Plant Diversity and Composition of the Forests in the Surroundings of Kwamalasamutu

Authors: Bánki, Olaf, and Bhikhi, Chequita

Source: A Rapid Biological Assessment of the Kwamalasamutu region, Southwestern Suriname: 43

Published By: Conservation International

URL: https://doi.org/10.1896/054.063.0104

Chapter 2

Plant diversity and composition of the forests in the surroundings of Kwamalasamutu

Olaf Bánki and Chequita Bhikhi

SUMMARY

During a rapid assessment of the plant diversity and composition of the forests in the surroundings of Kwamalasamutu we made 401 plant collections belonging to 62 families, 132 genera, and approximately 240 species. These collections were made in the nine vegetation types we distinguished. We found eight species previously unrecorded in Suriname, of which six were tree species, and two were herbaceous species. We also found a substantial number of rare plant species for Suriname, including six tree species listed on the IUCN Red List and three tree species protected under Surinamese law. The forests in the surroundings of Kwamalasamutu are heterogeneous, and different forest types can be found in close proximity to one another. The forests at the three sampling sites each had a distinct species composition. The forests along the Kutari River had one of the highest tree alpha diversity values ever recorded for Suriname. At the same time, the forests at Werehpai had relatively low tree alpha diversity values. Comparison of our results with data from forests in northern Suriname showed that forests in the Kwamalasamutu surroundings have to some extent a distinct species composition. Based on these results we argue that the forests in the surroundings of Kwamalasamutu have a high natural value, one that warrants appropriate conservation measures.

INTRODUCTION

Most of our knowledge of the diversity and species composition of different forest types is based on studies from the northern regions of Suriname, whereas the forests in the southern regions of Suriname (as well as Guyana and French Guiana) are relatively unexplored. We know very little about the diversity and species composition of these forests. This lack of knowledge of plant diversity and composition hampers the assessment of the natural value of forests in southern Suriname. This knowledge is very much needed for sound decision-making concerning the sustainable management of the forest in Suriname.

Very often the tropical lowland forests of the central and southern regions of the Guianas are considered as one uniform forest type. However, an analysis of 156 1-ha plots across the Guianas has demonstrated that tree diversity and composition of forests mostly follow geological formations (Bánki 2010). The northern regions of Suriname are mostly made up of new and old coastal plains with their specific vegetation and plant species composition (Lindeman and Moolenaar 1959). The Zanderij or Coesewijne formation, with its white and brown sands, separates the northern regions from the Guiana Shield basement complex that extends over the central and southern parts of Suriname. This change in geological formation is also (partly) reflected in a change in species composition and diversity, especially concerning the white sands (Bánki 2010). Extrapolations suggest that tree alpha diversity could be higher in southern Suriname compared to the northern regions of Suriname (ter Steege et al. 2006). Although results from niche modeling based on herbarium collections do suggest similar patterns, the findings also suggest that forests in the Kwamalasamutu region could be less diverse

(Haripersaud 2009). We are in need of quantitative data on tree diversity and species composition of the forests in southern Suriname.

Our objective during the rapid assessment in the surroundings of Kwamalasamutu was to provide baseline data on abundance and diversity of trees, and plant species in general, by vegetation surveys and plot inventories. These data are a first step in determining to what extent the diversity and species composition of the forest in the Kwamalasamutu surroundings differs from the northern region of Suriname. As the RAP sites are close to both Guyana and Brasil, we expected to encounter some new plant species for Suriname. For comparison we used extensive datasets on 1-ha plots (Bánki 2010) and 0.1-ha plots (O. Bánki unpublished data; C. Bhikhi unpublished data) assembled during previous years in the northern region of Suriname.

FLORISTIC TEAM

The floristic team consisted of the following people:

Dr. Olaf Bánki and Chequita Bhikhi
General Plant collecting, plot inventories, and species identification

Klassie Etienne Foon
Tree spotter, plot inventories

Aritakosé Asheja and Sheinh A Oedeppe
Local tree spotter, trainee, tree climbers

Reshma Jankipersad, Jonathang Sapa
Field assistants and trainee, plot inventories

Tedde Shikoei, Willem Joeheo, Mopi and Dennis
Boatmen, field assistants

METHODS

We sampled at three sites: the Kutari River (Site 1), the Sipaliwini River (Site 2), and at Werehpai and Wioemi Creek (Site 3). At each site we used the same sampling methods, consisting of general vegetation surveys and plot inventories.

General Vegetation Surveys

General plant collecting took place along trails in the forest and along the rivers, including while traveling between camps. All flowering and fruiting plants encountered were collected during these surveys, and we recorded the different vegetation types found. Plant collections were numbered in the number series of Olaf Bánki (using OSB), and were pressed and dried in the field above kerosene stoves. At least one duplicate was stored in the National Herbarium of Suriname. The other duplicates were sent to the National Center for Biodiversity Naturalis (NCB), which harbors all plant collections of the National Herbarium of the Netherlands. Identifications of the dried specimens took place in the Guianas collections of the NCB Naturalis. The specimens were identified using several plant identification books of the Guianas and plant identification keys (e.g., Pulle et al. 1932; Jansen-Jacobs 1985; Steyermark et al. 1995). After identification, the specimens were compared with herbarium specimens for confirmation. Duplicates of some plant families were sent to their respective taxonomic group specialist within the Flora of the Guianas network. We determined new records for Suriname by checking the occurrence of the species in the checklist of the Guianas (Funk et al. 2007) and the digital database of the Guianas collections of the NCB Naturalis, and by consulting the collections of the Missouri Botanical Gardens at www.discoverlife.org.

Plot Inventories

At each study site we created one 1-ha plot (250 × 40 m) in a dominant high forest type on dryland (terra firme) and identified all trees above 10 cm dbh (diameter at breast height) in the plots. Within each site, we placed one 0.1-ha plot several hundred meters from the 1-ha plot, in the same high forest type, and identified all tree species above 2.5 cm dbh. Palms were included in the assessment, whereas lianas were not assessed in these plots due to time constraints. Preliminary identification of trees in the plots was made by tree spotter Klassie Etienne Foon of SBB, Olaf Bánki, and ACT personnel Sheinh A Oedeppe and Aritakosé Asheja. For each species encountered for the first time in the plots, we made a plant collection. Collections of tree species were processed in a similar way as the plant collections of the general surveys.

In total, six plots were established (Table 1). The Kutari plots (Ku1 & Ku2) were established in high mature tropical rainforest on loamy sands. Soils were deep and well drained, and there were no boulders or traces of hard parent rock in the plot. The Sipaliwini plots (Si3 & Si4) were placed on a

Table 1. Metadata for the plots established at each site during the RAP. N = number of individuals, S = number of species, Fα = Fisher's alpha.

Plot Name	Ha	Dimensions	N	S	Fα	Lat	Long
Kutari River Plot 1	1	250 × 40 m	529	140	62.15	240377	524499
Kutari River Plot 2	0.1	100 × 10 m	142	81	78.3	240461	523639
Sipaliwini River Plot 3	1	250 × 40 m	443	116	51.14	252395	544182
Sipaliwini River Plot 4	0.1	100 × 10 m	123	54	36.74	253056	544157
Werehpai Plot 5	1	250 × 40 m	454	104	42.19	262877	535847
Werehpai Plot 6	0.1	100 × 10 m	158	46	21.8	262640	535547

hill approximately 200–300 meters above sea level. The forest was standing on shallow to deep loamy sandy soils on top of the hard parent rock of the Guiana Shield basement complex. A portion of plot Si3 contained forest transitioning into liana forests and low savannah forest due to large boulders and the hard parent rock reaching the surface. The Werehpai plots (We5 & We6) were placed in mature tropical rain forest on sandy soils with large boulders throughout the plots. Soils were deep at some points, but predominantly shallow on the hilltops because of the hard parent rock underneath.

Plot Comparison

To investigate the floristic and diversity differences between the forests in northern/central Suriname and the forests in the Kwamalasamutu surroundings, we compared the three 0.1-ha plots with unpublished 0.1-ha plot data from Olaf Bánki (6 plots from Gros Rosebel), Chequita Bhikhi (3 plots from the van Blommestein Lake, Brokopondo District), and Pieter Teunissen (12 plots from Gros Rosebel). We compared our data from the three 1-ha plots with data from 28 1-ha plots on the brown sands of the Zanderij/Coesewijne formation, and from the lowlands, slopes, and plateaus of the Brownsberg, the Lely Mountains, and the Nassau Mountains (Bánki 2010).

Plot analyses

The 1-ha and 0.1-ha plot datasets were analyzed as two separate datasets. Differences in floristic composition between plots were investigated with the ordination technique of Non-Metric Multi-Dimensional Scaling (NMS) with Relative Sörenson as the floristic distance measure, 250 real and randomized data runs, and 4–6 dimensions (NMS in PCORD 5; McCune & Grace 2002; McCune & Mefford 1999). We also performed a Detrended Correspondence Analysis on both the 0.1-ha and the 1-ha plot datasets (DCA in PCORD 5, McCune & Grace 2002; McCune & Mefford 1999). Only the results of the NMS are presented in this report. We also ran species indicator analyses on the 0.1-ha and 1-ha plot datasets to investigate which species were responsible for the division of the plots in several floristic groups (in PCORD 5; Dufrene & Legendre 1997; McCune & Grace 2002; McCune & Mefford 1999). The tree alpha diversity of the plots was expressed as Fisher's alpha (Fisher et al. 1943). Fisher's alpha is a diversity index describing the relation between the number of individuals and species in a plot. Differences in the averages of the number of species, number of individuals, and in Fisher's alpha were statistically tested through ANOVA (SPSS-Inc. 2007).

RESULTS

Vegetation Descriptions

At the three locations and between the camps, we encountered several vegetation types. Based on the vegetation descriptions of Lindeman and Moolenaar (1959) and Bánki (2010), we distinguished a total of nine different vegetation types:

1. **Tall herbaceous swamp vegetation and swamp wood.** This vegetation type was abundant in the bends of rivers and creeks, and was found around all three study sites. The herb layer consisted mostly of dense stands of *Montrichardia arborescens* (mokumoku, Araceae) intertwined with cyper grasses, grasses, and vines. Most of the shrub and tree layer consisted of *Inga* sp. (watra switibonki, Fabaceae). Dense stands of *Inga* trees occurred in the river bends, as well as along the river edges. Solitary and clumped palm trees with spiny trunks (*Bactris* sp., Arecaceae), solitary trees of *Cordia* sp. (tafrabon, Boraginaceae) with table-like crowns, and solitary trees of *Cecropia* sp. (bospapaja, Cecropiaceae) occurred in swampy areas in the river bends. At Wioemi Creek and the Sipaliwini River site, we observed individual *Triplaris surinamensis* (mira udu, Polygonaceae) trees. At the Kutari River we observed one *Erythrina fusca* (kofimama, Fabaceae) tree in the swamp wood. This vegetation type as well as its species composition shows resemblance to the coastal areas in northern Suriname (see Lindeman & Moolenaar 1959).

2. **Seasonally flooded forest.** We observed seasonally flooded forests with quite different species composition. At the margins of the black waters of the Wioemi Creek and the Kutari River we observed forests dominated by *Tachigali paniculata* (mira udu, Fabaceae), *Alexa wachenheimii* (neku or paku nyannyan, Fabaceae), *Eperua rubiginosa* (oeverwalaba, Fabaceae), and different species of Myrtaceae, Sapindaceae, Meliaceae, and Annonaceae. Large areas of seasonally inundated forest were found along both the Wioemi Creek and the Kutari River. Along the Wioemi Creek, the seasonally flooded forest was dominated by *Astrocaryum sciophilum* (bugru maka, Arecaceae), *Licania* sp. (fungu, Chrysobalanaceae), *Vouacapoua americana* (bruinhart, Fabaceae), *Terminalia amazonia* (djindja udu, Combretaceae), *Eschweilera corrugata* (umabarklak, Lecythidaceae), *Eperua falcata* (walaba, Fabaceae), *Goupia glabra* (Goupiaceae), *Ceiba pentandra* (kankantri, Malvaceae), *Elizabetha princeps* (Fabaceae) and different species of Burseraceae. The composition of this seasonally flooded forest seemed to resemble to some extent the composition of the high tropical rainforest on dryland (terra firme).

   We sampled along the Kutari River downriver from our first camp site (towards the Aramatau River) and noted the forest at the river margin changed in terms of species composition. In addition to the aforementioned tree species found along the Wioemi Creek and the Kutari River, trees of *Virola* sp. (babun udu, Myristicaceae), *Triplaris surinamensis*, *Ceiba pentandra*, and palm (*Attalea maripa, A. microcarpa*) appeared in the forest. We found a similar species composition along the Sipaliwini River, despite the higher riverbanks.

Downstream from the confluence of the Kutari and Aramatau Rivers, we found stretches of floodplain forest with a swampy character. *Astrocaryum sciophilum* did not occur in this area, suggesting that soils could be wet throughout the year. The forest composition was dominated by trees of *Virola* sp., *Alexa wachenheimii*, and *Bixa orellana* (kusuwe, Bixaceae). Along the Sipaliwini River this floodplain forest only occurred where the riverbanks were low.

3. **(Seasonally flooded) palm swamp forest.** Close to the Kutari River camp, we observed patches of *Euterpe oleracea* (pina palm, Arecaceae) swamp forest, with occasional *Geonoma baculifera* (taspalm, Arecaceae). This swamp forest was slowly flooded during our stay by a nearby overflowing creek. At the hinterland of the Sipaliwini River camp, we found a stretch of swamp forest with a dense cover of *Geonoma baculifera*. This swamp forest was also close to a creek, and could be seasonally inundated.

4. **High tropical lowland rainforest on dryland (terra firme).** This was one of the most dominant forest types in the Kwamalasamutu region, occurring at all RAP survey sites. The understory of the high tropical rainforest on dryland at the Kutari River (Site 1) was dense and dominated by *Astrocaryum sciophilum*. Soils at the Kutari site appeared to contain a higher proportion of loam and clay than sand compared to the other RAP sites. Some other frequently encountered species were *Vouacapoua americana*, *Bocoa viridiflora* (ijzerhart, Fabaceae), *Bocoa marionii*, *Croton matourensis* (tabakabron, Euphorbiaceae), *Protium* and *Tetragastris* sp. (Burseraceae), *Licania* sp., *Eschweilera* sp., *Sagotia racemosa* (zwarte taja udu, Euphorbiaceae), *Bixa orellana*, and several Meliaceae and Lauraceae species.

   At Werehpai (Site 3), we encountered many creeks along the main trail to the Werehpai caves. The forest along this trail was diverse, shifting from secondary forest to swampy, low and open vegetation, to high forest over short distances. The high tropical rainforest was dominated by *Astrocaryum sciophilum*, *Eperua falcata*, *Apeiba petoumo*, *Alexa imperatricis*, *Licania* sp., *Carapa guianensis*, *Eschweilera* and *Lecythis* sp., *Protium* and *Tetragastris* sp., *Inga* sp., *Guarea grandifolia* (Meliaceae), and *Couratari stellata* (ingi pipa, Lecythidaceae).

5. **High Tropical forest on laterite/granite hills.** This forest type was especially dominant in the higher areas along the Sipaliwini River (Site 2), but occurred at Werehpai as well (Site 3). *Astrocaryum sciophilum* was dominant where soils were deep and the understory of the forest relatively open. Also common here were *Alexa imperatricis*, *Vouacapoua americana*, *Inga* sp., *Protium* and *Tetragastris* sp., *Licania* sp., *Eschweilera* and *Lecythis* sp., *Carapa guianensis*, *Bocoa alterna*, and *Osteophloeum platyspermum*. On small granite hills with relatively shallow soils, we observed *Sterculia pruriens* (okro udu, Malvaceae), *Zanthoxylum rhoifolium* (pritjari, Rutaceae), *Lacmellea aculeata* (zwarte pritjari, Apocynaceae), *Hevea guianensis* (Euphorbiaceae), *Jacaranda copaia* (gubaja, Bignoniaceae), *Eschweilera corrugata*, *Sloanea* sp. (rafunyannyan, Elaeocarpaceae), *Cupania scrobiculata* (gawetri, Sapindaceae), *Licania ovalifolia* (santi udu, Chrysobalanaceae), and *Geissospermum sericeum* (bergi bita, Apocynaceae).

6. **Savannah (moss) forest.** In the surroundings of the Sipaliwini River site, we encountered savannah forest with a low canopy dominated by many lianas (e.g. Bignoniaceae) in higher areas where boulders and hard parent rock were at the surface, causing shallow soils (e.g., in a portion of plot Si3). At Werehpai we encountered some patches of this forest type along the main trail to the petroglyphs. Near the inselberg at Site 2, we found a small, narrow stretch of savannah forest with some moss coverage and grasses, and a low canopy forest with trees of *Neea* sp. (Nyctaginaceae) and Myrtaceae species. This savannah moss forest occurred at the edge of the open rock face (see below).

7. **Open rock (inselberg) vegetation.** At the hinterland of the Sipaliwini River site, we found a small inselberg rising up above the forest canopy. The vegetation of this inselberg was similar to the vegetation found on the Voltzberg in central Suriname. On the rocky outcrop itself, we observed *Furcraea* sp. (Agavaceae), *Neea* sp. (Nyctaginaceae), *Cissus verticillata* and *C. erosa* (Vitaceae), *Cochlospermum orinocense* (Cochlospermaceae), *Clusia* sp. (Clusiaceae), *Ernestia* sp. (Melastomataceae), and different species of Orchidaceae, Gesneriaceae, Myrtaceae, Poaceae, and Bromeliaceae.

8. **Secondary vegetation.** The camp at Werehpai (Site 3) was established on an old abandoned farm. The forest around this camp was a secondary forest dominated by *Cecropia* sp. and *Guadua* sp., (bamboo, Poaceae) and domesticated plants such as *Musa* sp. (bacove, Musaceae) and big trees of *Spondias mombin* (mope, Anacardiaceae). Along the Sipaliwini River we also observed open areas completely covered by vines such as *Dioclea virgata* (Fabaceae).

9. **Bamboo forest.** At all three study sites, and especially along the Sipaliwini River, patches of bamboo (*Guadua* sp.) occurred in the forest along the river edge. During reconnaissance flights, we were able to distinguish several square patches of bamboo, suggesting that bamboo had colonized areas previously cleared by humans. Bamboo was less common along Wioemi Creek.

Plant collections: new records and noteworthy plant species

In total we made 401 plant collections (see Appendix) with the following geographical distribution: 214 plant collections at the Kutari River (Site 1), 99 plant collections at the Sipaliwini River (Site 2), and 88 plant collections at Werehpai (Site 3). Of these 401 plant collections, 185 specimens were fertile; most of these specimens were collected during the general plant surveys. The rest of the collections were sterile and all originated from the plot inventories. To date, more than 90% of all the plant collections have been identified at least to family level (62 families), and almost 70% to genus (132 genera) and species level. We estimate that we have collected almost 240 species in total. A substantial part of the sterile collections and a small part of the fertile collections still need further identification to species level; therefore, it is possible that the total number of species in our sample will increase in the near future.

In the general plant collecting and plot surveys, we encountered eight plant species new to Suriname. *Bocoa marionii* (Fabaceae), a tree with unifoliolate leaves and white flowers, is a species just recently described based on two collections from the upper Essequibo River in Guyana (Aymard and Ireland 2010). We collected two fertile collections that are the first collections for Suriname and the fourth collections for the species as a whole (Ben Torke pers. comm.). Another new tree species for Suriname is *Bocoa alterna* (Fabaceae). This species was previously only collected from the Guiana Shield region in central Guyana and in Amapá (Brasil), but has an Amazonian distribution reaching into Peru, Bolivia, and the central and western parts of Brasil. Also new for Suriname is the tree species *Trichilia surumuensis* (Meliaceae). This species is thought to be endemic to the Roraima area of Guyana and Brasil, where it has been collected. For this reason it was placed on the IUCN Red List (see below). *Cupania macrostylis* is a species newly described (and still unpublished) by Pedro Acevedo of the Smithsonian Institution in the USA. We collected the second record of this species for Suriname. *Buchenavia parvifolia* (Combretaceae) is a tree species that was previously known in the Guianas from southern Guyana and French Guiana. The tree species is new for Suriname, but it has an Amazonian distribution in Brasil, Bolivia, Peru, and Ecuador. Another tree species new for Suriname is *Machaerium floribundum* (Fabaceae). It has a wide geographic distribution in Amazonia and Mesoamerica. The sixth new tree species for Suriname is *Licania granvillei* (Chrysobalanaceae), which also has an Amazonian distribution. We found two new species of herbs for Suriname: *Justicia sprucei* (Acanthaceae), previously known only from French Guiana, and *Dichorisandra hexandra* (Commelinaceae) which is new for Suriname according to the checklist of the Guianas (Funk et al. 2007), although Missouri Botanical Gardens mentions one collection of this species for Suriname (www.discoverlife.org). The geographical distribution of this species extends south of Amazonia and north into Mesoamerica.

We encountered several rare or noteworthy species for Suriname. We collected the second specimen of the tree species *Duguetia cauliflora* (Annonaceae) for Suriname (Paul Maas pers. comm.). We also collected what appears to be the second collection for Suriname of the liana *Byttneria cordifolia* (Malvaceae). The first collection for Suriname dated from 1926 and was collected by Gerold Stahel along the Upper Suriname River. Our specimen is the eighth collection for the Guianas in the NCB Naturalis. A collection of the tree species *Mosannona discolor* is the fourth collection for Suriname and the tenth collection for this species in general (Lars Chatrou pers. comm.). Noteworthy observations included an uncommon Myristicaceae tree species (*Osteophloeum platyspermum*) with amber-colored latex in the bark. The tree is called lapa lapa by the Trio people of Kwamalasamutu, and is quite common along the Sipaliwini River in high tropical rainforest on laterite/granite hills. On the banks of the Sipaliwini River we also found *Herrania kanukuensis* (Malvaceae), a small tree with a spectacular flower with long purple petals on the stem. This species is not common, and ours is the first specimen with flowers in the Guianas collection of the NCB Naturalis and the National Herbarium of Suriname. On the small inselberg close to the Sipaliwini camp we collected a tree, *Cochlospermum orinocense,* that is restricted to rocky outcrops and has large showy yellow flowers.

Plant species with a special status

During our fieldwork we recognized several plant species that are protected under Surinamese law, or have a special designation on the IUCN Red List or CITES.

We encountered six tree species listed on the IUCN Red List:

- *Aniba rosaeodora* Endangered (EN) A1d+2d ver 2.3 (1998)
- *Cedrela odorata* Vulnerable (VU) A1cd+2cd ver 2.3 (1998)
- *Corythophora labriculata* Vulnerable (VU) D2 ver 2.3 (1998)
- *Minquartia guianensis* Lower Risk / Near Threatened (LR/nt) ver 2.3 (1998)
- *Trichilia surumuensis* Endangered (EN) B1+2c (1998)
- *Vouacapoua americana* Critically Endangered (CR) A1cd+2cd ver 2.3 (1998)

We encountered three tree species protected under Surinamese law:

- *Aniba rosaeodora* (rozenhout) — also on CITES Appendix II
- *Dipteryx odorata* (tonka)
- *Manilkara bidentata* (boletri)

The taspalm (*Geonoma baculifera*) does not have protected status. However, the leaves of this small palm tree are used for roof thatch. In the northern regions of Suriname, populations of the taspalm have seriously declined in recent years, potentially causing local extinctions. In the forests of the Kwamalasamutu region, this palm species still appears to be relatively abundant.

Plot Inventories

In all plots combined, we found a total of 1849 individual trees belonging to 54 families, 119 genera, and approximately 250 species. The twenty most common species were: *Astrocaryum sciophilum* (174 individuals), *Alexa imperatricis* (105), *Pausandra martinii* (82), *Vouacapoua americana* (74), Lecythidaceae sp. (62), *Bocoa viridiflora* (61), *Protium* sp. (60), *Eperua falcata* (53), *Licania albiflora* (42), *Balizia pedicellaris* (39), *Carapa guianensis* (33), *Licania majuscula* (29), *Tetragastris altissima* (28), *Geissospermum sericeum* (26), *Guarea* OSB 1340 (25), *Lecythis corrugata* (23), *Inga* OSB 1338 (22), *Chrysophyllum argenteum* (20), *Iryanthera hostmannii* (20), and *Rheedia benthamiana* (17).

In terms of tree alpha diversity, the Fisher's alpha values were highest in the Kutari River plots (Ku1&2; Table 1). The Fisher's alpha values were lowest in the Werehpai plots (We5&6), and intermediate in the Sipaliwini River plots (Si3&4). The Kutari River plots could be classified as 'high tropical lowland rainforest on dryland' (vegetation type 4, above); and the Sipaliwini plots as 'high tropical rainforest on laterite/granite hills' (vegetation type 5, above). The Werehpai plots were mixed between these two forest types, but most resembled the 'high tropical rainforest on laterite/granite hills' forest type.

We compared the 0.1-ha and 1-ha plots with other datasets from Suriname to determine the floristic differences (beta diversity) between the forests of the Kwamalasamutu region and forests in northern Suriname. The three 0.1-ha plots from the Kwamalasamutu area were separated floristically from plots in northern Suriname (Fig. 1). At the same time, the three 0.1-ha plots from the Kutari River, Sipaliwini River and Werehpai were to some extent also floristically separated from each other. The same patterns were found in the 1-ha plot dataset comparison (Fig. 2). This suggests beta diversity is substantial between the plots from the Kwamalasamutu area and those from northern Suriname. It also suggests that beta diversity among the plots of the three RAP sites is substantial.

We used indicator species analyses to investigate the number and identity of the species that were responsible for the separation of plots into different floristic groups. Only 18% of the species in the 0.1-ha plot dataset had a significant indicator value, and the number of indicator species for the plots in the Kwamalasamutu area was low (ca. 5% of all species). Several of the indicator species occurred in low numbers in the plots in northern Suriname, or were known to have a wide distribution. However, the plots in the Kwamalasamutu area contained specific indicator species. Again the 1-ha plots showed similar results. In both the 0.1-ha and 1-ha plot comparisons, the number of individuals, the number of species, and the values of Fisher's alpha did not differ significantly between the Kwamalasamutu area and northern Suriname.

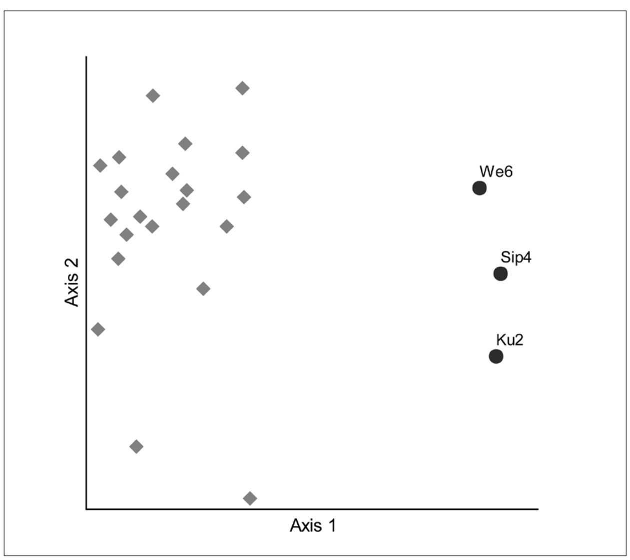

Figure 1. Non-metric multidimensional scaling (NMS) showing the floristic differences of the 0.1-ha plots of the Kutari River (Ku2), Sipaliwini River (Si4), and Werehpai (We6) with 0.1-ha forest plots in northern Suriname (diamond symbols). The first axis represents the most variation in floristic differences (52%) separating the 0.1-ha plots of the Kwamalasamutu surroundings from all other plots. The second axis represents 25% of the floristic variation mostly showing differences among the plots in northern Suriname, but also some floristic differences between the 0.1-ha plots of the three RAP sites.

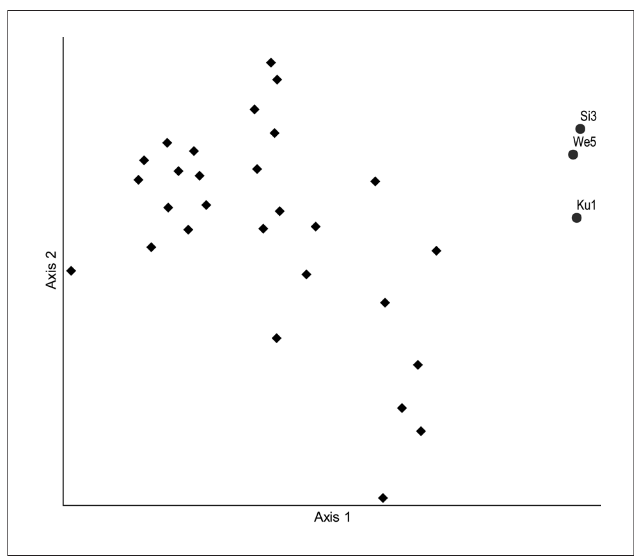

Figure 2. Non-metric multidimensional scaling (NMS) showing the floristic differences of the 1-ha plots of the Kutari River (Ku1), Sipaliwini River (Si3), and Werehpai (We5) with 1- ha plots of the forests in northern Suriname (diamond symbols). The first axis represents the most variation in floristic differences (55%) separating the 1-ha plots of the Kwamalasamutu surroundings from all other plots. The second axis represents 21% of the floristic variation mostly showing differences among the plots in northern Suriname, but also some floristic differences between the 1-ha plots of the three RAP sites.

DISCUSSION

The forests in the Kwamalasamutu region contradict the view that forests in southern Suriname are uniform. Instead, it is clear that the landscape is quite heterogeneous, forming a mosaic of different forest types over short geographic distances. Each of the three sites that we surveyed had a distinct species composition. At the same time, the alpha diversity of trees in our study plots differed substantially among the three sites. The Fisher's alpha values for the Kutari plots are comparable to the highest value calculated in Suriname to date (from a plot in the Lely Mountains; Bánki 2010). The values of Fisher's alpha for the Werehpai plots are in the range that is typically calculated for savannah forests, which are rather low values for tropical forests. And the Fisher's alpha values for the Sipaliwini plots are close to those found in plots on brown sands in the northern regions of Suriname (Bánki 2010). Although data from six plots are insufficient to extrapolate to the region as a whole, they do support the view that there are dramatic differences in tree alpha diversity over short geographic distances in the forests of the Kwamalasamutu region.

The differences in forest composition and diversity among plots from the three sites in the Kwamalasamutu area could be partly a result of the soils found in the plots. The forests in the Kutari plots stand on deep sandy to loamy soils, enabling a high canopy. In this forest type we also found the highest number of timber species. Nevertheless, in general, forests in the Kwamalasamutu area seem to have a low abundance and occurrence of commercial timber species. In the Sipaliwini and Werehpai plots, the species composition seemed to change instantly when the soils became shallow due to the hard parent rock underneath. These shallow soils could be relatively nutrient-poor and may have a reduced water retention capacity. Canopy height was reduced at those places where bedrock was close to the surface.

Compared to plots in northern Suriname, the plots in the Kwamalasamutu area had a distinct species composition, to some extent. We found a substantial number of tree species and two herbaceous species that were not previously recorded for Suriname. The forests in the Kwamalasamutu region are likely to resemble forests in southern Guyana; several of the new species for Suriname were previously known from there, including one species that was thought to be endemic to the Roraima area of Guyana and Brasil. Some of the other new species for Suriname had a much wider geographic distribution across Amazonia and some even beyond, to Mesoamerica. Despite the lower tree alpha diversity values from plots at the Sipaliwini River and especially at Werehpai, the number of new tree species records indicates these forests have a high natural value for Suriname.

The forests of the Kwamalasamutu region differed from other forests in Suriname in several ways. The seasonally flooded forest was quite extensive, with rivers and creeks actually flowing through the forests. Within the meandering rivers and creeks, the short swamp vegetation resembled coastal swamp vegetation types. Also of interest was the extent of semi-xerophytic forest types and open rock vegetation on small inselbergs that formed typical features in the landscape of the Kwamalasamutu region. Patchy bamboo forest was a conspicuous feature of the landscape. These forests were more extensive around Kwamalasamutu than elsewhere in Suriname.

CONSERVATION RECOMMENDATIONS

Based on our findings during this rapid assessment in the Kwamalasamutu region, we have formulated the following conservation recommendations:

The forests in the surroundings of Kwamalasamutu seem to have a high conservation value. This is expressed in the forest composition of the plots in the Kwamalasamutu surroundings that are to some extent different from forests in other plot datasets from northern Suriname. It is strengthened by the fact that we found eight species new for Suriname and a substantial number of rare species during the RAP survey. More field data on plant diversity and forest composition from the southern Suriname is very much needed to better determine the differences between these forests and those of northern Suriname, in terms of biomass and other ecosystem services.

The high conservation value is also demonstrated by the fact that the Kutari forest plots had one of the highest tree alpha diversity values ever recorded for Suriname. At the same time, the forests sampled at Werehpai had relatively low alpha diversity values relative to other forests in Suriname and the Guianas. Within the whole study area, the landscape was quite heterogeneous, with a high turnover of different vegetation types over short geographic distances. At sites where the landscape is a fine mosaic of different vegetation types, as is the case at Werehpai, conservation measures such as community managed protected areas are justified and should be promoted.

The majority of the forests in the surroundings of Kwamalasamutu are in a natural and healthy state. To ensure their continued health into the future, some matters need to be addressed in close cooperation with the Kwamalasamutu community. In the direct surroundings of Kwamalasamutu, the pressure of slash-and-burn agricultural methods is visible, especially on those forest types with a high tree alpha diversity. In the long run, this form of agriculture may not be sufficient to feed the population of Kwamalasamutu. At the same time, bamboo forest could spread over the area following human-induced disturbance, inhibiting the growth of other plant species. We therefore recommend that agricultural methods that better incorporate standing forests be tested in a community-supported approach in the Kwamalasamutu region.

REFERENCES

Aymard, G.A. & Ireland, H.E. 2010. A new species of *Bocoa* (leguminosae-Swartzieae) from the Upper Essequibo region, Guyana. Blumea 55: 18–20.

Bánki, O.S. 2010. Does neutral theory explain community composition in the Guiana Shield forests? Ph.D. dissertation, Universiteit Utrecht, Netherlands.

Dufrene, M. & Legendre, P. 1997. Species assemblages and indicator species: the need for a flexible asymmetrical approach. *Ecological Monographs*, **67**, 345–366.

Fisher, R.A., Corbet, A.S., & Williams, C.B. 1943. The relation between the number of species and the number of individuals in a random sample of an animal population. Journal of Animal Ecology, 12, 42–58.

Funk, V., Hollowell, T., Berry, P., Kellof, C., & Alexander, S.N. 2007. Checklist of the Plants of the Guiana Shield (Venezuela: Amazonas, Bolivar, Delta Amacuro; Guyana, Surinam, French Guiana). *Contributions from the United States National Herbarium*, **55**, 584.

Haripersaud, P.P. 2009. Collecting biodiversity. Ph.D. thesis, plant ecology and biodiversity group, institute of environmental biology, Utrecht University. 143pp.

Jansen-Jacobs, M.J. 1985. Flora of the Guianas. Royal Botanical Gardens Kew, Koelz Scientific Books.

Lindeman, J.C., and S.P. Moolenaar. 1959. Preliminary survey of the vegetation types of northern Suriname. Van Eeden Fonds, Amsterdam.

McCune, B. & Grace, J.B. 2002. Analysis of Ecological Communities. MjM Software Design, Gleneden Beach, Oregon, U.S.A.

McCune, B. & Mefford, M.J. 1999. PC-ORD. Multivariate Analysis of Ecological Data. MjM Software, Gleneden Beach, Oregon, U.S.A.

Pulle et al. 1932. Flora van Suriname. Rijksherbarium Utrecht, Van Eedenfonds & Bril Leiden, The Netherlands.

SPSS, Inc. 2007. SPSS 16.0 for windows; release 16.0.1 (Nov. 15, 2007).

Steyermark, J.A, Berry, P.E., Yatskievych, K., & Holst, B.K. 1995. Flora of the Venezuelan Guayana. Missouri Botanical Garden, St Louis, Missouri, USA.

ter Steege, H., Pitman, N.C.A., Phillips, O.L., Chave, J., Sabatier, D., Duque, A., Molino, J.-F., Prevost, M.-F., Spichiger, R., Castellanos, H., von Hildebrand, P., & Vasquez, R. 2006. Continental-scale patterns of canopy tree composition and function across Amazonia. *Nature*, 443, 444–447.

Appendix. List of plants collected on the Kwamalasamutu RAP survey. Numbers indicate number of specimens collected from each survey site.

Family	Genus	Species	Trio Name	Kutari	Sipaliwini	Werehpai
Acanthaceae	*Justicia*	*sprucei*			1	
Amaranthaceae					1	
Amaranthaceae	*Cyathula*	*prostrata*				1
Anacardiaceae			mapatalu			1
Anacardiaceae	*Loxopterygium*	*sagotii*			1	
Annonaceae	*Bocageopsis*	*multiflora*	lasaj	2		
Annonaceae	*Duguetia*	*cauliflora*	ariwera	1		
Annonaceae	*Duguetia*	*riparia*			1	
Annonaceae	*Duguetia*			3	2	
Annonaceae	*Fusaea*	*longiflora*			1	
Annonaceae	*Mosannona*	*discolor*	onote		1	1
Annonaceae	*Pseudoxandra*	*lucida*		1		
Annonaceae	*Unonopsis*	*glaucopetala*				1
Annonaceae	*Unonopsis*	*guatterioides*		1		
Annonaceae	*Xylopia*					1
Apocynaceae				1		
Apocynaceae	*Cynanchum*	*blandum*		1		
Apocynaceae	*Geissospermum*	*sericeum*	wataki	1		
Apocynaceae	*Mesechites*	*trifida*		2		
Apocynaceae	*Odontadenia*	*macrantha*		2		
Apocynaceae	*Pacouria*	*guianensis*		1		
Apocynaceae	*Tabernaemontana*	*heterophylla*				1
Apocynaceae	*Tabernaemontana*	*undulata*			1	
Araceae	*Heteropsis*	*flexuosa*				1
Asteraceae	*Mikania*	*cordifolia*		1		
Asteraceae	*Mikania*	*guaco*		1		
Bignoniaceae				1		
Bignoniaceae	*Arrabidaea*	*tuberculata*			1	
Bignoniaceae	*Cydista*	*aequinoctialis*		1		1
Bignoniaceae	*Martinella*	*obovata*		1		
Bignoniaceae	*Memora*	*schomburgkii*		1	1	
Bixaceae	*Bixa*	*orellana*	Wiseima, Kanawirike	2		
Boraginaceae	*Tournefortia*	*cuspidata*			1	
Burseraceae						1
Burseraceae	*Protium*			3		
Burseraceae	*Protium*	*aracouchini*	srisrituri	1		
Burseraceae	*Protium*	*heptaphyllum*			1	
Burseraceae	*Protium*	*robustum*			1	
Burseraceae	*Protium*	*trifoliolatum*				2
Burseraceae	*Tetragastris*	*altissima*	Arita	3	1	1
Burseraceae	*Tetragastris*	*hostmannii*	Arita	1		
Cecropiaceae	*Pourouma*	*bicolor*	alawata puruma	2		
Cecropiaceae	*Pourouma*	*minor*	wedinaiennu	1		

table continued on next page

Family	Genus	Species	Trio Name	Kutari	Sipaliwini	Werehpai
Celastraceae						1
Celastraceae	*Cheiloclinium*	*cognatum*		1		
Chrysobalanaceae	*Couepia*	*caryophylloides*		1		
Chrysobalanaceae	*Hirtella*	*racemosa*	merimeri	3	1	
Chrysobalanaceae	*Licania*			3		
Chrysobalanaceae	*Licania*	*albiflora*	paripo	1		
Clusiaceae	*Rheedia*	*benthamiana*	kaiquiennorepereke	1		
Clusiaceae	*Tovomita*			1	2	
Cochlospermaceae	*Cochlospermum*	*orinocense*			1	
Combretaceae						1
Combretaceae	*Buchenavia*	*parvifolia*	otaima	1		
Combretaceae	*Combretum*			1		
Combretaceae	*Combretum*	*laxum*		2	1	1
Combretaceae	*Combretum*	*rotundifolium*		1		
Combretaceae	*Terminalia*	*dichotoma*				1
Commelinaceae	*Dichorisandra*	*hexandra*	Lue	2		
Convolvulaceae	*Evolvulus*	*alsinoides*			1	
Convolvulaceae	*Ipomoea*	*batatoides*		1	1	
Convolvulaceae	*Ipomoea*	*tiliacea*			1	
Cyperaceae	*Diplasia*	*karataefolia*		1		
Cyperaceae	*Rynchospora*					1
Dichapetalaceae	*Tapura*	*amazonica*	awaima	1		
Elaeocarpaceae	*Sloanea*			2		
Elaeocarpaceae	*Sloanea*	*grandiflora*				1
Euphorbiaceae				1		1
Euphorbiaceae	*Conceveiba*	*guianensis*	kananamang ipaimu		1	1
Euphorbiaceae	*Croton*	*matourensis*	kuapehe	1		
Euphorbiaceae	*Croton*	*sipaliwinensis*		1		
Euphorbiaceae	*Omphalea*	*diandra*			1	
Euphorbiaceae	*Pausandra*	*martinii*	masiwewarito	1		1
Fabaceae				3	2	1
Fabaceae	*Alexa*	*imperatricis*	otoima, hotojarang	5	1	
Fabaceae	*Andira*	*surinamensis*		1		
Fabaceae	*Bocoa*	*alterna*				1
Fabaceae	*Bocoa*	*marionii*	pade	4		
Fabaceae	*Bocoa*	*viridiflora*	kutari	1		
Fabaceae	*Cynometra*	*marginata*			2	
Fabaceae	*Dalbergia*	*riedelii*		1	1	
Fabaceae	*Dioclea*	*virgata*		1		
Fabaceae	*Eperua*	*rubiginosa*		1		
Fabaceae	*Hydrochorea*	*corymbosa*		1		1
Fabaceae	*Inga*			1	1	2
Fabaceae	*Inga*	*bourgonii*		1		1
Fabaceae	*Inga*	*disticha*		1		

table continued on next page

Family	Genus	Species	Trio Name	Kutari	Sipaliwini	Werehpai
Fabaceae	*Inga*	*nobilis*		2		1
Fabaceae	*Inga*	*sertulifera*				1
Fabaceae	*Machaerium*	*floribundum*		1	1	
Fabaceae	*Machaerium*	*leiophyllum*		1		
Fabaceae	*Macrolobium*	*acaciifolium*			1	
Fabaceae	*Peltogyne*	*venosa*		1		
Fabaceae	*Senna*	*bicapsularis*			1	
Fabaceae	*Senna*	*quinquangulata*				1
Fabaceae	*Stylosanthes*	*hispida*			1	
Fabaceae	*Swartzia*			1		1
Fabaceae	*Swartzia*	*arborescens*		1		
Fabaceae	*Swartzia*	*benthamiana*		1		2
Fabaceae	*Swartzia*	*grandifolia*		1		
Fabaceae	*Swartzia*	*guianensis*			1	
Fabaceae	*Tachigali*	*paniculata*		1		
Fabaceae	*Vouacapoua*	*americana*	wacapu	1		
Fabaceae	*Zygia*	*inaequalis*		1		
Fabaceae	*Zygia*	*latifolia*			1	1
Fabaceae	*Zygia*	*racemosa*	krikriia	2		
Goupiaceae	*Goupia*	*glabra*			1	
Humiriaceae	*Humiria*	*balsamifera*	weikepauudu	1		
Lauraceae				8	1	1
Lauraceae	*Kubitzkia*	*mezii*			1	
Lauraceae	*Licaria*	*cannella*			1	
Lecythidaceae					1	1
Lecythidaceae	*Corythophora*	*labriculata*		1		
Lecythidaceae	*Eschweilera*			1		
Lecythidaceae	*Eschweilera*	*pedicellata*		1		
Lecythidaceae	*Eschweilera*	*sagotiana*				1
Lecythidaceae	*Eschweilera*	*subglandulosa*			1	
Lecythidaceae	*Gustavia*	*augusta*				1
Lecythidaceae	*Gustavia*	*hexapetala*	kanaimanagpataimu, patunailophue	2		
Lecythidaceae	*Lecythis*	*corrugata*	tuhaima	1		
Lecythidaceae	*Lecythis*	*poiteaui*	adiwera	1		
Loganiaceae	*Strychnos*	*guianensis*		1		
Malphigiaceae	*Hiraea*	*faginea*		1		1
Malpighiaceae	*Heteropterys*	*macrostachya*		2		
Malpighiaceae	*Stigmaphyllon*	*sinuatum*		2		
Malvaceae	*Apeiba*	*albiflora*		1		
Malvaceae	*Apeiba*	*petoumo*	mukete		1	
Malvaceae	*Byttneria*	*cordifolia*			1	
Malvaceae	*Herrania*	*kanukuensis*				1
Malvaceae	*Hibiscus*	*sororius*		1		

table continued on next page

Family	Genus	Species	Trio Name	Kutari	Sipaliwini	Werehpai
Malvaceae	*Melochia*	*ulmifolia*			1	
Malvaceae	*Quararibea*	*guianensis*		1		
Melastomataceae				1		
Melastomataceae	*Clidemia*			1		2
Melastomataceae	*Ernestia*				2	
Melastomataceae	*Miconia*					3
Melastomataceae	*Miconia*	*serrulata*		1		
Meliaceae					2	
Meliaceae	*Guarea*			8		
Meliaceae	*Guarea*	*guidonia*		1		
Meliaceae	*Trichilia*	*quadrijuga*			1	1
Meliaceae	*Trichilia*	*surumuensis*				1
Meliaceae	*Trichilia*				1	
Memecylaceae	*Mouriri*	*grandiflora*		1		
Menispermaceae				1		
Moraceae	*Bagassa*	*guianensis*			1	
Moraceae	*Brosimum*	*lactescens*			1	
Moraceae	*Brosimum*	*parinarioides*				1
Moraceae	*Brosimum*	*rubescens*				1
Moraceae	*Ficus*	*pertusa*		1		
Moraceae	*Ficus*	*trigona*		1		
Moraceae	*Helicostylis*	*tomentosa*	huhwe	1		
Moraceae	*Pseudolmedia*	*laevis*	mapanu	1		1
Moraceae	*Trymatococcus*	*amazonicus*				1
Myristicaceae	*Iryanthera*			1		1
Myristicaceae	*Iryanthera*	*hostmannii*	ponikrima	1		
Myristicaceae	*Osteophloeum*	*platyspermum*	lapalapa		1	
Myristicaceae	*Virola*			2	1	
Myrsinaceae	*Stylogyne*	*atra*				1
Myrtaceae				10	6	6
Myrtaceae	*Campomanesia*	*aromatica*				1
Myrtaceae	*Eugenia*		phumaime	1		
Myrtaceae	*Psidium*	*acutangulum*		3		1
Nyctaginaceae					1	
Ochnaceae				1		
Onagraceae	*Ludwigia*			2		
Opiliaceae	*Agonandra*	*silvatica*	alukaw	1	1	
Piperaceae	*Piper*			2		
Poaceae				1	2	2
Polygalaceae	*Securidaca*			1		1
Pteridophyte						2
Putranjivaceae	*Drypetes*	*variabilis*	tokirimang		1	1
Quiinaceae	*Lacunaria*	*crenata*		1		
Rhabdodendraceae	*Rhabdodendron*	*amazonicum*	payfayoinapiru	1		

table continued on next page

Family	Genus	Species	Trio Name	Kutari	Sipaliwini	Werehpai
Rubiaceae					3	5
Rubiaceae	*Genipa*	*americana*			1	
Rubiaceae	*Palicourea*	*guianensis*	alugeluge, pyia pyiama		1	
Rubiaceae	*Posoqueria*	*longiflora*		1		
Salicaceae				1		
Salicaceae	*Casearia*			1		
Sapindaceae	*Cupania*	*macrostylis*		1		
Sapindaceae	*Cupania*	*scrobiculata*	mapanu			1
Sapindaceae	*Matayba*			2		
Sapindaceae	*Matayba*	*arborescens*		1		
Sapindaceae	*Matayba*	*camptoneura*		1		
Sapindaceae	*Paullinia*	*capreolata*			1	
Sapindaceae	*Paullinia*	*trilatera*		1		
Sapindaceae	*Talisia*	*sylvatica*		1		
Sapindaceae	*Toulicia*	*pulvinata*			1	
Sapindaceae	*Toulicia*	*elliptica*		1		
Sapindaceae	*Vouarana*	*guianensis*			1	
Sapotaceae				7	10	2
Sapotaceae	*Chrysophyllum*	*argenteum*	tumuri	1		
Sapotaceae	*Pouteria*		awaribalata	1		
Sapotaceae	*Pouteria*	*guianensis*	kununima	1		
Siparunaceae	*Siparuna*	*cuspidata*	idakaipu	4		
Siparunaceae	*Siparuna*	*decipiens*	kandadeennu		1	
Solanaceae	*Brunfelsia*	*guianensis*				1
Solanaceae	*Cestrum*	*latifolium*			1	
Solanaceae	*Schwenkia*	*grandiflora*		1		
Solanaceae	*Solanum*	*pensile*		1		
Ulmaceae	*Ampelocera*	*edentula*		1		
Violaceae	*Corynostylis*	*arborea*				1
Violaceae	*Rinorea*			2		
Viscaceae	*Phoradendron*			1		
Vitaceae	*Cissus*	*erosa*	Napokaima	1	1	
Vitaceae	*Cissus*	*verticillata*		1	1	
Undetermined				13	9	11