected erosional plains, formed on basic metamorphic and igneous rock:			
ferralic Cambisols, rudic phase	?	hill soils	mixed forest on steep high hills
dystric Leptosols, rudic phase	Mabura Gravelly Sandy Clay	Laterite	mixed forest on steep high hills
dystric Leptosols, petroferric phase	Ekuk Clay Loam	Laterite	mixed forest on steep high hills
dystric/lithic Leptosols	Seballi Gravelly Clay Loam	Laterite	mixed forest on steep high hills
acri-haplic Ferralsols, skeletic phase	Tiger Creek Gravelly Clay	Laterite	mixed forest on footslopes
on dissected sedimentary plains, formed in the Berbice formation (White Sands plateau)			
albic Arenosols	Tiwiwid Sand	White Sand	wallaba forest, dakama forest, muri scrub
carbic Podzols	Ituni Sand	White Sand	(palm-)swamp forest, muri scrub
ferralic/luvic Arenosols	Tabela Sand	Brown Sand	mixed forest on gently undulating terrain
acri-haplic/acri-xanthic Ferralsols	Kasarama Loamy Sand	Brown Sand	mixed forest on gently undulating terrain
same	Ebini Sandy Loam	Brown Sand	mixed forest on gently undulating terrain
in Alluvial plains			
terric Histosols	Anira Peat	pegasse	swamp forest
terric Histosols/gleyic Cambisols	Lama Muck	pegasse	swamp forest
gleyic Cambisols, Fluvisols	Barima Silt Loam	alluvial soils	mora forest, other marsh forests

Forest type 1: mixed forest on gently undulating terrain, mainly sediments (30,448 ha)



Forest type 1: mixed forest on gently undulating terrain, mainly sediments (30,448 ha)

Most mixed forest in the north-western part of the area are found on brown sands of the sedimentary plain (Ferralsols). The most common species found are given in table 4.

Table 4. Species with abundance over 1 tree per ha (trees larger than 30 cm DBH) in mixed forest on the Ferralsols of the sedimentary plains (type 1)

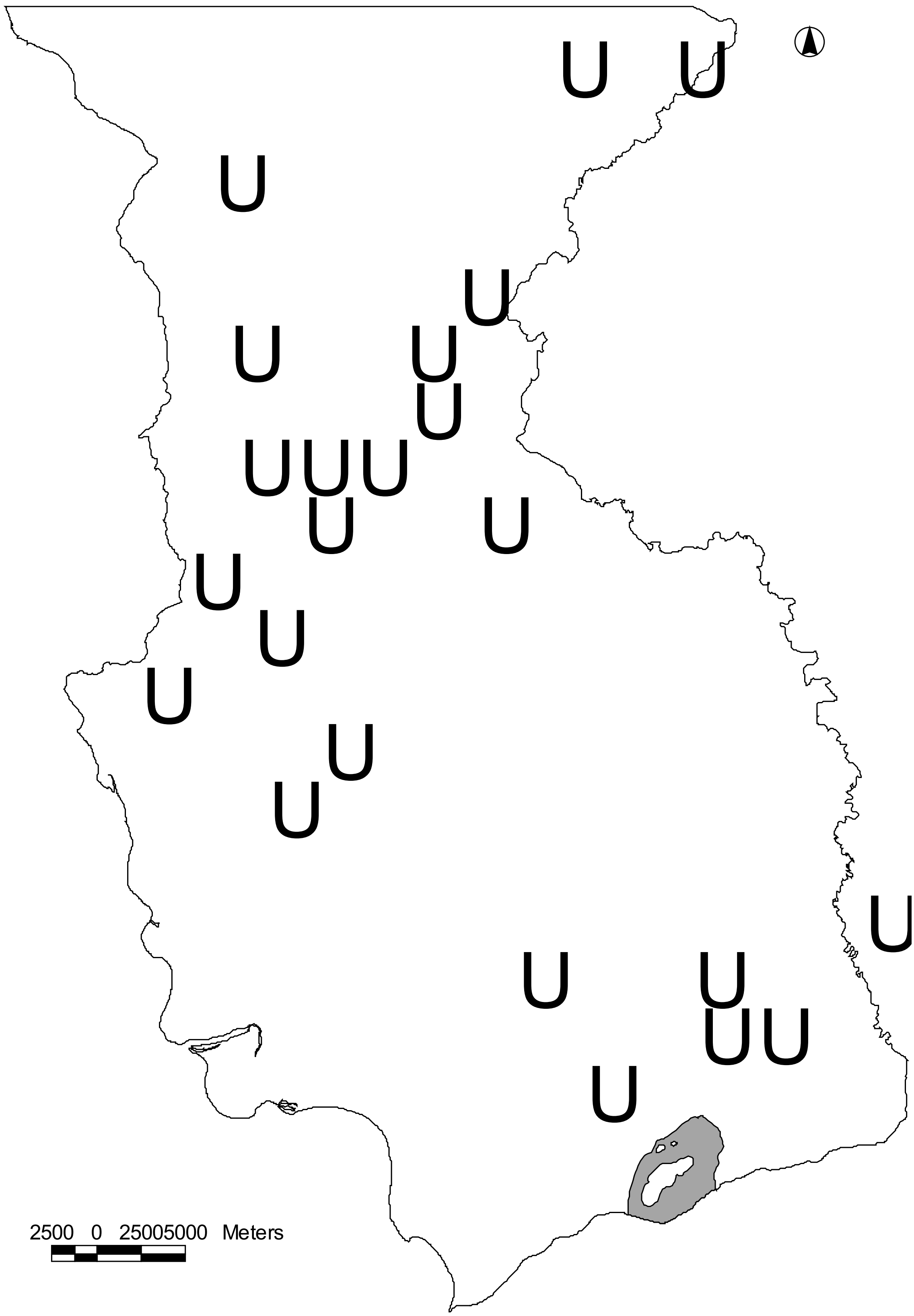
Vernacular name	Scientific Name	Trees/ha
Clump wallaba	Dicymbe altsonii	12.51
Soft wallaba	*Eperua falcata*	8.32
Black kakaralli	*Eschweilera sagotiana*	6.31
Greenheart	*Chlorocardium rodiei*	6.10
Crabwood	*Carapa guianensis*	5.04
Morabukea	*Mora gonggrijpii*	5.04
Wamara	*Swartzia leiocalycina*	4.93
Kakaralli, others	*Eschweilera* spp.	4.13
Trysil	*Pentaclethra macroloba*	3.66
Ituri grandiflora	*Eperua grandiflora*	3.50
Baromalli	*Catostemma* spp.	3.26
Mora	*Mora excelsa*	2.78
Aromata	*Clathrotropis brachypetala*	1.62

Clump wallaba (*Dicymbe altsonii*) and Watapa (*Eperua rubigiosa*) are only found in the northwestern part of the area, where it is extremely dominant in some areas (ter Steege *et al*. 1993).

Diversity
In total 3341 individuals were enumerated, amounting to 141 species. This results in a Fisher's alpha of 29.8 Several 1 ha plots have been laid out in Type 1: Waraputa (Ek, unpublished data), FRMH (Zagt unpublished data), 2Km (Ek unpublished data). Their Fisher's alpha, which is a more correct estimate of alpha diversity, is slightly lower, with an average of 15.3.

Biomass and carbon store
Mixed forests on brown sands have an average number of trees per area (Appendix 1), with a basal area of 18.12 (for trees over 30 cm). The total biomass estimate for this forest is 384 t/ha (Appendix 2) giving a carbon estimate of 192 t/ha. There is an average amount of organic carbon in the soils (Ferralic Arenosols Ferralsols) (appendix 3) and deep rooting is expected because of the sandy structure of most brown sands. Thus carbon for the soil between 100 and 800 cm is estimated according to Nepstad *et al*. (1994) at 98 t/ha (Appendix 3). This brings the total at organic carbon on the soil at 163 t/ha and that of the forest at 355.

Forest type 1d: Liana forest (1,726 ha)



Forest type 1d: Liana forest (1,726 ha)

Liana forest occurs throughout the area in small patches. It is, however more common in areas with steep slopes, especially along the Mabura Ridge and Akaiwan Mts. Most patches are to small to be mapped, except for one area in the south of the Mabura concession. Trysil (*Pentaclethra macroloba*), together with other pioneers such as Congo pump(*Cecropia* spp.), Futui (*Jacaranda copaia*), and Karahoro (*Schefflera morototonii*) are common.

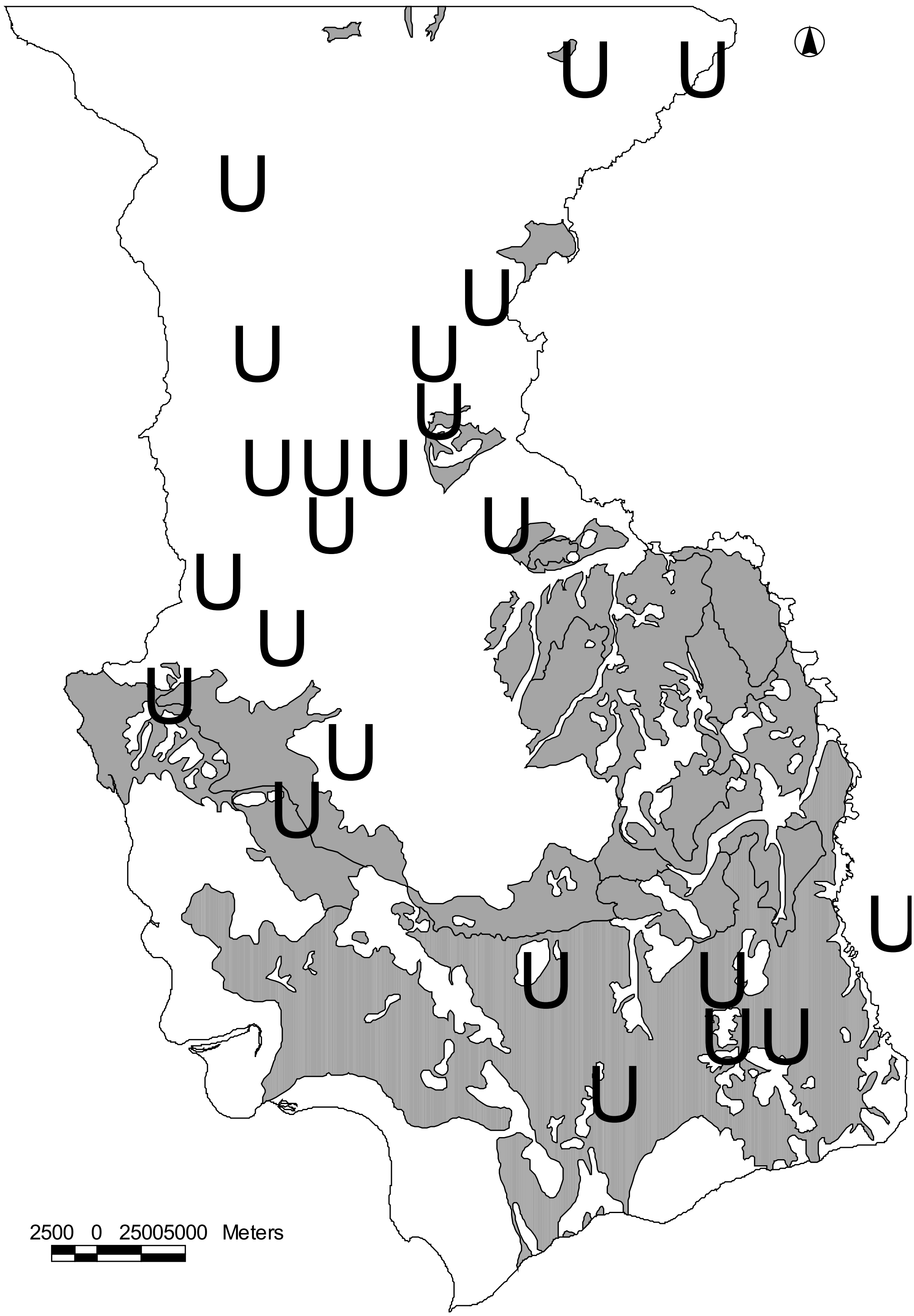
Table 5. Species with abundance over 1 tree per ha (trees larger than 30 cm DBH) in liana forest (1c).

Vernacular name	Scientific name	#/ha
Trysil	Pentaclethra macroloba	11.47
Crabwood	Carapa guianensis	7.06
Kakaralli, others	Eschweilera _spp	4.85
Wamara	Swartzia leiocalycina	3.97
Mora (ak,ar)	Mora excelsa	2.21
Warakosa	Inga __sp	2.21
Table tree	Cordia exalta	1.76
Aromata	Clathrotropis brachypetala	1.32

Diversity
There are too few plots in liana forest too make estimates about its diversity. It is expected too be relatively low.

Biomass and carbon store
Biomass of liana forest is low (176 t/ha, Appendix 2). Assuming that many patches of liana forest occur on the lateritic soils in this area, with a soil carbon of 136 (Appendix 3), the estimate for the total carbon store of this forest is 224 t/ha.

Type 1e: mixed forests on flat to undulating terrain (73,594 ha)



Type 1e: mixed forests on flat to undulating terrain (73,594 ha)

The differences between 1e and 1 are slight and gradual. On aerial photographs the crowns are smaller in 1e (Welch & Bell 1971). The main difference is found in the abundance of Clump wallaba (*Dicymbe altsonii*), which is very common to dominant in the mixed forests of Type 1 of the north western part and is absent in the south east. There is replaced by Morabukea (*Mora gonggrijpii*), which occurs at densities of 40 to 70 per ha (trees over 30 cm DBH) in the southern parts. Total stem densities are not different and biomass and carbon store are assumed to be equal to that of Type 1.

Table 6. Species with abundance over 1 tree per ha (trees larger than 30 cm DBH) in small crowned mixed forest (1e).

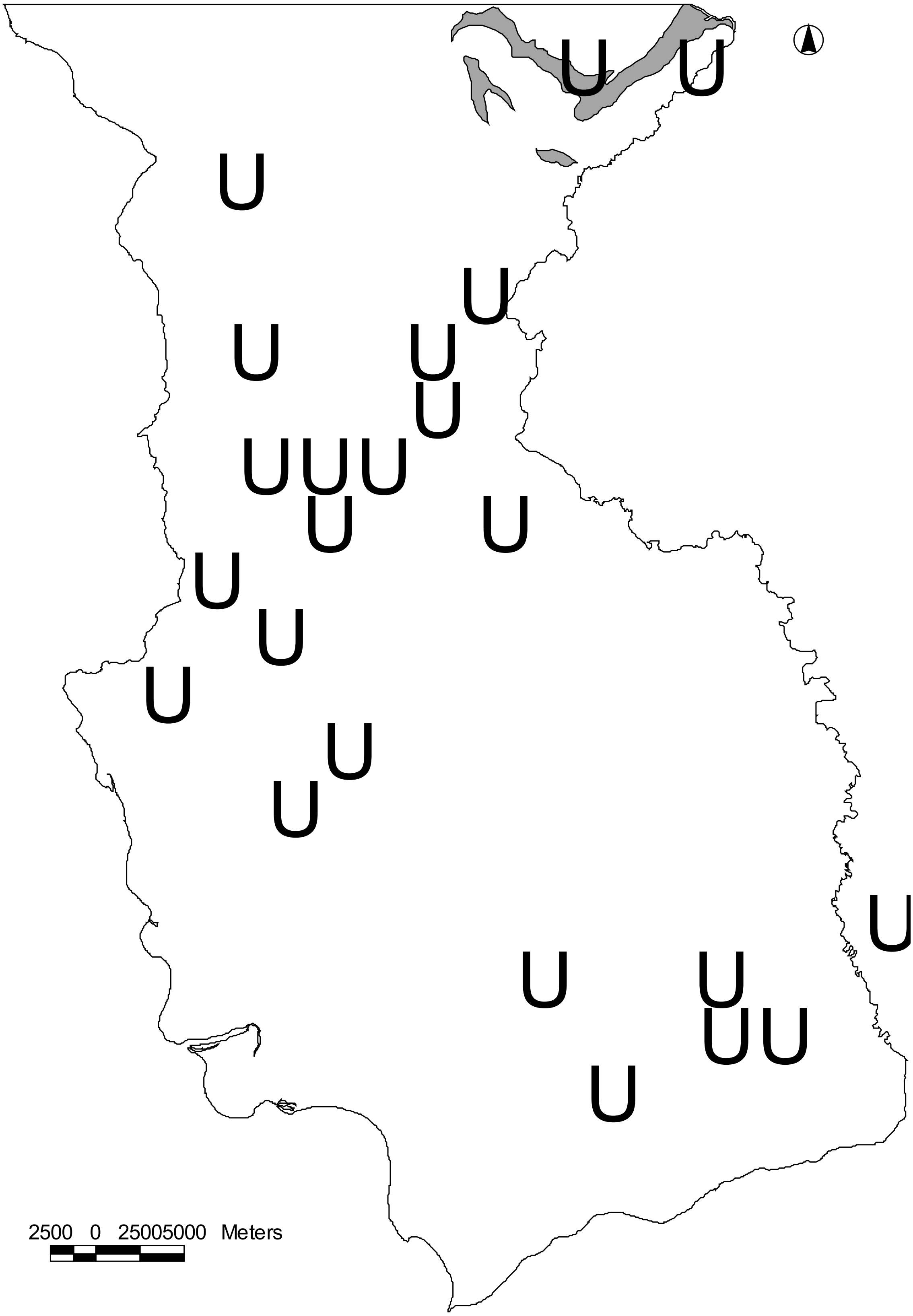
Vernacular name	Scientific name	#/ha
Morabukea	Mora gonggrijpii	23.58
Greenheart	Chlorocardium rodiei	10.87
Wallaba, soft	Eperua falcata	9.88
Kakaralli, black	Eschweilera sagotiana	5.99
Wamara	Swartzia leiocalycina	5.25
Kakaralli, others	Eschweilera _spp	3.23
Baromalli	Catostemma __sp	3.06
Sarebebeballi	Vouacapoua macropetala	1.72
Kautaballi	Licania alba	1.69
Crabwood	Carapa guianensis	1.64
Trysil	Pentaclethra macroloba	1.27
Banya	Swartzia bannia	1.14
Mora (ak,ar)	Mora excelsa	1.09
Goupi	Goupia glabra	1.04
Ruri, common	Chaetocarpus schomburgkianus	1.04

Fifteen ha plots have been laid out in this forest type in the Pibiri Experimental site. Most common species in these plots are Greenheart (*Chlorocardium rodiei*), Wirimiri (*Lecythis confertiflora*), Baromalli (*Catostemma fragrans*), Waiaballi (*Tapura guianensis*), Karishiri (*Oxandra asbeckii*), Marishiballi (*Licania canesecens*), Black kakaralli (*Eschweilera sagotiana*), Kairiballi (*Licania heteromorpha*), Crabwood (*Carapa guianensis*), Kautaballi (*Licania alba*), and Morabukea (*Mora gongrijpii*). The abundance of species like Waiaballi and Karishiri is due to the lower diameter limit taken in these plots (10 cm).

Diversity
In total 3665 individuals were enumerated, amounting to 130 species. This results in a Fisher's alpha of 26.3. The 15 Pibiri plots have and average Fisher's alpha of 19.8. Eleven species have been found exclusively in this forest type.

Biomass and carbon store
Mixed forests Type 1e have a high number of trees per area (Appendix 1), with a basal area of 17.18 (for trees over 30 cm). The total biomass estimate for this forest is 367 t/ha (Appendix 2) giving a carbon estimate of 183 t/ha. There is an average amount of organic carbon in the soils (Ferralic Arenosols Ferralsols) (appendix 3) and deep rooting is expected because of the sandy structure of most brown sands. Thus carbon for the soil between 100 and 800 cm is estimated according to Nepstad *et al*. (1994) at 98 t/ha (Appendix 3). This brings the total organic carbon on the soil at 163 t/ha and that of the forest at 346, very comparable to that of mixed forest type 1.

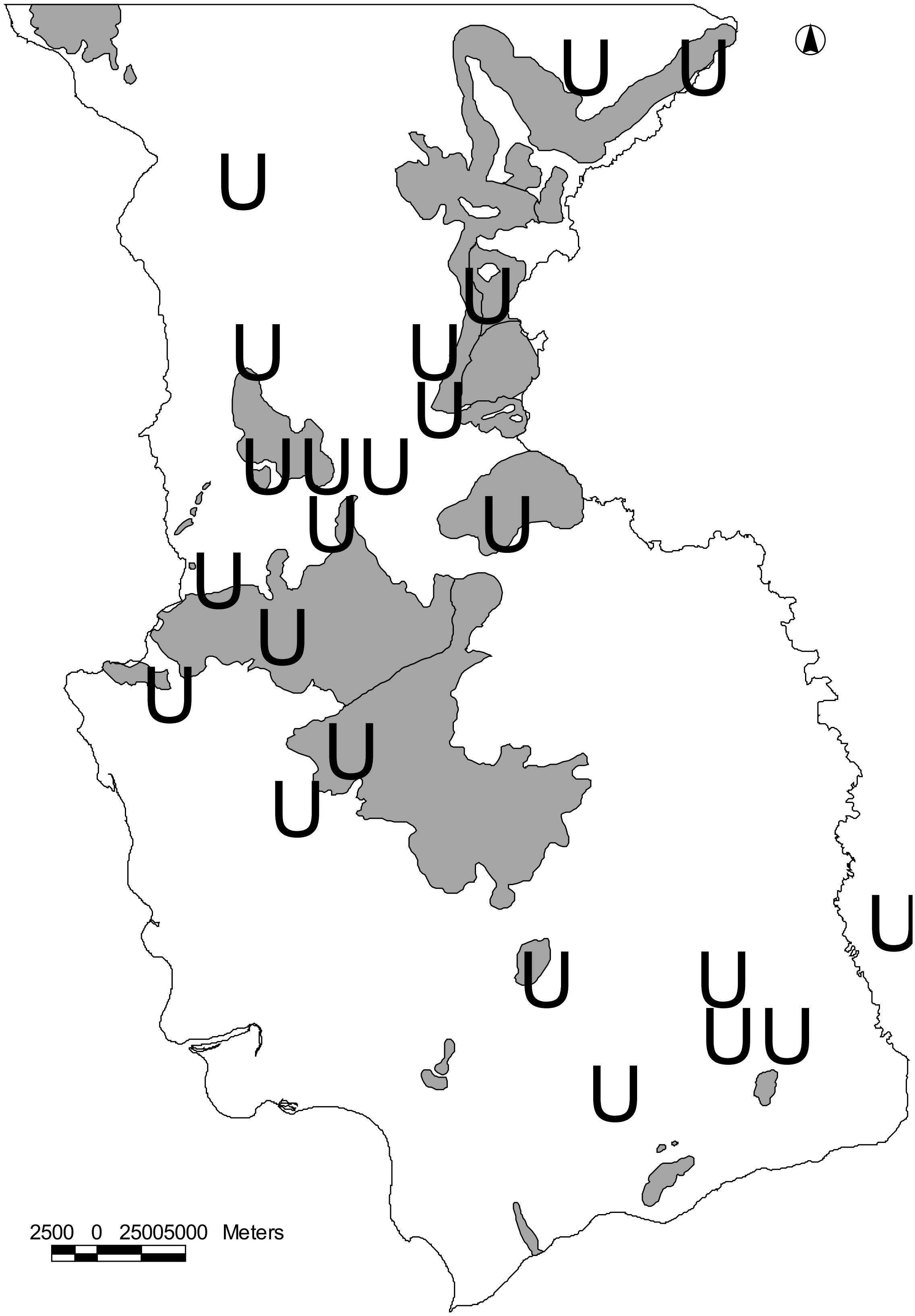
Type 1fs: Mixed forest on footlsopes (2,501 ha)



Type 1fs: Mixed forest on footlsopes (2,501 ha)

Forest on footslopes is mainy found in the north-western section at the base of the Mabura ridge. Only very few plots have been laid out in it and its composition will be discussed under forest type 1h, with which it is very comparable.

Type 1h: Mixed forest on steep high hills (40,298 ha)



Type 1h: Mixed forest on steep high hills (40,298 ha)

Forest on steep high hills is found mainly in the two hill systems of the area, the Mabura ridged, and Akaiwan Mountains. Wamara (*Swartzia leiocalycina*), an endemic to Guyana, is the most abundant species. In the northern hill system (Mabura ridge) Sarebebeballi (*Vouacapoua macropetala*), an endemic to the region is very abundant. It is absent from the central hill system (Akwaiwan Mts.). Clump wallaba, another endemic to Guyana, is very common in the central Hill system.

Table 7. Species with abundance over 1 tree per ha (trees larger than 30 cm DBH) in forest on steep high hills (1h).

Vernacular name	Scientific name	#/ha
Wamara	Swartzia leiocalycina	10.44
Greenheart	*Chlorocardium rodiei*	8.78
Kakaralli, black	*Eschweilera sagotiana*	7.14
Aromata	*Clathrotropis brachypetala*	6.58
Wallaba, clump	*Dicymbe altsonii*	6.05
Morabukea	*Mora gonggrijpii*	5.15
Kakaralli, others	*Eschweilera* spp.	4.54
Wallaba, soft	Eperua falcata	4.49
Trysil	*Pentaclethra macroloba*	3.55
Crabwood	*Carapa guianensis*	3.19
Sarebebeballi	*Vouacapoua macropetala*	2.17
Baromalli	*Catostemma spp.*	1.51
Aruadan	*Sloanea guianensis*	1.22
Manariballi	*Balizia pedicellara*	1.05

Three more plots have been laid out in this forest type in the Forest Reserve Mabura Hill. Most common species here are typical for the Mabura Ridge laterite area: Sarebebeballi (*Vouacapoua macropetala*), Morabukea (*Mora gonggrijpii*), Not Sure (*Poecilanthe hostmanii*), Unknow Z (*Maburea trinervis*), Aromata (*Clathrotropis macrocarpa*), Black Kakaralli (*Eschweilera sagotiana, E. subglandulosa*), Wamara (*Swartzia leiocalycina*), Greenheart (*Chlorocardium rodiei*), and Trysil (*Pentaclethra macroloba*).

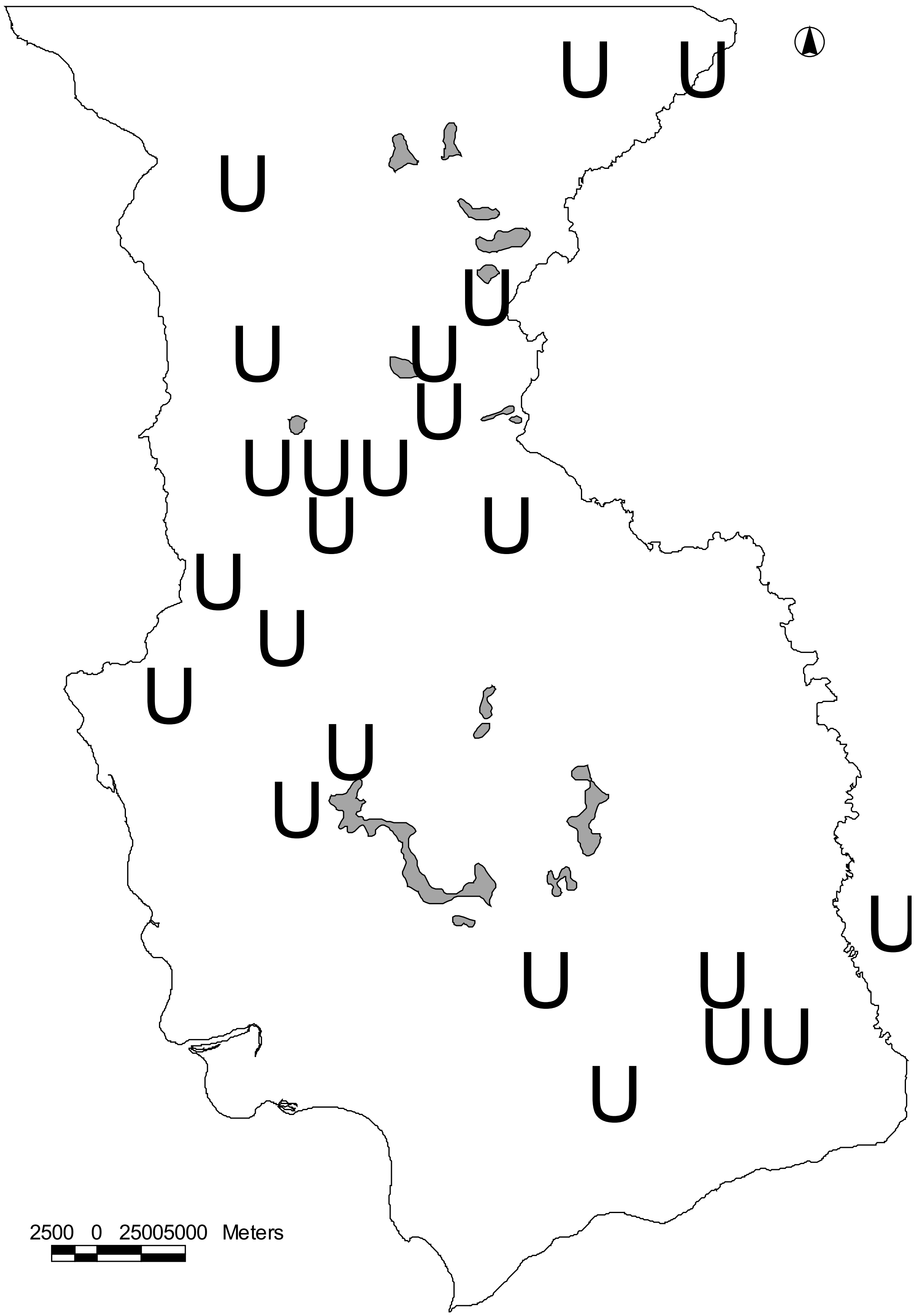
Diversity

In total 3488 individuals were enumerated, amounting to 136 species. This results in a Fisher's alpha of 28.2. The 3 FRMH plots have and average Fisher's alpha of 17.5.

Biomass and carbon store

Mixed forests steep high hills have an average number of trees per area (Appendix 1), with a relatively high basal area of 18.6 (for trees over 30 cm). The total biomass estimate for this forest is 387 t/ha (Appendix 2) giving a carbon estimate of 193 t/ha. There is a high amount of organic carbon in the soils (Leptosols) (appendix 3) but deep rooting is not expected. The total organic carbon of the soil is estimated to be 136 t/ha and that of the forest 339.

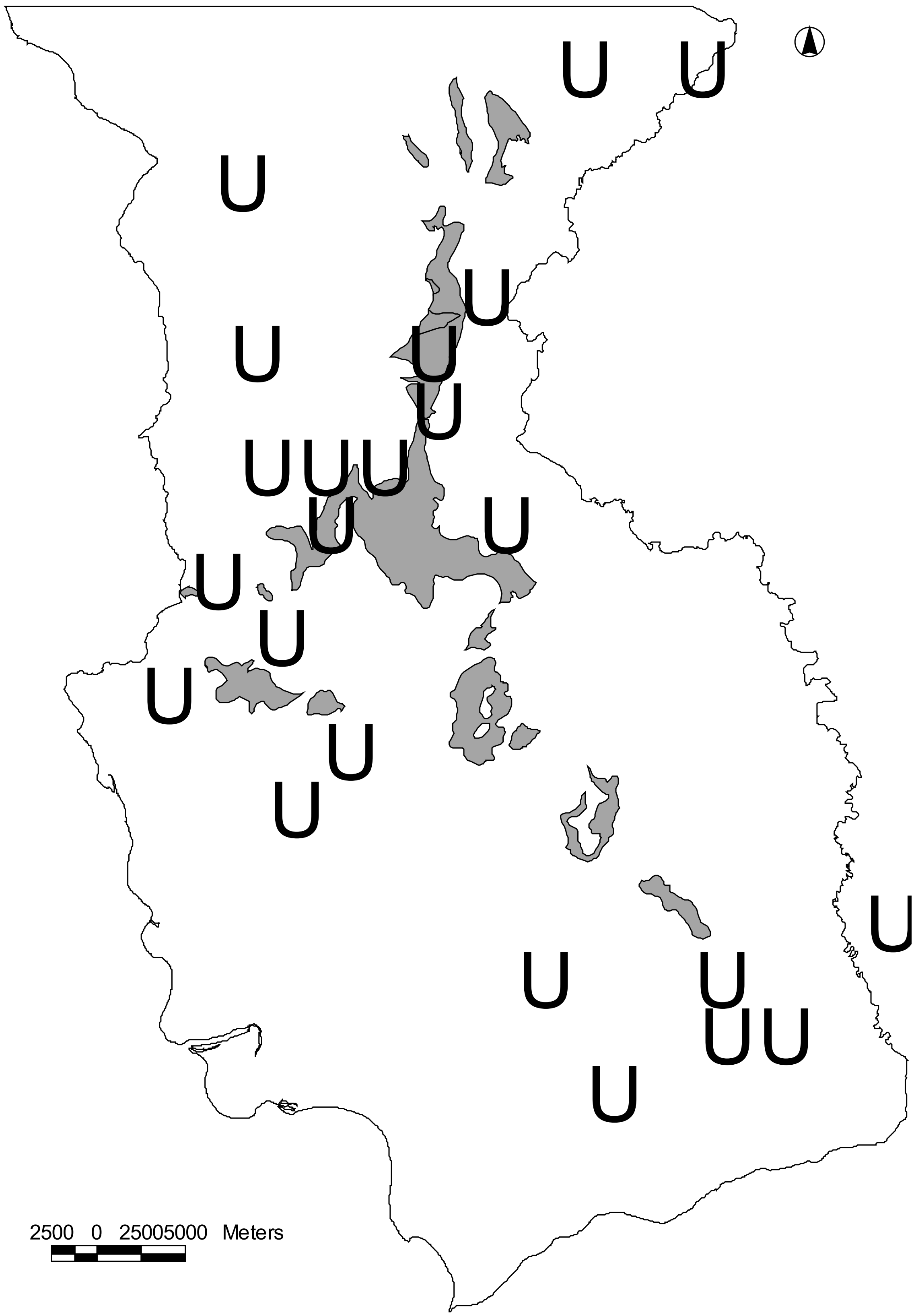
Type 1k: Low mixed forest on steep high hills (2,873 ha)



Type 1k: Low mixed forest on steep high hills (2,873 ha)

No information on composition or structure

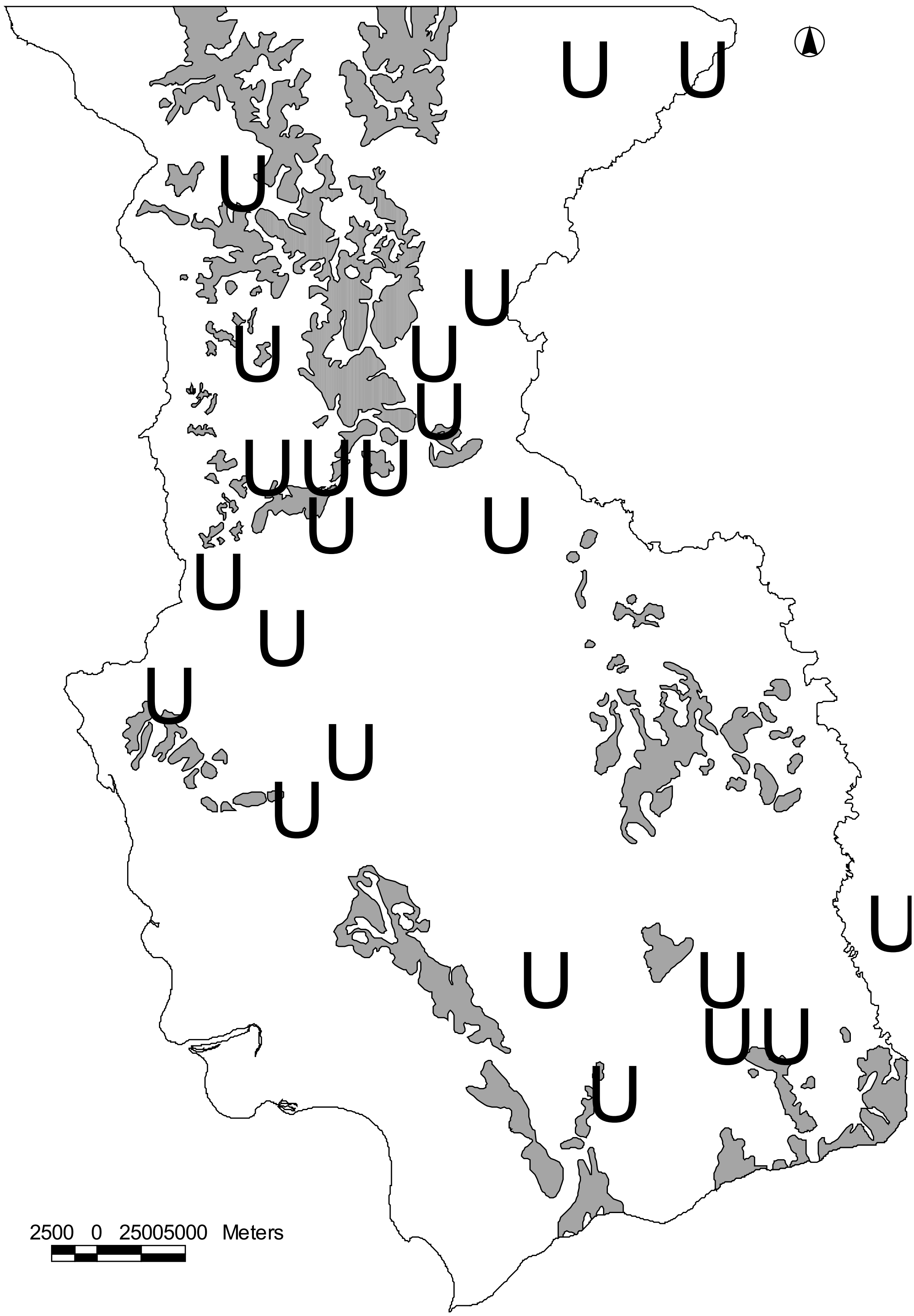
Type 1lp: Mixed forest on dissected plateaux (11,190 ha)



Type 1lp: Mixed forest on dissected plateaux (11,190 ha)

FIDS: no info

Type 2 & 2a: Wallaba and Clump wallaba forest on white sand soils (50,065 ha)



Type 2 & 2a: Wallaba and Clump wallaba forest on white sand soils (50,065 ha)

Clump wallaba forest and wallaba forest are very similar in composition. In small areas I Clump wallaba forest, though, Clump wallaba (*Dicymbe altsonii*) may be very strongly dominant. The average composition of wallaba forest is given in table 8. Wallaba forests are almost exclusively found on the excessively drained white sands at the higher parts of the watershed.

Table 8. Species with abundance over 1 tree per ha (trees larger than 30 cm DBH) in wallaba forest (2a).

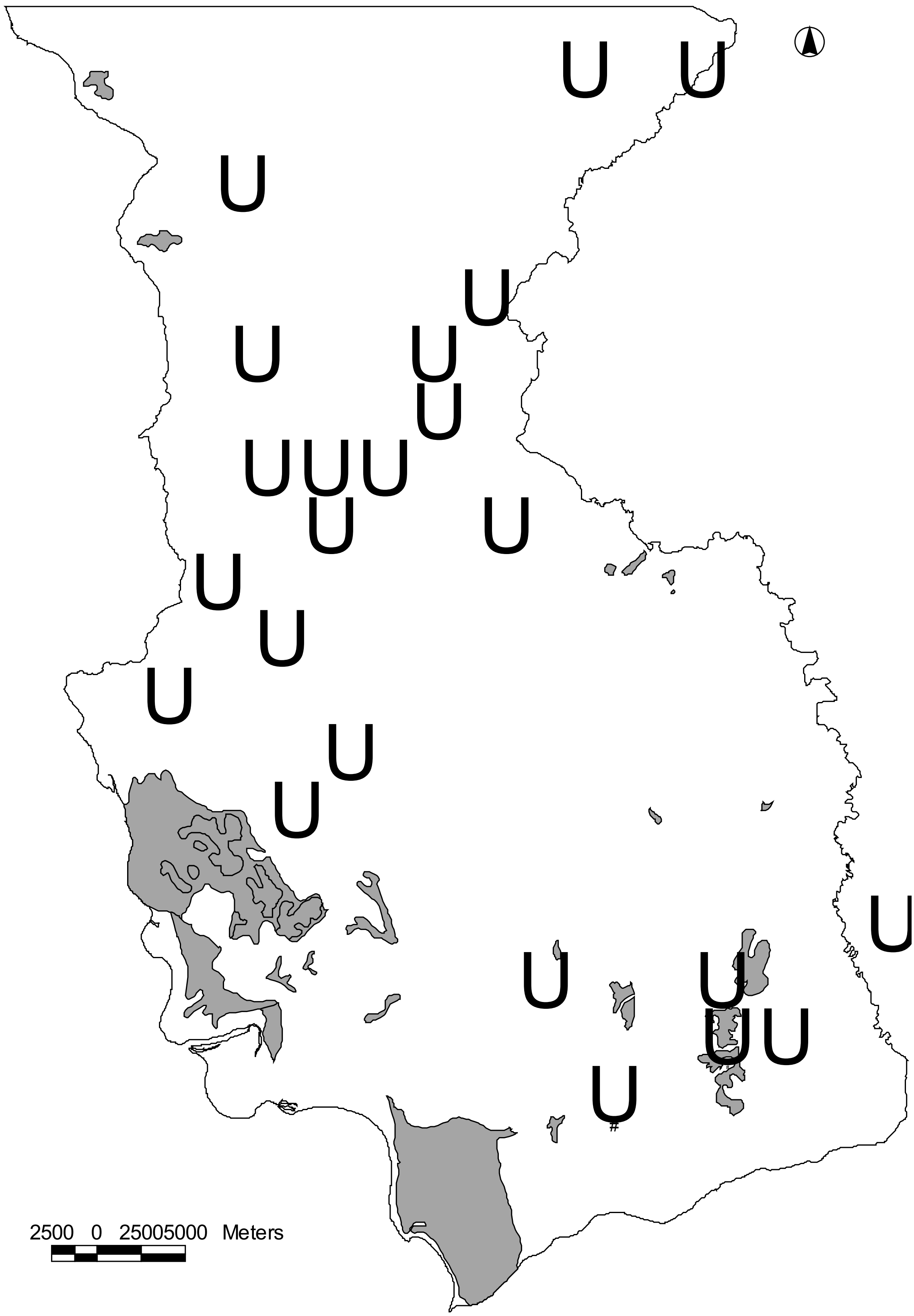
Vernacular name	Scientific name	#/ha
Wallaba, soft	Eperua falcata	33.01
Ituri grandiflora	Eperua grandiflora	31.12
Wallaba, clump	Dicymbe altsonii	10.3
Baromalli	Catostemma __sp	6.98
Korokororo	Ormosia coutinhoi	4.32
Moroballi	Talisia squarrosa	2.99
Imirimiaballi	Chamaecrista adiantifolia	2.33
Marishiballi	Licania canescens	2.1
Kuyama, others	Xylopia spp	1.77

Plots in the NW part of the concession have much higher densities of Wallabas (*Eperua* spp., 52-80/ha) and total number of stems than plots in the SE part, where the plots on white sand are found on the Ituni sands (Gleyic Arenosol) or degraded wallaba forest/muri-dakama scrub. The more detailed inventories of wallaba forest in the Waraputa watershed and the FRMH show similar results, although the order of abundance may differ. For example Ituri wallaba (*E. grandiflora*) is the most abundant species in these areas on white sand, followed by Clump wallaba (*Dicymbe altsonii*) and Soft wallaba (*E. falcata*) in the Waraputa watershed, and by Soft wallaba (*E. falcata*) and Baromalli (*Catostemma fragrans*) in the FRMH. Clump Wallaba (*Dicymbe altsonii*) and Ituri Wallaba (*E. grandiflora*) are not found in the southern part of the concession and also seem to be absent in the Wallaba forests of the Iwokrama forest.

Diversity
In total 991 individuals were enumerated, amounting to 64 species. This results in a Fisher's alpha of 14.9. Two ha plots (1 in FRMH, 1 in Iwokrama) had an average Fisher's alpha of 11.3. A high number of endemic species are found in Wallaba forest and very common in it.

Biomass and carbon store
Wallaba forests on white sands have a very high number of (mostly small) trees per area (Appendix 1), with a basal area of 18 (for trees over 30 cm). The total biomass estimate for this forest is 401 t/ha (Appendix 2) giving a carbon estimate of 200 t/ha. There is low average amount of organic carbon in the soils (Albic Arenosols) (appendix 3) and deep rooting is expected because of the sandy structure of most brown sands. Thus carbon for the soil between 100 and 800 cm is estimated according to Nepstad *et al*. (1994) at 98 t/ha (Appendix xx). This brings the total at organic carbon on the soil at 141 t/ha and that of the forest at 341.

Type 2d, e: Dakama forest and degraded Wallaba forest (14,427 ha)



Type 2d, e: Dakama forest and degraded Wallaba forest (14,427 ha)

Low poor Wallaba forest and Dakama forest and Dakama-Muri scrub is mainly found in the southern part of the area.

Table 9. Species with abundance over 1 tree per ha (trees larger than 30 cm DBH) in degraded Wallaba forest (based on very few plots).

Vernacular name	Scientific name	#/ha
Dakamaballi	Aldina insignis	30.31
Moroballi	*Talisia squarrosa*	5.61
Baromalli	*Catostemma* spp.	3.37
Dakama	*Dimorphandra conjugata*	3.37
Korokororo	*Ormosia coutinhoi*	2.25
Silverballi, yellow	*Aniba hypoglauca*	1.12
Ulu	*Trattinickia* spp.	1.12
Barakaro	*Ormosia coccinea*	1.12
Corkwood, hill	*Pterocarpus rohrii*	1.12

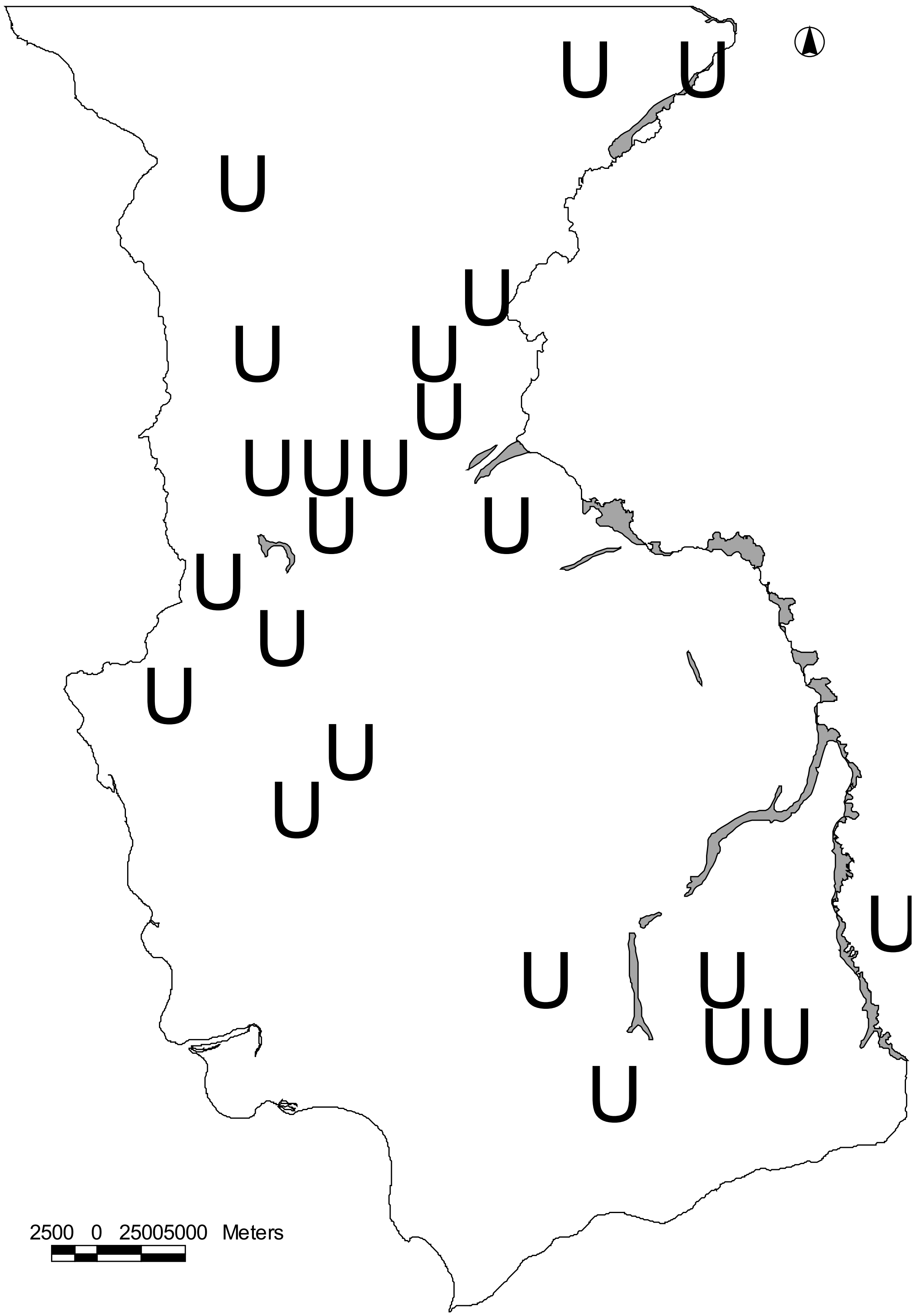
Many species do not grow to large size in this very impoverished vegetation type. Typical species found are Dakama (*Dimorphandra conjugata*), Yaruru (*Aspidosperma excelsum*), Banya (*Swartzia bannia*), Manabodin (*Emmotum fagifolium*), Soft wallaba (*Eperua falcata*). Very degraded patches are dominated by Dakama (*Dimorphandra conjugata*) and Muri (*Humiria balsamifera*).

Dakama forest is thought to be a fire climax and evidence of fire is everywhere to be found in the forest. Still annually fires occur in this forest type during the dry season.

Diversity
Not enough data. Poor.

Biomass and carbon store
Degraded Wallaba forests have low stem number (Appendix 1), low basal area (6.97 for trees over 30 cm). The total biomass estimate for this forest is 160 t/ha (Appendix 2) giving a carbon estimate of 80 t/ha (for the few existing plots). There is low average amount of organic carbon in the soils (Albic Arenosols) (appendix 3) and deep rooting is expected because of the sandy structure of most brown sands. Thus carbon for the soil between 100 and 800 cm is estimated according to Nepstad *et al*. (1994) at 98 t/ha (Appendix xx). This brings the total at organic carbon on the soil at 141 t/ha and that of the forest at 221. In more degraded patches it may be as low as 60t/ha (ter Steege 1998b). Where the soil is seasonally flooded a small layer of pegasse may be present. Here soil carbon may be considerable but data are not available.

Type 3: Low swamp forest (3,537 ha)



Type 3: Low swamp forest (3,537 ha)

Low swamp forest is found along the Demerara River but also along most of the smaller creeks and rivers draining the white sand vegetation of the area.

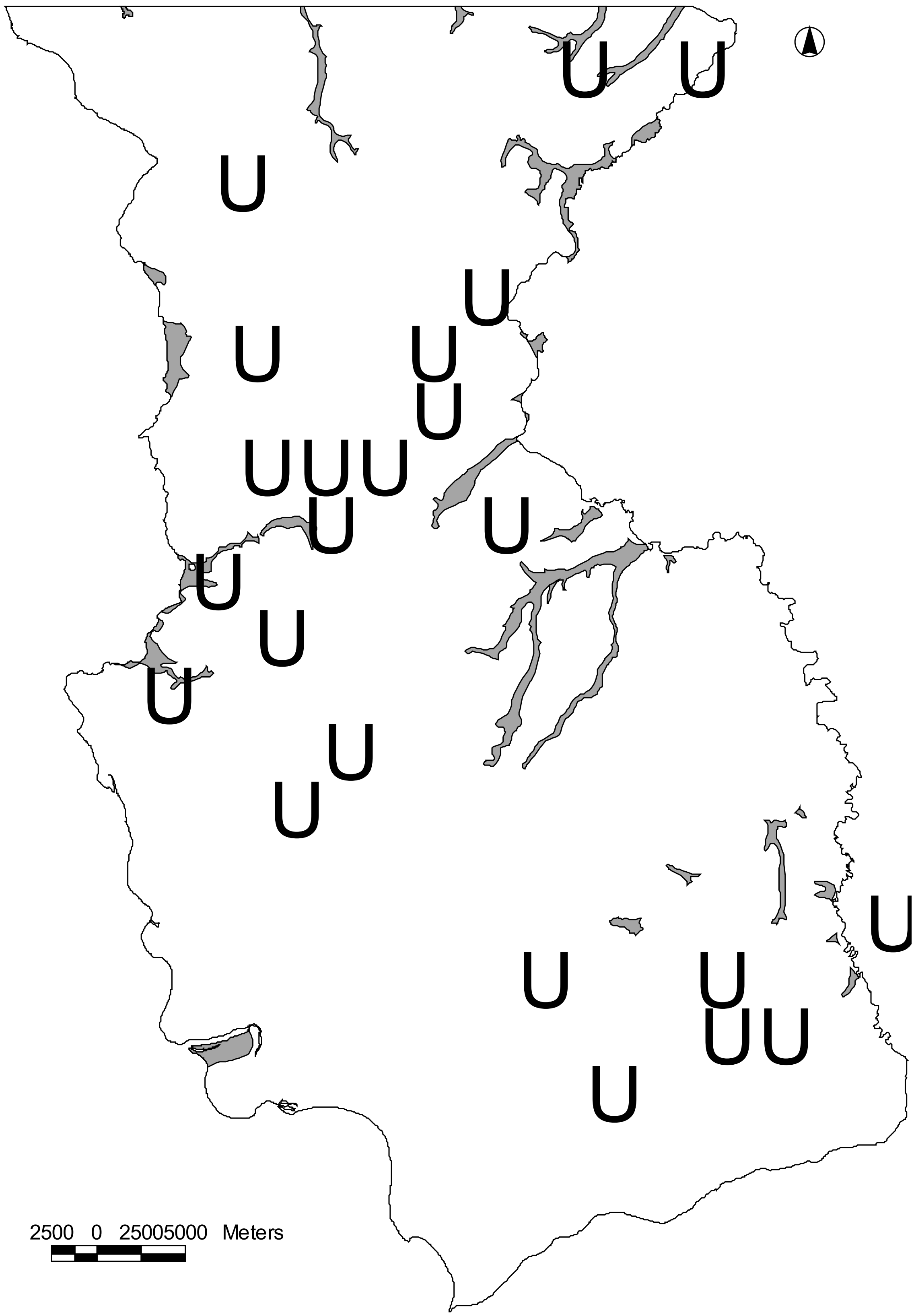
There are not many plots in the main patches of this forest type. Most common species enumerated were Crabwood (*Carapa guianensis*), White cedar (*Tabebuia insignis*), Soft wallaba (*Eperua falcata*), Baromalli (*Catostemma* spp.), and Ituri wallaba (*Eperua grandiflora*).

In swamp forest along the small creeks palms (Turu (*Jessenia bataua*) and Ite (*Maurtia flexuosa*)) are usually a common and often co-dominant feature.

Diversity
Not enough data. Poor

Biomass and carbon store
The few plots enumerated had an low number of trees per area (Appendix 1), with a basal area of 11.4 (for trees over 30 cm). The total biomass estimate for this forest is 258 t/ha (Appendix 2) giving a carbon estimate of 129 t/ha. An average for all forests on Histosols is 163 t/ha. There is potentially a huge amount of organic carbon in the soils (Histosols), depending on the thickness of the peaty layer (appendix 3). Peat soils in the coast may store over 1900 t C/ha (ter Steege 1998b). Each 10 cm of peat deposit would amount to approximately 245 t C/ha. Van Kekem, estimated the average peat layers in central Guyanan swamp forest to be 20cm. Thus a estimate for the total carbon content would be 619 t/ha. But for areas with large peat deposits this could be a serious underestimate. Though swap forest are small in extent they may thus contribute significantly to the carbon store of an area.

Type 3b: Mora forest along creeks and rivers (6,132 ha)



Type 3b: Mora forest along creeks and rivers (6,132 ha)

Mora forest is mainly found along the larger creeks and rivers on clayey sediments. Mora (*Mora excelsa*) is the most dominant species.

Table 10. Species with abundance over 1 tree per ha (trees larger than 30 cm DBH) in Mora forest (3b).

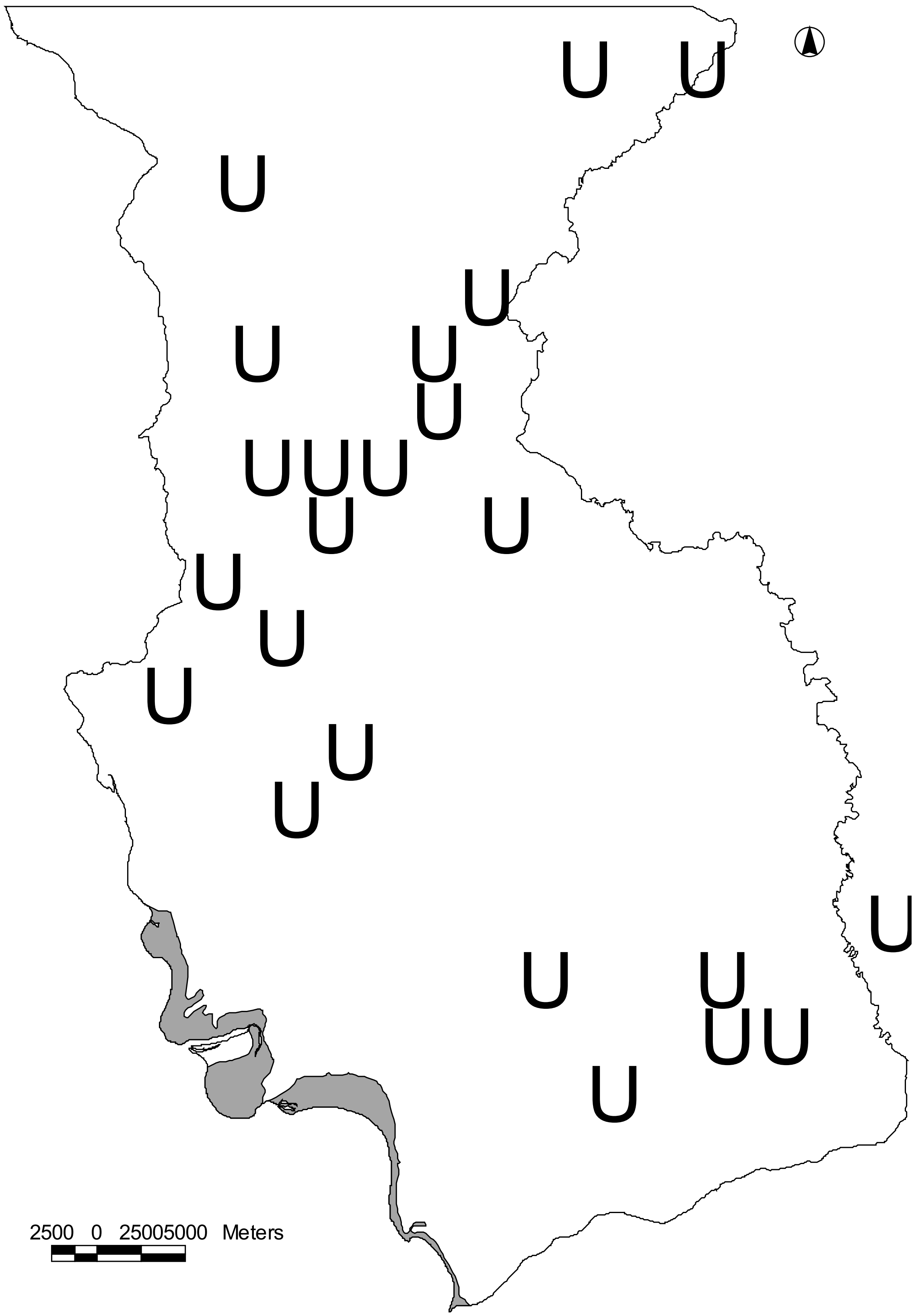
Vernacular name	Scientific name	#/ha
Mora	Mora excelsa	41.17
Crabwood	*Carapa guianensis*	22.64
Simapura	*Simarouba amara*	6.18
Soft wallaba	*Eperua falcata*	4.12
Baromalli	*Catostemma* spp.	4.12
Manariballi	*Balizia pedicellara*	4.12
Duru	*Apeiba petoumo*	4.12
White Cedar	*Tabebuia insignis*	2.06
common Ruri	Chaetocarpus schomburgkianus	2.06
Karohoro	*Schefflera* spp.	2.06
Warakosa	*Inga* spp.	2.06
common Kurokai	*Protium decandrum*	2.06
Arara	*Unonopsis glaucopetala*	2.06

The co-dominant species like Crabwood (*Carapa* spp.) and, in the north-western section, Watapa (*Eperua rubiginosa*) can be dominant over small parts.

Diversity
There are too few trees enumerated to calculate Fisher's alpha. Two ha plots (1 in FRMH, 1 in Iwokrama) had an average Fisher's alpha of 20.7.

Biomass and carbon store
Mora forests have an average number of trees per area (Appendix 1), with a basal area of 18.6 (for trees over 30 cm). The total biomass estimate for this forest is 402 t/ha (Appendix 2) giving a carbon estimate of 201 t/ha. There is a fairly high amount of organic carbon in the top soils (Fluvisols, 167 t/ha) (Appendix 3) but deep rooting is not to be expected. The total carbon estimate for the forest is 569 t/ha.

Type 3d: Low open swamp/Muri scrub on inundated soils (4,253 ha)



Type 3d: Low open swamp/Muri scrub on inundated soils (4,253 ha)

Low swamp on 'hog-wallowed' terrain is found on the gleyic, periodically flooded, areas along the southern parts of the Essequibo. Composition is not exactly known but is partly similar to 2d/e. Ite palm (*Mauritia flexuosa*) is common in the permanently wet areas. Madaburi (*Clusia fockeana*) is common too.

No information on diversity or biomass is availabe.

5 The Forest Reserve Mabura Hill

The Forest Reserve Mabura Hill is situated just 15 km south of the township Mabura Hill (Figure 3). The reserve is approximately 1800 ha. The FRMH was established late 1987 through a mutual agreement between DWL (a predecessor of DTL) and the Forest Project Mabura Hill (a joint research project of the Universities of Guyana and Utrecht). The major forest types of the northern part of the MHCA can be found within the FRMH.

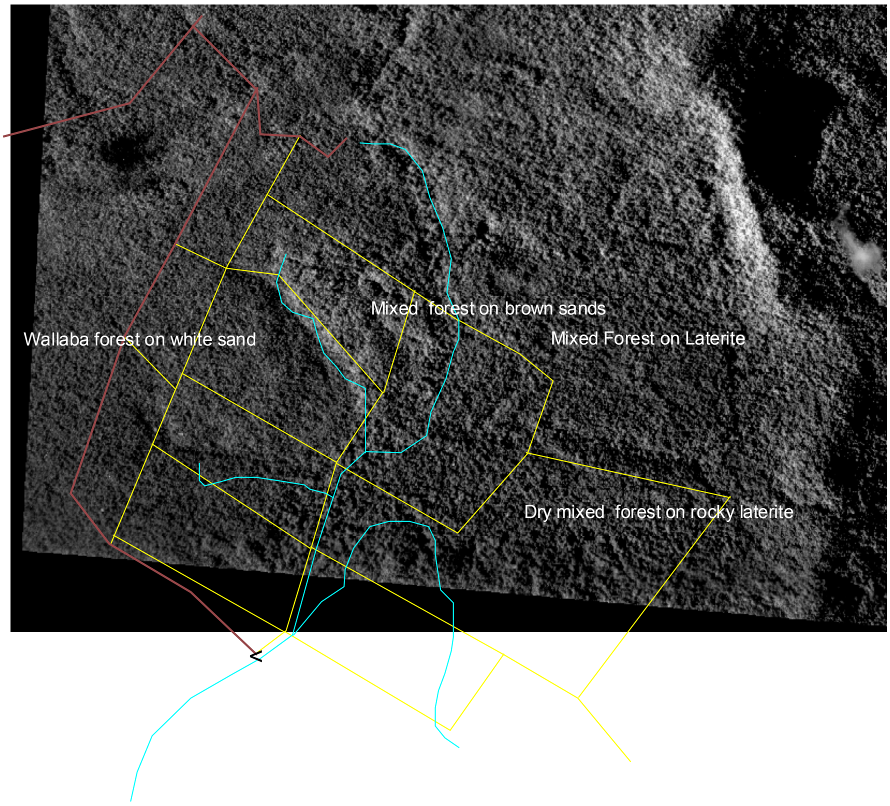


Figure 4. Air-photo impression of the Forest Reserve Mabura Hill, with major forest types and trail system

Soils of the FRMH

Based on the FAO classification system, 12 soil types are recognised in the FRMH (Figure 5). On the west side of the main creek sands and sandy loams are found which are classified as Arenosols and Ferralsols. On the east side clayey soils with thick laterite layers and laterite gravel beds occur, classified as Plinthosols. In the swamps and valley floor Histosols and Fluvisols occur.

ARa - Albic Arenosols (Tiwiwid Sand, unit 700):
The White Sand Plateau consists for more than 86% of quartz with a texture of medium sand and no clay. The A-horizon may consist of greyish brown sand with evenly mixed organic matter, or the organic matter is present in small distinct particles giving the soil a "pepper and salt" appearance. Sometimes the texture changes to coarse sand below several meters and the colour becomes light grey. In the research area Albic Arenosols have a pH between 4 and 4.5 and both CEC and total bases that are about 1.5 meq/100g.

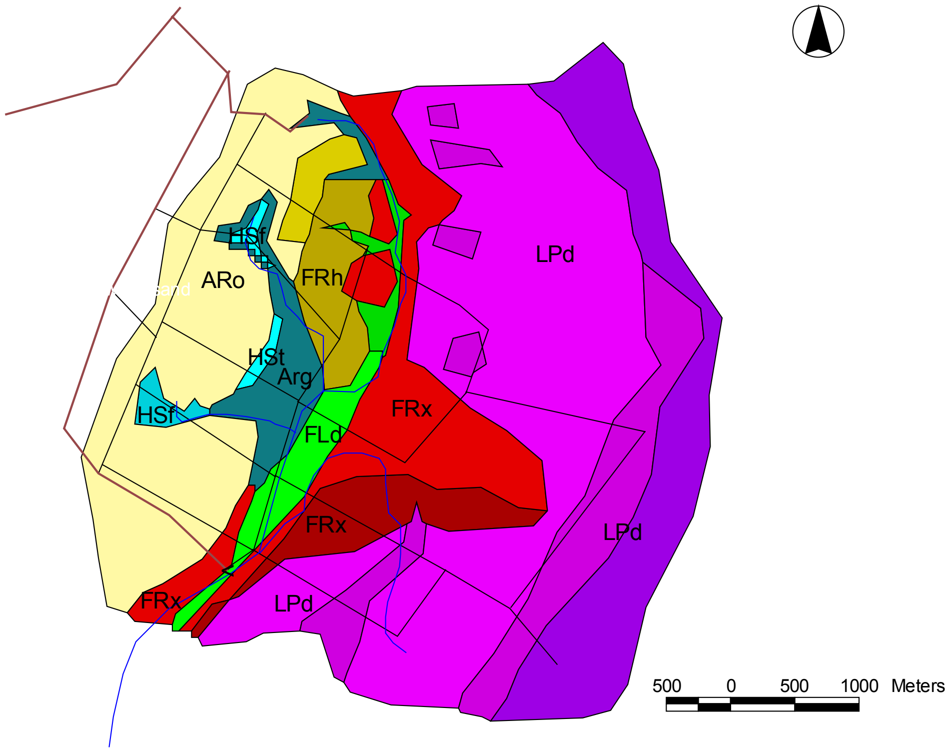


Figure 5. Digital soil map of the FRMH, according to the FAO classification (see text above and below for abbreviations and descriptions).

ARg - Gleyic Arenosols (Ituni Sand, unit 701):
The upper part of the soil is similar to the Albic Arenosol but a very dark brown to black, very dense sandy layer occurs within 1 meter of the surface. Below this layer one can often find a white kaolinitic clay layer. Both layers are virtually impermeable and a perching or permanent groundwater table causes a reduced environment. From field observations it seems that this layer stretches out over large areas beneath the Albic Arenosols but only on the lower slopes it does reach the surface, where it causes a change in classification from Albic to Gleyic Arenosols. According to Khan et al. (1980)Khan et al. (1980) the black pan may be a result of lateral movement of water with a high content of soluble organic acids, which precipitate as organic complexes and chelates with aluminum and iron. Although the organic matter content of the pan is somewhat higher, the acidity, total bases and CEC in the rest of the soil are similar to the Albic Arenosol.

ARo - Ferralic Arenosols (Tabela Sand, unit 800):
These soils have a sand to loamy sand texture. Because of the dark brown A-horizon over a yellowish to reddish brown C-horizon, this soil type is a member of the "Brown Sands" group in Guyana. The Ferralic Arenosols also consist mainly of quartz sand but the higher clay and silt content may have prevented extensive podzolization. These soils are often found adjacent to the Albic Arenosols with very sharp lateral boundaries (changes from a typical ARo to a typical ARa may occur within 20 m). In the research area they are always found in a sequence from the loamier Brown Sands (see below) to the White Sands, indicating that the Ferralic Arenosols were possibly formed during the deposition of the Berbice Formation as a mixture of sediments with

the weathering material formed in situ on the granite. On the other hand, the variation in texture could also be a result of sedimentation in a different environment. Acidity is high (pH = 4 - 4.5) and total bases and CEC are about 6 meq/100g in the topsoil to less than 2 meq/100g below.

FRh - Haplic Ferralsols (Kasarama Loamy Sand, unit 810):
The soil has a dark brown loamy sand A-horizon over a strong brown to yellowish brown sandy loam B and C-horizons and is also a member of the Brown Sands group. In the area the soil can be more than 5 m deep with weathered rock at the lower boundary. Intensive ferralitisation of the crystalline basement complex rocks has resulted in a relative accumulation of resistant primary minerals and formation of kaolinite and iron oxides and hydroxides (hematite and goethite). Because the parent material is rich in quartz the ferralitisation process is slow and kaolinite is formed rather than aluminum hydroxide (gibbsite). However on the intrusions the parent material is mainly dolerite which has a lower quartz content, causing a more intensive ferralitisation process is stronger and possible presence of gibbsite. The iron oxides are strong binding agents which form very stable micro aggregates in the soil. Acidity can be very low (pH < 4) and because of the higher clay content the total bases and CEC can be between 2 and 6 meq/100g over the whole profile.

FLd - Dystric Fluvisols (Mixed Alluvial Colluvial, unit 366; Barima Silt Loam, unit 370):
These weakly developed soils consist of recent deposits in floodplains and can have any texture from sand to silty clay. Colours vary from yellowish brown to light grey. The sedimentation processes may cause stratification. They are subject to flooding several times a year and the topsoil is rich in organic matter. Acidity is high (pH 3.1 - 4.5) and CEC is low (1.8 to 6.3 meq/100g).

HSs/HSf - Terric and Fybric Histosols (Lama Muck, Anira Peat, unit 60 and 20):
Dark grey to black sandy soils rich in partly decomposed organic matter. They are formed in small swamps in gully heads and along the floodplain, and are inundated most of the year. High acidity (pH 3.1 to 3.5) and low CEC (2.5 - 5.1 meq/100g).

FRx – Xanthic Ferralsol (Tiger creek gravelly clay, unit 390)
Soils mainly found in the footslopes of hills. High ironstone gravel content, very low nutrient status and low pH.

LPd - Distric Leptosols (Mabura very gravelly sandy clay, unit 398, Seballi very gravelly clay loam, unit 400, Ekuk clay loam, unit 405, Wappu clay, unit 410)
Leptosols are found on the high hills and slopes. Lithic phases within 20 cm are present in the higher parts of the slopes. High gravel content is found midslope. Leptosols have very high Al saturation and low pH.

Forest types in the FRMH

A forest inventory was carried out in 5 metres on both sides of the major trails in the FRMH. In total 883 plots were established (Figure 6).

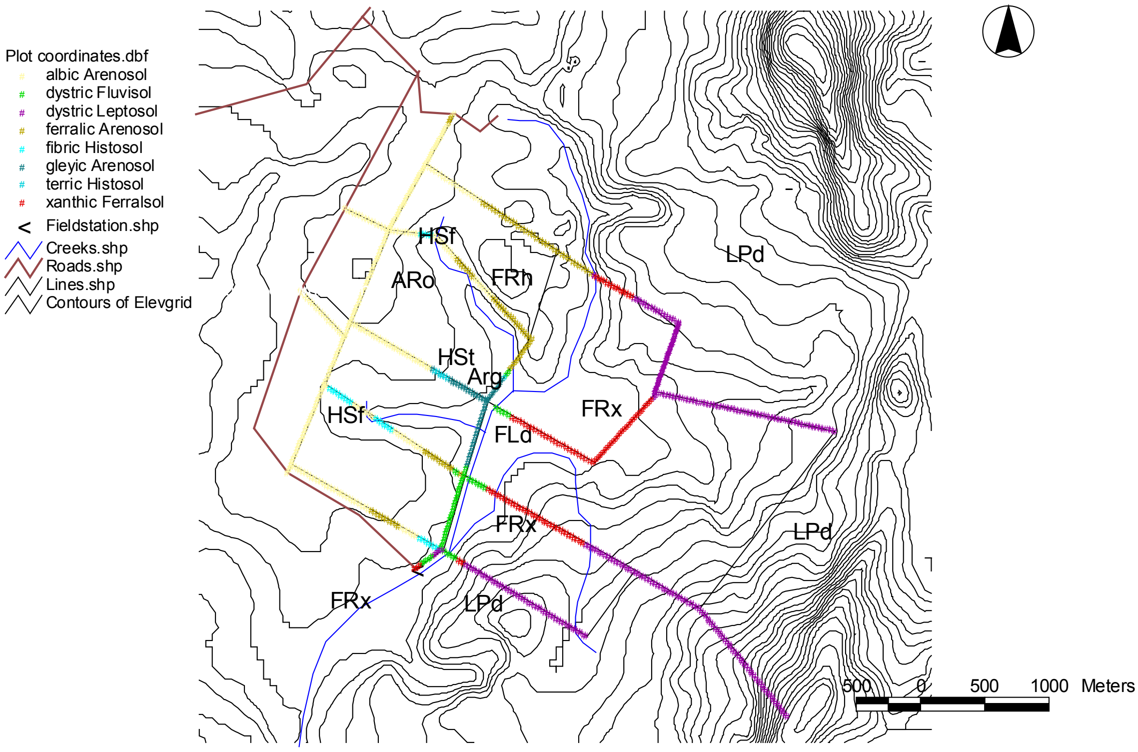


Figure 6. Forest inventory plots in the FRMH. Plots are classified on the basis of the FAO soil classification (see Figure 5).

A total of 18,121 (GBH > 7 cm) were measured and labelled with an aluminium tag. The resulting database and GIS serve as a perfect training tool for treespotters.

Most common species in the inventory were Eperua grandiflora, Catostemma fragrans, Eperua falcata, *and* Vouacapoua macropetala. *As expected several species were well segregated between soil types, with the biggest differences between the white sands (Ara and Arg) and brown sand and laterites.*

A description of the most clear forest types is given below.

Wallaba forest

Wallaba forest is found exclusively on the white sands (ARa). The main dominant species are Eperua grandiflora *and* E. falcata. *Together they account for 34% off all individuals in this forest type. There is a gradient in species from the wetter (bottom) part of the slope to the excessively drained top parts. Close to the swamps e.g.* Ormosia coutinhoi *is commonly found, followed by* Dicymbe altsonii*, which dominates the slightly moist white sands.* Eperua falcata *and finally* E. grandiflora *are found abundantly on the excessively drained parts. Several common species show high fidelity for the white sands. E.g. 91% of all* E.grandiflora *individuals of the inventory are found on white sand. Other species with over 90% of their individuals on white sand are* Chrysophyllum sanguinolentum, Duroia eriopila, Rhabdodendron amazonicum, *and* Vouarana guianensis. *All common species are species of the Guiana lowlands and several species, endemic to Guyana, are abundantly found in Wallaba forest, most notably* Licania buxifolia *and* L. cuprea.

Diversity is low in Wallaba forest. Eight trail segments with ARa soils had an average Fisher's alpha of 12.6. One ha plot has been established in the Wallaba forest (Thomas 1999), with a Fisher's alpha of 10.5.
Despite the relatively low alpha diversity the Wallaba forest, having a high proportion and abundance of endemic species, has high conservation value for Guyana

***Table 11**. Twenty most abundant species in Wallaba forest. Total of dbh is the total number of individuals found in the complete inventory; N is the total number of individuals found on Ara; % is the percentage of individuals of N belonging to the species – a measure of dominance; inX is the percentage of the individuals of Total of dbh occurring in this forest type – a measure of specificity.*

Family	Species	Total Of dbh	N	%	inX
Caesalpiniaceae	Eperua grandiflora	1629	1484	21.7	91.1
Caesalpiniaceae	*Eperua falcata*	1157	824	12.0	71.2
Bombacaceae	*Catostemma fragrans*	1180	743	10.9	63.0
Chrysobalanaceae	*Licania buxifolia*	692	588	8.6	85.0
Sapotaceae	*Chrysophyllum sanguinolentum*	552	499	7.3	90.4
Caesalpinaceae	*Dicymbe altsonii*	624	351	5.1	56.3
Guttiferae	*Tovomita grata*	181	176	2.6	97.2
Sapindaceae	*Talisia squarrosa*	194	151	2.2	77.8
Rubiaceae	*Duroia eriopila*	148	138	2.0	93.2
Chrysobalanaceae	*Licania cuprea*	160	132	1.9	82.5
Papilionaceae	*Ormosia coutinhoi*	176	119	1.7	67.6
Papilionaceae	*Swartzia oblanceolata*	201	117	1.7	58.2
Lauraceae	*Aniba kappleri*	141	111	1.6	78.7
Rhabdodendraceae	*Rhabdodendron amazonicum*	90	84	1.2	93.3
Sapindaceae	*Vouarana guianensis*	88	83	1.2	94.3
Dichapetalaceae	*Tapura guianensis*	244	75	1.1	30.7
Mimosaceae	*Zygia racemosa*	77	72	1.1	93.5
Sapindaceae	*Talisia elephantipes*	69	66	1.0	95.7
Guttiferae	*Clusia fockeana*	82	65	0.9	79.3
Euphorbiaceae	*Pera bicolor*	122	61	0.9	50.0

Wallaba Forest on wet white sands (Arg)
On the white sands with a hardpan within 1.20 m of the soil surface many species typical of the lower parts of well-drained white sand watersheds are found. Thus, Catostemma fragrans, Eperua falcata, Eperua grandiflora, Ormosia coutinhoi*, and* Chrysophyllum sanguinolentum *are commonly found. Certain species of the valley bottoms and peat swamps are found as well:*
Eperua rubiginosa, Mora excelsa, Tabebuia insignis*, and* Iryanthera sagotiana*.*

The forest has low alpha diversity. Fisher's Alpha based on five trail segments passing through this forest is 13.8.

Table 12*. Twenty most abundant species in Wallaba forest on sandy gley soils. Abbreviations as in Table 11.*

Family	species	Total Of dbh	N	%	inX
Bombacaceae	Catostemma fragrans	1180	123	13.8	10.4
Caesalpiniaceae	*Eperua falcata*	1157	95	10.6	8.2
Caesalpiniaceae	*Eperua grandiflora*	1629	93	10.4	5.7
Caesalpiniaceae	*Eperua rubiginosa*	281	62	6.9	22.1
Dichapetalaceae	*Tapura guianensis*	244	41	4.6	16.8
Caesalpinaceae	*Chamaecrista adiantifolia*	93	40	4.5	43.0
Papilionaceae	*Ormosia coutinhoi*	176	32	3.6	18.2
Sapotaceae	*Chrysophyllum sanguinolentum*	552	28	3.1	5.1
Chrysobalanaceae	*Licania laxiflora*	47	27	3.0	57.4
Annonaceae	*Oxandra asbeckii*	207	24	2.7	11.6
Euphorbiaceae	*Hevea pauciflora*	39	22	2.5	56.4
Caesalpiniaceae	*Chaemaecrista apoucouita*	345	18	2.0	5.2
Lauraceae	*Aniba kappleri*	141	16	1.8	11.3
Bignoniaceae	*Tabebuia insignis*	123	15	1.7	12.2
Myristicaceae	*Iryanthera sagotiana*	64	13	1.5	20.3
Euphorbiaceae	*Pera bicolor*	122	12	1.3	9.8
Myrtaceae	*Marlierea cuprea*	520	12	1.3	2.3
Euphorbiaceae	*Sandwithia guyanensis*	124	11	1.2	8.9
Chrysobalanaceae	*Licania buxifolia*	692	11	1.2	1.6
Caesalpiniaceae	*Mora excelsa*	98	10	1.1	10.2

Palm swamp forest on Histosols (HSf, HSt)

Palm swamp forest is found mainly in the gully heads of small creeks penetrating into the white sands. A permanent high water table creates swamp conditions in which palms are the most characteristic (but not dominant) feature. The most common species are listed in Table 13.

Alpha diversity is relatively low, with a Fisher's alpha (based on six trail segments) of 12.6.

***Table 13**. Twenty most abundant species in Palm Swamp forest on peat soils. Abbreviations as in Table 11.*

Family	Species	Total Of dbh	N	%	inX
Bombacaceae	Catostemma fragrans	1180	107	11.2	9.1
Bignoniaceae	*Tabebuia insignis*	123	97	10.2	78.9
Caesalpiniaceae	*Eperua falcata*	1157	68	7.1	5.9
Caesalpiniaceae	*Senna multijuga*	160	43	4.5	26.9
Caesalpiniaceae	*Eperua grandiflora*	1629	42	4.4	2.6
Dichapetalaceae	*Tapura guianensis*	244	37	3.9	15.2
Myristicaceae	*Iryanthera sagotiana*	64	36	3.8	56.3
Palmae	*Jessenia bataua*	38	35	3.7	92.1
Chrysobalanaceae	*Licania buxifolia*	692	35	3.7	5.1
Chrysobalanaceae	*Licania densiflora*	43	31	3.3	72.1
Caesalpinaceae	*Dicymbe altsonii*	624	27	2.8	4.3
Arecaceae	*Mauritia flexuosa*	26	24	2.5	92.3
Papilionaceae	*Ormosia coutinhoi*	176	24	2.5	13.6
Ebenaceae	*Diospyros ierensis*	50	23	2.4	46.0
Guttiferae	*Symphonia globulifera*	28	21	2.2	75.0
Euphorbiaceae	*Chaetocarpus __sp*	35	17	1.8	48.6
Chrysobalanaceae	*Licania laxiflora*	47	16	1.7	34.0
Sapindaceae	*Talisia squarrosa*	194	16	1.7	8.2
Lauraceae	*Aniba excelsa*	37	15	1.6	40.5
Myrtaceae	*Marlierea schomburgkiana*	24	15	1.6	62.5

Creek/Marsh forest along main creeks (FLd)

Marsh forest dominated by Eperua rubiginosa *and* Mora excelsa *is found along the main creek in the FRMH.* E. rubiginosa *is strongly dominant in the lowest lying portion in the central to south area of the FRMH.*

Fishers alpha based on five trail segments passing through this forest is 13.8, indicating relatively low diversity. This is expected given the high dominance of the two most commons species. A 15 ha plot (partially sampled) had a Fisher's alpha of 18.7 (Thomas 1999).

Table 14*. Twenty most abundant species in Marsh forest along the main creek. Abbreviations as in Table 11.*

Family	Species	Total Of dbh	N	%	InX
Caesalpiniaceae	Eperua rubiginosa	281	192	25.1	68.3
Caesalpiniaceae	*Mora excelsa*	98	55	7.2	56.1
Lecythidaceae	*Eschweilera sagotiana*	247	44	5.8	17.8
Bombacaceae	*Catostemma fragrans*	1180	35	4.6	3.0
Caesalpiniaceae	*Chaemaecrista apoucouita*	345	35	4.6	10.1
Mimosaceae	*Pentaclethra macroloba*	387	32	4.2	8.3
Meliaceae	*Carapa guianensis*	67	26	3.4	38.8
Caesalpiniaceae	*Vouacapoua macropetala*	915	24	3.1	2.6
Caesalpiniaceae	*Mora gonggrijpii*	304	23	3.0	7.6
Caesalpiniaceae	*Eperua falcata*	1157	16	2.1	1.4
Papilionaceae	*Swartzia leiocalycina*	342	16	2.1	4.7
Lecythidaceae	*Eschweilera wachenheimii*	220	16	2.1	7.3
Olacaceae	*Maburea trinervis*	303	13	1.7	4.3
Caesalpinaceae	*Dicymbe altsonii*	624	12	1.6	1.9
Fabaceae	*Poecilanthe hostmanii*	456	11	1.4	2.4
Papilionaceae	*Swartzia oblanceolata*	201	11	1.4	5.5
Dichapetalaceae	*Tapura guianensis*	244	10	1.3	4.1
Annonaceae	*Unonopsis glaucopetala*	77	9	1.2	11.7
Melastomataceae	*Tococa aristata*	21	9	1.2	42.9
Fabaceae	*Clathrotropis brachypetala*	208	7	0.9	3.4

Mixed forest on brown sands (FRo, FRh)

Traditionally known as Morabukea forest, Greenheart forest, Kakaralli-Kauta forest, themixed forest shows relative constant composition over the research area. Certain species may become dominant on particular stretches of a watershed, suggesting a gradient from the wetter to the dryer parts (ter Steege 1993). Such a gradient with Mora gonggrijpii *and* Dicymbe altsonii *at the bottom parts and* Chlorocardium rodiei *and* Eschweilera sagotiana *is also found in the FRMH. The most abundant species are found in table 14.*

Diversity is relatively high with an average Fisher's alpha of 21.9 for five trail segments crossing this forest type. Two ha plots in the central part had a Fisher's alpha of 14.4 and 11.9 respectively, which is much lower than the average.

***Table 15**. Twenty most abundant species in Mixed forest on brown sands. Abbreviations as in Table 11.*

Family	species	Total Of dbh	N	%	inX
Caesalpinaceae	Dicymbe altsonii	624	186	11.8	29.8
Caesalpiniaceae	*Mora gonggrijpii*	304	88	5.6	28.9
Chrysobalanaceae	*Licania heteromorpha*	107	80	5.1	74.8
Caesalpiniaceae	*Chaemaecrista apoucouita*	345	73	4.6	21.2
Bombacaceae	*Catostemma fragrans*	1180	70	4.4	5.9
Lecythidaceae	*Eschweilera sagotiana*	247	67	4.3	27.1
Olacaceae	*Maburea trinervis*	303	65	4.1	21.5
Caesalpiniaceae	*Eperua falcata*	1157	60	3.8	5.2
Lauraceae	*Chlorocardium rodiei*	160	57	3.6	35.6
Lecythidaceae	*Lecythis confertiflora*	168	54	3.4	32.1
Dichapetalaceae	*Tapura guianensis*	244	50	3.2	20.5
Annonaceae	*Oxandra asbeckii*	207	42	2.7	20.3
Papilionaceae	*Swartzia oblanceolata*	201	34	2.2	16.9
Caesalpiniaceae	*Vouacapoua macropetala*	915	31	2.0	3.4
Fabaceae	*Poecilanthe hostmanii*	456	31	2.0	6.8
Euphorbiaceae	*Pera bicolor*	122	29	1.8	23.8
Fabaceae	*Clathrotropis brachypetala*	208	28	1.8	13.5
Annonaceae	*Guatteria atra*	73	27	1.7	37.0
Caesalpiniaceae	*Eperua rubiginosa*	281	26	1.7	9.3
Euphorbiaceae	*Sandwithia guyanensis*	124	23	1.5	18.5

Mixed forest on gravelly clay (FRx)

Mixed forest on gravelly clay is mainly found at the footslopes of the lateritic hill system of the FRMH. The species composition is quite comparable with that of the forest of the higher parts of the hills.

Diversity is relatively high, with an average Fisher's alpha of 21.9 for four trail segments passing through this forest type.

***Table 16**. Twenty most abundant species in Mixed forest on brown sands. Abbreviations as in Table 11.*

Family	species	Total Of dbh	N	%	inX
Caesalpiniaceae	Vouacapoua macropetala	915	295	16.0	32.2
Fabaceae	*Poecilanthe hostmanii*	456	95	5.2	20.8
Mimosaceae	*Pentaclethra macroloba*	387	89	4.8	23.0
Lecythidaceae	*Eschweilera wachenheimii*	220	87	4.7	39.5
Caesalpiniaceae	*Mora gonggrijpii*	304	86	4.7	28.3
Papilionaceae	*Swartzia leiocalycina*	342	82	4.4	24.0
Myrtaceae	*Marlierea cuprea*	520	79	4.3	15.2
Olacaceae	*Maburea trinervis*	303	72	3.9	23.8
Caesalpiniaceae	*Chaemaecrista apoucouita*	345	67	3.6	19.4
Fabaceae	*Clathrotropis brachypetala*	208	62	3.4	29.8
Lecythidaceae	*Eschweilera sagotiana*	247	55	3.0	22.3
Annonaceae	*Oxandra asbeckii*	207	50	2.7	24.2
Rhizophoraceae	*Cassipourea lasiocalyx*	251	45	2.4	17.9
Euphorbiaceae	*Sandwithia guyanensis*	124	41	2.2	33.1
Lauraceae	*Chlorocardium rodiei*	160	38	2.1	23.8
Caesalpinaceae	*Dicymbe altsonii*	624	33	1.8	5.3
Lecythidaceae	*Lecythis confertiflora*	168	29	1.6	17.3
Caesalpiniaceae	*Eperua falcata*	1157	28	1.5	2.4
Bombacaceae	*Catostemma fragrans*	1180	26	1.4	2.2
Annonaceae	*Unonopsis glaucopetala*	77	24	1.3	31.2

Mixed forest on laterite (LPd)

Comparable to Wallaba forest, forest on lateritic soil has a relatively high number of common species that are almost totally restricted to this type. When the numbers of the xanthic Ferralsols are added to this the number is even larger. The most common species are listed in table 17. Species almost restricted to the lateritic soils are Sterculia rugosa *and* Ampelocera edentula.
If we combine FRx with LPd, a large number of common species is almost exclusive for this forest type: Trichilia rubra *(N= 149, inX=100),* Ampelocera edentula *(103, 100),* Cassipourea lasiocalyx *(249, 99.2),* Sterculia rugosa *(504, 94.9),* Marlierea cuprea *(493, 94.8),* Vouacapoua macropetala *(853, 93.2),* Eschweilera wachenheimii *(202, 91.8),* Poecilanthe hostmanii *(411, 90.1),* Swartzia leiocalycina *(303, 88.6),* Guatteria sandwithii *(147, 86.5),* Pentaclethra macroloba *(333, 86.0).*

Diversity is relatively high. Six trail segment passing through the laterite showed an average Fisher's alpha of 23.9. Three ha plots in this forest type showed a somewhat lower Fisher's alpha of 15 to 19 (Thomas 1999, van Essen 1999).

Because of the high specificity of the forest flora and the insular character of the lateritic outcrops in central and NW Guyana, this forest has high conservation potential. Several endemics (e.g. Vouacapoua macropetala *and* Swarzia Leiocalycina*) are found in this forest (see also Davis 1941).*

Table 17*. Twenty most abundant species in Mixed forest on lateritic soils. Abbreviations as in Table 11.*

Family	Species	Total Of dbh	N	%	inX
Caesalpiniaceae	**Vouacapoua macropetala**	915	558	10.6	61.0
Sterculiaceae	*Sterculia rugosa*	531	489	9.3	92.1
Myrtaceae	*Marlierea cuprea*	520	414	7.9	79.6
Fabaceae	*Poecilanthe hostmanii*	456	316	6.0	69.3
Mimosaceae	*Pentaclethra macroloba*	387	244	4.7	63.0
Papilionaceae	*Swartzia leiocalycina*	342	221	4.2	64.6
Rhizophoraceae	*Cassipourea lasiocalyx*	251	204	3.9	81.3
Olacaceae	*Maburea trinervis*	303	153	2.9	50.5
Meliaceae	*Trichilia rubra*	149	146	2.8	98.0
Annonaceae	*Guatteria sandwithii*	170	137	2.6	80.6
Caesalpiniaceae	*Chaemaecrista apoucouita*	345	132	2.5	38.3
Elaeocarpaceae	*Sloanea guianensis*	165	128	2.4	77.6
Lecythidaceae	*Eschweilera wachenheimii*	220	115	2.2	52.3
Fabaceae	*Clathrotropis brachypetala*	208	109	2.1	52.4
Ulmaceae	*Ampelocera edentula*	103	101	1.9	98.1
Caesalpiniaceae	*Mora gonggrijpii*	304	100	1.9	32.9
Caesalpiniaceae	*Senna multijuga*	160	86	1.6	53.8
Sapotaceae	*Sapotaceae ___1*	98	85	1.6	86.7
Annonaceae	*Oxandra asbeckii*	207	82	1.6	39.6
Lecythidaceae	*Lecythis confertiflora*	168	79	1.5	47.0