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A REPORT TO
THE NATURE CONSERVANCY

VEGETATION OF THE ADELBERT RANGE MADANG PROVINCE, PNG

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1 Summary

The Adelbert Range is a small mountain range (maximum elevation 1,672 m) in northeast Papua New Guinea. The mixed Tertiary and Quaternary igneous and sedimentary rocks are recently uplifted, and rapidly weathering, leading to a deeply dissected landscape with numerous unstable slopes. Villages are scattered fairly evenly throughout the range, creating a mosaic of gardens and secondary forest. Because of the steep terrain, however, there has been minimal logging in the uplands (above ca. 400 m).

The Nature Conservancy has been developing a community-based conservation project in the northern and eastern Adelberts, and as a contribution to developing a conservation plan for the whole range, we have produced a vegetation map of the area. The map is based on various GIS layers, Landsat satellite images, and the results of fieldwork during June and July 2005. The forest in the area appears to be fairly homogeneous, due to the restricted elevation range and relatively homogeneous geology, and is dominated by lowland hill forest. A number of subtypes are however described.

Analyses of the regional species composition of forests, and of island-wide combinations of edaphic and climatic factors, indicated that the Adelberts are representative of forest over a large area, and probably not particularly unique. Plant collections also failed to detect any new species or range extensions. The Adelberts do, however, have a very high diversity of edaphic/climatic levels given their their size. This, combined with small-scale variation in geological substrate, and variation in elevation, indicates that while not unique, the Adelberts offer a compact conservation target that would capture a very wide range of PNG biodiversity.

The conservation context of the Adelberts is primarily small to large areas of unlogged but hunted forest, owned by village communities. The lack of access to roads and the steep terrain mean that logging is not a very serious threat at the moment. Fire however may be the most serious threat in the future.

2 Introduction

TNC has been working in the Adelbert Mountains area for several years and has been making internationally recognized progress in truly community-based conservation. Unlike most tropical areas where CW has worked, nearly all PNG forest is owned by local peoples. This reduces the likelihood of large-scale logging operations that ignore the importance of the forest to traditional culture, but it also makes forming large conservation areas difficult. Human population density in the Adelberts is low, but evenly scattered, leaving few areas of forest farther than a day's hunting trip from a village. TNC has been working with several villages in the Northern Adelberts to set aside small conservation areas in traditionally owned lands, promoting the benefits to populations of hunted animals, and for providing options for the future.

As part of supporting these conservation activities, we were asked to produce a vegetation map for the Adelberts. Because of the importance of the botanical substrate for most animals, a vegetation map is the most important first step in understanding the distribution of biodiversity in an area. The explicit goals of our project were to:

1. provide detailed information about the vegetation types in pre-existing conservation areas, commenting on the conservation values and threats at this local scale,

2. produce a vegetation map for the whole Adelberts, to guide regional conservation planning and choice of future areas of TNC work, and

3. compare the Adelberts with other comparable regions, thus placing the Adelbert range in a New Guinea-wide context.

3 Sources of Information

We were fortunate to have very good background information for this vegetation mapping project.

3.1 Prior surveys and literature

Through the years of work by CSIRO in PNG, the Adelberts have been relatively well surveyed and are described a number of times. We used a 1976 Land System report (Robbins et al. 1976; Table 2), the Papua New Guinea Resource Information System (PNGRIS) and the Forest Inventory Mapping System (FIMS; McAlpine and Quigley 1998). A short report by John McAlpine (2005) provides an excellent introduction to some of these sources. More recent, more biologically-oriented studies include Takeuchi (2000) in the Josephstaal area ('west-north-west' Adelberts), Pahau et al. (2002), and Salas (2004). Takeuchi (2000) outlines the history of collecting in the northern Adelberts. A thorough ethnographic account of the northern Adelberts was made by Sullivan (2003).

3.2 Remote sensing

We acquired a series of recent Landsat 7 images from the University of Maryland archive. Four images covered the entire area. These images were analyzed separately, since they had been pretreated in different ways, and were taken on different dates. The Space Shuttle SRTM data (digital elevation model) for the Adelberts was also downloaded from the NASA servers.

CSIRO also commissioned a set of aerial photographs that covered most of PNG. These were probably used as the basis for crown size classing in FIMS. We found the originals still at the National Mapping Bureau in Port Moresby, and acquired several sheets for comparison with the satellite images, and to test the classification.

3.3 GIS data layers

Both the Papua New Guinea Resource Information System (PNGRIS), and the Forest Inventory Mapping System (FIMS; McAlpine and Quigley 1998), mentioned above, were available as GIS data layers. The scale of the former (Fig. 2) is significantly coarser than the latter (Fig. 1), and was used primarily as a indication of the extent of different rock substrates in the area. Both PNGRIS and FIMS are based on FMUs (Forest Management Units): polygons of combinations of levels of important factors (substrate, forest type, agricultural use ...), which can be dissolved into larger polygons when single factors are considered (e.g., forest type, see Fig. 1). The FIMS forest typing (Table 1) was very useful as a guide for areas not visited, but did not contain enough floristically-based divisions for the current project. It was based on the interpretation of aerial photographs, and was therefore particularly useful for showing the distribution of crown sizes. This was the the main way we incorporated this data layer (see Section 6.1). The 1976 Land System report (Robbins et al. 1976) was also photographed and orthorectified.

3.4 Field surveys

Ground-truthing a vegetation classification is vital. We were able to spend three weeks in the field in June and July 2005. The optimal sampling would have covered variation in geology, elevation and gross aspect (W slope vs. E slope). However, as well as having only limited time, access to sites was complicated by the politics of village land ownership. Some areas were in a disputed state, with unsafe conflict going one, and other areas were off-limits because of temporary miscommunication between TNC and village leaders.

In the end, were were able to visit forest in the Swapim area (24 June–26 June; including Keki Lodge), Wadakinam area (Guam riverbanks; 27 June–28 June), and on a long route from Nelobo to Erevenam (29 June–10 July), via Yawera, Munsiamunat and Dudura. A long detour was taken into the mountains above Munsiamunat. MS was also able to visit forest in the Inbab area. See the waypoint file for full coordinates of CW's trip.

Careful notes were kept of estimated vegetation type, notable plants, geology and GPS position. In the Munsiamunat area, we were fortunate to have the assistance of Ali, a plant collector from Lae, and trainee of Wayne Takeuchi, and over 200 specimens were collected (Fig. 3). I took numerous plant photos. I also took systematic sets of pictures of 100 plant morphotypes in various sites, a method I have used on many surveys, and which I call PURIs (Photographic Ultra-Rapid Inventories). These sets of photos can be analyzed as if they were sample plots, to give measures of similarity between different locations, but on this survey, I simply used then to record the overlap in common, identifiable species between different sites.

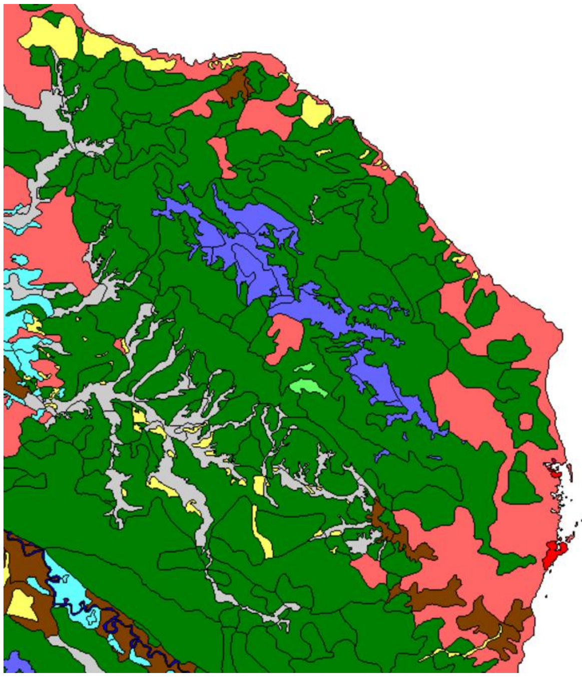

Figure 1: General forest classes in FIMS. Key: purple = lower montane (1000 m), dark green = upland (medium crowns), pale green = upland with small crowns, brown = forest on plains (medium crowns), grey = forest on plains (small crowns), pale blue = swamps, straw = grassland, salmon = agricultural areas. See Table 1 for summary of vegetation types in FIMS in the Adelberts.

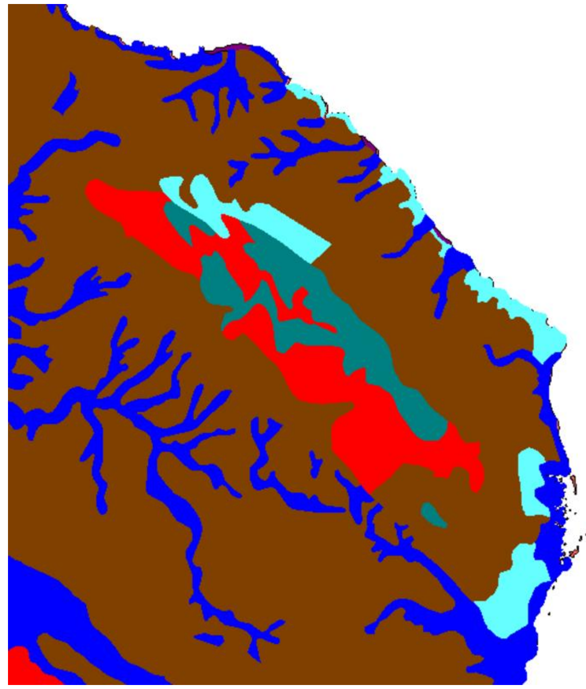

Figure 2: Geology data in PNGRIS. Key: red = basic or intermediate igneous, pale blue = limestone (and mixed with sedimentary), teal = mixed sedimentary and igneous, brown = sedimentary, dark blue = alluvial.

4 Physical factors

4.1 Geology

The area is young, geologically (Robbins et al. 1976), and represents first the accretion of near-shore deposits (limestone, then sandstones) during the middle Miocene. Folding and uplift then occurred in the upper Miocene and lower Pliocene. Further, strong uplift occurred in the Pliocene and lower Pleistocene, with block- and trough-faulting on NW lines. This period was associated throughout with minor volcanism. The oldest surviving elements of the landscape are some of the rounded ridges in the high Adelberts.

An alternative hypothesis from Robert Hall's group at Royal Holloway has the Adelberts originating as one of a string of islands in an arc to the NE of New Guinea (islands that would later also become the Huon peninsula, and the Torricelli range), and only becoming connected to mainland New Guinea ca. 3 Mya. These two hypotheses should generate very different biogeographic expectations, the latter suggesting a high level of endemism in the North Coast ranges. For plants, we do not yet have enough information to critically assess these hypotheses, although preliminary data (this and other reports) suggests no outstanding endemism in the Adelbert flora.

Table 1: Vegetation types in Adelberts on FIMS maps. Types in bold dominate most of the area. See Fig. 1 for distribution of grassland, lower montane, upland, plain, swamp and agricultural areas.

Vegetation code	Description
Fsw	Mixed swamp forest
G	Grassland
Gf	Grassland with some forest
Gr	Grassland reverting to forest
Gri	Riverine successions dominated by grass (mainly on Ramu river)
Gsw	Swamp grassland (mainly on Ramu river)
Hm	Medium crowned forest on uplands (below 1,000 m)
Hm.1	Medium crowned forest on uplands, landslips common
HmAr	Medium crowned forest on uplands, *Araucaria* common
Hmd	Medium crowned damaged forest on uplands
Hs	Small crowned forest on uplands
L	Small crowned lower montane forest (above 1,000 m)
L.1	Small crowned lower montane forest, landslips common
O	PNGRIS agricultural land use intensity class 0–4
Ps	Small crowned forest on plains and fans (indicator of alluvial forest)
Pl	Large to medium crowned forest on plains and fans
Po	Open forest on plains and fans
Wsw	Swamp woodland (mainly on Ramu river)

There is, however, clearly a wide range of substrates within the Adelberts, from limestone to conglomerates and sand- and mudstones (and igneous-associated metamorphosed quartzite) to basalt. The substrate can quite strongly determine the basic landforms, and evidenced by slow river meanders over mudstone, separated by rapids over sections of conglomerate.

4.2 Land systems

Robbins et al. (1976) carefully describe a comprehensive set of Land Systems (Table 2; Fig. 4). In general, these land systems map very closely onto the final vegetation types.

Figure 3: A day's collections, at Lazarus' garden house

4.3 Rainfall

Few climate stations exist, but Short's report in Robbins et al. (1976) indicates that the east and west sides of the Adelberts have similar rainfall patterns, but that there is a general decrease in total rainfall moving northwest-wards. The area around Bogia fits a different climatic classification from the rest of the Adelberts ('tropical monsoonal' vs. 'tropical wet'). The total annual rainfall in the former area is ca. 83 in, vs. 126–142 in the latter. In all areas there is pronounced seasonality of rainfall, with the wet months being between October and May.

5 Vegetation Types

The majority of the study area is generally classed as lowland hill forest (< 1400 m), which has received less attention from botanists than montane forest (Johns 1982), and we have had to initiate its subdivision, based on field observations. These subdivisions (between submontane, upland, lowland and alluvial) do not however occur at clearly defined floristic boundaries, and are added primarily as indicators that forest composition does turn over between the lowlands and uplands.

As is always the case with mapping vegetation from GIS and remote sensing (RS) data, some classes observed in the field are not easy to detect in RS layers, and similarly, some variation in RS layers is not easy to interpret given field experience. A one-to-one mapping is seldom possible, and we have provided a cross-walk table (Table 3) to assist this comparison.

5.1 Submontane forest

Above 1400 m, we have classed the forest as submontane. At the highest point we visited (1224 m), the forest continued to change in composition from upland forest, and so we reasoned that at some point this continuous change would be sufficient to warrant a new class. Locally, castanopsis forest or araucaria forest may dominate, on exposed ridges or broad summits, respectively. We

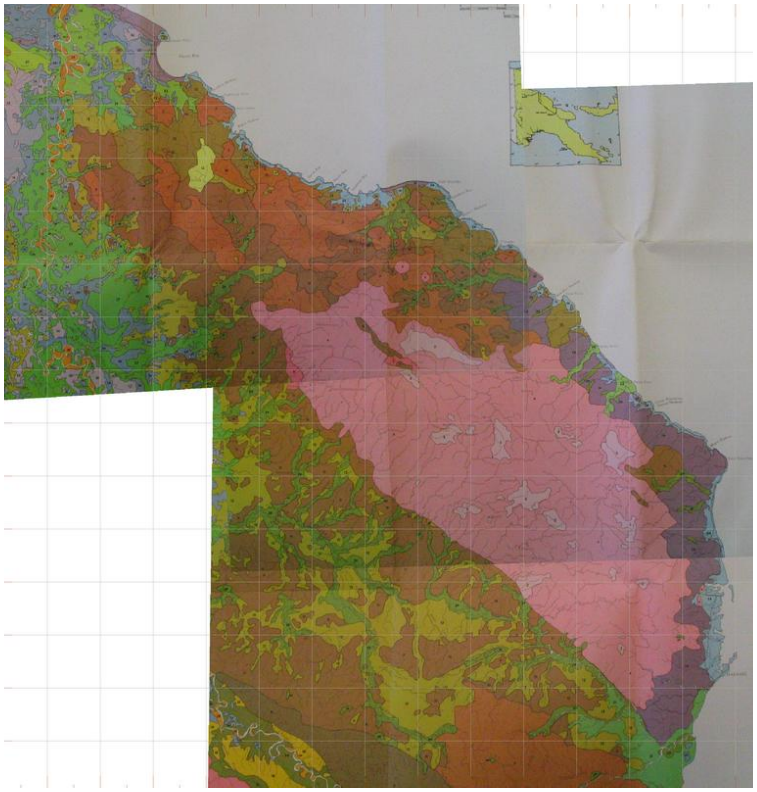

Figure 4: Land systems of the Adelberts, orthorectified from paper map. The primary, dark-pink area is the Gal land system (Table 2).

found no evidence of the presence of *Nothofagus* which comes to dominate at higher elevations. The Forest Resources map in Robbins et al. (1976) (Fig. 5) indicates 'lower montane forest' on the highest peaks, with small patches of 'oak forest' which corresponds to our *Lithocarpus*-rich upland forest. On the same map, a *Nothofagus* class existed, but was not used anywhere in the Adelberts. We had one excellent long-distance view of the highest point in the Adelberts, and careful observation through binoculars suggested that neither the distinctive stands of *Araucaria* nor short, even, montane forest covered the ridges. Instead, it appears that medium-height, diverse mixed submontane forest grows in the highest regions of the Adelberts. A visit to the summit region would be valuable to confirm this.

5.2 Upland forest

Forest between 800 m and 1400 m we have classed as Upland forest. In the map accompanying his report, Paijmans (1976) classes the majority of Adelberts forest lower than 1400 m as medium-crowned lowland forest (FHm): "Most common type in the hills and mountains below 1400 m, very mixed floristically. Canopy relatively uniform in crown size (8–15 m), height (25–30 m), and closure (60–80 %). *Pometia, Canarium, Anisoptera, Cryptocarya, Terminalia, Syzygium, Ficus, Celtis*." We never observed *Anisoptera* in the Adelberts. After ascending and descending to 1000 m several times, we have placed a arbitrary lower limit of 800 m on upland forest, where it grades into hill forest, the most abundant type in the Adelberts.

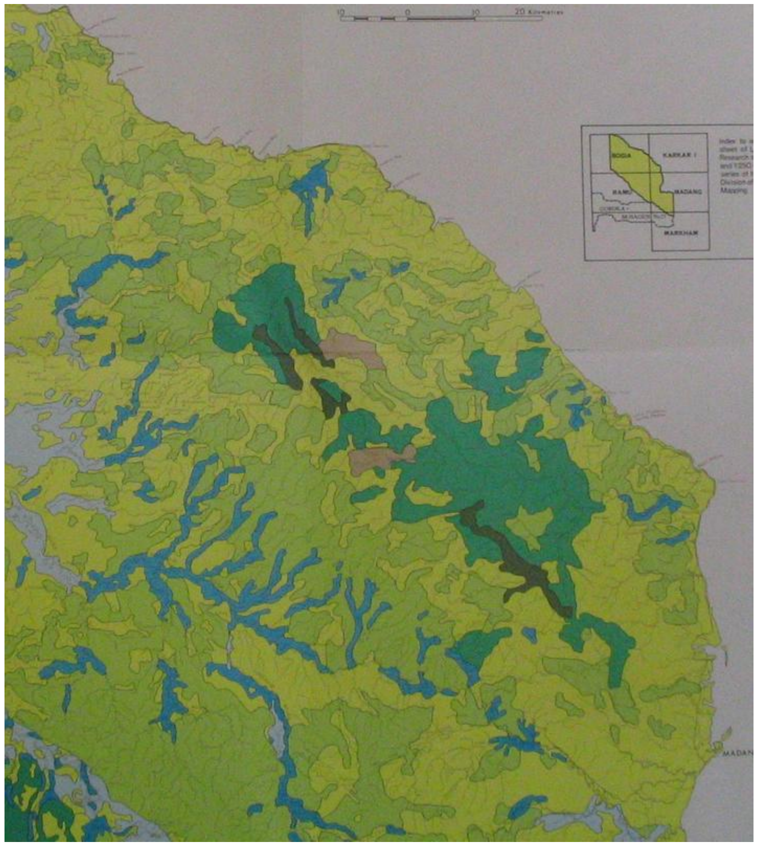

Figure 5: Forest resources of the Adelberts, from Robbins et al. (1976). Mid green = lowland hill forest with high stocking rate, pale green = lowland hill forest with low stocking, dark green = lower montane forest, tan = oak (*Castanopsis*) forest, dark blue = well-drained alluvial forest, light blue = floodplain forest, yellow = other areas.

Substantial variation exists within the upland forest that we were unable to map. The dominant substrate is steeply sloping sandstone and mudstone, leading to stable soils on ridge tops and relatively tall forest (Fig. 6). Other types include:

- Forest on volcanic substrate, similar in composition to sandstone sites, but with more urticaceous understory herbs (*Elatostema* spp.), indicative of richer soils. Old garden sites were often found on these substrates.
- Forest on very hard, level sandstone. This formed a flat rock plateau, with quaternary soil buildup on the banks of streams running directly over the rocks. Stream-side taxa probably had a swamp affinity.
- Forest on the lower half of steep V-shaped ravines, of very moist character. Very well developed understory of gingers, and urticaceous herbs (Fig. 7).

Figure 6: Interior of upland forest, ca. 1100 m.

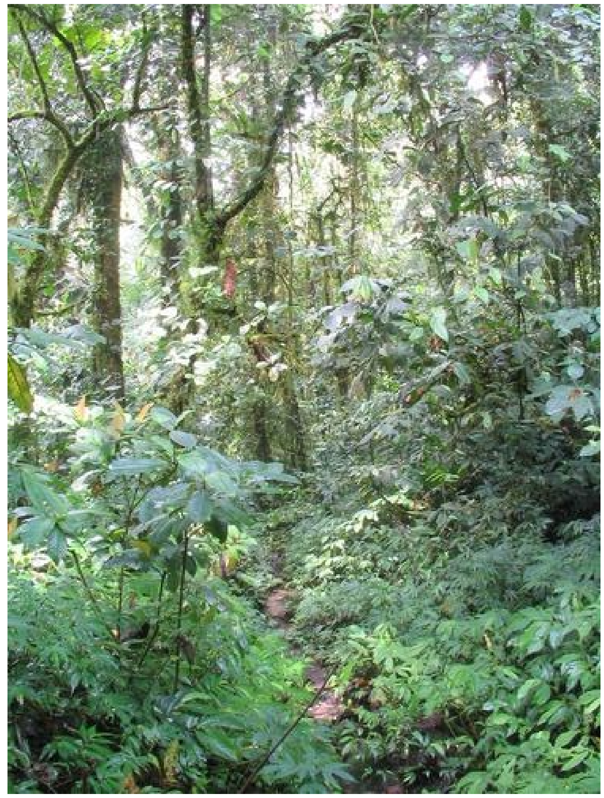

Figure 7: Moist, ravine-side forest, in upland zone.

5.3 Castanopsis forest

On exposed ridges, patches of *Castanopsis acuminatissima* form nearly pure stands. This amazing species coppices very easily (as seen by the adventitious shoots around the base of most trees), and is widespread to Indochina. CW has seen this species in a pure stand on top of Mt. Aural in Cambodia. Here we saw it form small patches (ca. 0.05 ha) in upland forest, although it may form more extensive stands higher up.

5.4 Araucaria forest

At Kumbu, we encountered several trees of *Araucaria hunsteinii* (klinki pine) and *A. cunninghamii* (hoop pine). In the distance, it was clear that patches of these species dominated rounded hilltops at elevations of > 1000 m (Fig. 8), although we did not have the opportunity to examine any closely. Elsewhere in PNG, these araucaria forests drive major timber operations, but their density in the Adelberts appears sparse.

5.5 Hill forest

Hill forest is the forest type with the largest area in the Adelberts. It occurs on steeply slopes and ridges below 800 m, and inside the 'ring' of lowland forests on the low hills. It is dominated by *Pometia pinnata*, and is of high species richness. Many subtypes occur, from ridge to slope

Figure 8: A patch of *Araucaria* forest on a distant hill.

Figure 9: Giant *Agathis* tree in an isolated stand of just a few individuals.

formations, and forest on limestone. We even encountered an isolated patch of *Agathis* trees (Fig. 9), the first know record of this genus in the Adelberts.

5.6 Lowland forest

We have added another subclass to the previously described Lowland-hill forest which occurs on the low hills on the outskirts of the Adelberts. These forests were characterized by generally taller, larger trees, and a higher density of gaps and disturbance (Figs. 12, 10 & 11). They may also be marginally drier, being exposed to winds blowing in from the coast and off the savannas of the Ramu valley. We mapped this class by finding contiguous areas without hills exceeding 400 m. Again, we expect the species composition of lowland forest to intergrade with hill forest above it, and, to a lesser extent, with alluvial forest below it.

Takeuchi (2000) discusses the small-scale variation in species composition observed between ridges and valleys. This variation is characteristic of all forest systems (e.g., Webb and Peart 2000), and increases the apparent α-diversity at medium scales.

5.7 Deciduous forest

In the most northern areas of the Adelberts, annual rainfall lessens and a more seasonal climate prevails. Here, semi-natural grasslands cover the mid and upper slopes of rounded hills, with forest restricted to stream courses. Near the town of Bogia, forests of deciduous legume trees have been planted long ago, and have taken on the form of natural deciduous forest.

5.8 Alluvial forest

True alluvial forest occurs in the wider valleys where the river begins to meander and flood into alluvial plains. The forest appears to have the highest density of gaps of any forest types visited, due to the perpetually inundated soils with little stabilizing rock structure (Fig. 13). The forest is classed by both Paijmans (1976) and FIMS as having a mean small crown size, although some

Figure 10: Palm-dominated understory in lowland forest.

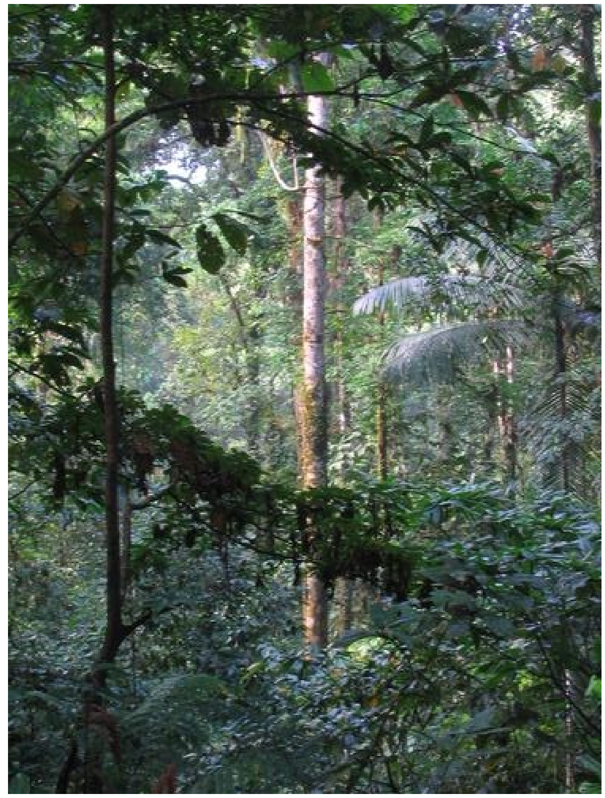

Figure 11: Interior of lowland forest, near Nelobo.

of the tallest trees observed on our surveys were seen in the alluvial forest. While *Pometia pinnata* continues to be abundant, *Terminalia* species become enormous here, and achieve a higher observed density than elsewhere. Other genera include *Alstonia, Diospyros, Garcinia, Myristica, Microcos* (all Laurasian in origin).

5.9 Swamp forest

While not visited, the alluvial forest eventually grades into freshwater swamp forest, towards the edge of the Ramu river, and just within our area of interest. We expect this forest to lie behind natural alluvial levees, and to be inundated for most of the year. Both FIMS and Paijmans (1976) map tongues of swamp forest.

5.10 Liana tangle

On the steepest slopes lies a permanently disturbed vegetation type, best described as a 'liana tangle' (Fig. 14). Soils here are either continually shifting, or pure rock, and do not permit the establishment of tall trees. In addition, the liana mat prevents the growth of many species of tree, both by shading and by physical harassment. Because of the severe topography in the Adelberts, this vegetation type is of more prominence here than in other rain forest areas.

Figure 12: Lowland forest, viewed to NE from Keki lodge.

5.11 Secondary forest

After logging and garden-making (primarily in the coastal hill sand in the area around Josephstal), secondary species grow rapidly, and the forest crown surface becomes very uneven.

5.12 Garden

At any one time, the villagers have converted much of the area around a village into gardens, chopping down trees by hand, burning the slash, and planting with bananas and root crops (*Ipomea, Dioscorea, Manihot* and various Araceae species). We were continually surprised at the steepness of these gardens. This may represent the availability of remaining, suitable area, but in a number of locations it seemed like the very steepest slopes have been targeted. This may represent selection for optimal soil drainage. From a clear viewpoint above Alois' garden near Munsiamunat, we observed that ca. 40% of the opposite hill slope (ca. 1000 ha) was influence by gardens, either current or regrowing.

One of the threats to species that occupy the regrowth phase of forest succession is *Piper aduncum*, an invasive, neotropical species that forms nearly 100% pure stands on abandoned gardens sites. It has spread throughout most of the lowlands of New Guinea over the last three decades (Leps et al. 2002).

5.13 Grassland

Semi-natural grasslands of *Imperata cylindrica* and other species occur throughout the Adelbert lowlands, and especially in the northern, drier area. They burn on a frequent (sub-annual) basis, and prevent the invasion of woody plant species (as elsewhere in SE Asia). They are easily mapped from the Landsat images. A visual comparison of distinctively shaped grassland patches between aerial photos taken in the 70's and Landsat images taken in the 90's showed that many of the patches were unchanged in area and shape.

Figure 13: A spur of alluvial forest near the Guam river.

Figure 14: Liana tangle on steep slopes, near Inbab.

5.14 Mangrove

The coastal areas near the Adelberts are mainly raised coral benches (Madang land system), and not conducive to mangrove formation. Only small areas of mangroves have been formed. These are also easy to map from the Landsat images.

5.15 Coconut plantation

German planters established extensive coconut (copra) plantations along the whole coastline from Madang to the mouth of the Ramu river (on the Madang land system). These are still in production, managed by PNG companies. Little growth by mixed, understory species appears to have taken place, and the biodiversity value of these plantations is very low.

6 Mapping

6.1 Methods

After carefully examining the Landsat images by eye, and with an unsupervised classification, we determined that it would not be possible to use the spectral signature to differentiate among forest sub-types in mature forest. Our general approach to mapping was therefore i) to use the digital elevation model to differentiate major closed forest classes (alluvial, lowland, upland and sub-montane), ii) add crown size information from the FIMS vector layer, and iii) use the Landsat image to indicate disturbed forest classes. In detail our method was:

1. For each Landsat tile, we performed an unsupervised classification to form 30 classes.
2. We visually inspected the position of the classes, with our field notes and GPS tracks, and assigned the 30 classes to i) closed forest, ii) degraded forest and liana tangle, iii) scrubby regrowth, including gardens, iv) grassland, and v) cloud.

3. Using the DEM, we reclassed some closed forest as lowlands (contiguous areas without hills exceeding 400 m), hill forest (0–800 m, but not 'lowland'), upland (800 m to 1400 m), submontane (above 1400 m).

4. Using the FIMS layer, we added to lowland forest a small crown size subclass, and interpreted this as alluvial forest, and overlaid mangrove, coconut and swamp forest.

5. Using the FIMS layer, we overlaid 'urban.'

6. Finally, we performed a 3x3 majority neighbor function (twice) to remove stray pixels.

7. The output grid layer was converted to a shapefile.

The final maps of both the northern Adelberts focal region (Fig. 16), and the whole Adelberts (Fig. 15) was made aesthetically pleasing by Stuart Sheppard.

7 Community Conservation Areas

The conservation context in the northern Adelberts is unique in my experience (but common in PNG). All forest is owned by one village or another, and so making large parks to conserve forest types and biodiversity is not an option. TNC has been working instead to encourage villagers to set aside areas of their land as conservation areas. No hunting or logging is then allowed in these areas. The expected/promoted benefits are: i) that these areas provide a refuge for game animals, and ii) that they represent a tangible investment for the future: the sustainable harvesting of these areas is an eventual possibility, but by being gazetted, these forests will be assured of being managed well, and for the mutual benefit of all the village. Another benefit is expected by some villagers, and causes problems for TNC: that by setting aside the forests, they will be directly compensated, particularly by the building of roads, schools and clinics. While most people seemed relatively healthy and well-fed, access to markets for cash crops was the single biggest perceived lack in their lives. Indeed, some villagers would think nothing of walking 20 km to sell a few vanilla pods, and returning in the same day. TNC's conservation officers must walk a fine line between raising unrealistic, un-fulfillable expectations, and not engaging deeply with the communities. I discussed the idea of fair-trade marketing of cash crops with a number of locals, and they all thought this would be a great; I hope the TNC community development officer will look into this.

7.1 Vegetation types in conservation areas

Because of the homogeneity of the forest types throughout the Adelberts, most of the conservation areas in the TNC study area capture a fairly similar selection of vegetation types (Fig. 16, Table 4), dominated by the general hill forest type. The types that are not well represented are submontane forest (no areas), upland forest (just in the Munsiamunat area), lowland forest (just Turutapa) and alluvial forest (no areas). Adding conservation areas that increase the representation of these types would be beneficial for overall biodiversity conservation. The percentage of non-forest (adding degraded, garden and village classes) also varies among village conservation areas, with Urumarav being the most degraded (8.7%). In all places, the conservation area has a lower percentage of degraded forest than the larger clan area.

7.2 Ethnobotany

I was very impressed how well people still knew their plants, and how dependent they still were on them. I was taken out several times by teams of guides that included children, and the kids already knew names for most of the trees were encountered. This is a far higher level of botanical knowledge that I usually see: often it is only the old men and women who know the plants. This skill is a cultural treasure, and I sincerely hope that changing times in the Adelberts do not cause its loss. The villages also had a far lower incidence of 'plastic goods,' with nearly all articles used in daily life coming from the forest. The local ('tok ples') names for most of the specimens we collected (Section 13) were given by Rafael (in consultation with others in Munsiamunat).

8 Plant Biogeography and Regional Context

The plants of the lowland forests of New Guinea have primarily arrived from the west over the past 2–10 My, while the indigenous Gondwanan flora tends now to dominate the uplands of New Guinea. In addition, it appears that the Gondwanan element is most speciose in the southern parts of New Guinea, with the Malesian elements most diverse in the northern, accreted terranes (Heads 2001). If Robert Hall's hypothesis of the origin of the Adelberts being an island arc is correct, we should see significant differences in the floristic composition of the Adelberts from surrounding lowlands and from the other northern mountain ranges (e.g., the Torricellis).

We do not have the collections yet to test this rigorously, although the online database of New Guinea plant collections at the Royal Botanical Gardens, Sydney website might offer such a means, with significant work. I downloaded all the plants with 'Madang' in their collection records, and attempted to geo-reference them using BioGeoMancer (www.biogeomancer.org). Unfortunately, the gazette sources of BioGeoMancer were fairly limited for the details of the Adelberts, and the geo-referencing success was poor. However, another source of floristic variation was available, in the FIM system:

8.1 PNG-wide Forest Composition Comparison

The FIM system distribution disk contains summary data for hundreds of forest inventory plots throughout PNG. While the species identifications in these tables are only made to genus, we still expect major biogeographic shifts to be detectable at this taxonomic level (Slik et al. 2003).

Methods

We first converted the numerous Excel spreadsheets into plain text, using the Perl-script xls2csv.pl by Takanori Kawai. These were concatenated into a single file and parsed using an AWK-script. The FIM system included both actual plots (with place-names), and a summary for each forest-type, for each site; we only analyzed the summary data. We used the 'vegan' package in R to compute inter-site Bray-Curtis distances for an average plot in medium-crowned lowland forest at that site (averaging over those forests at a site that included 'Hm' in their compound name). These distances were displayed as a dendrogram, using Ward's method (Fig. 17). The choice of distance metric and clustering method did not greatly change the structure of the dendrogram. Note that this analysis did take into account abundance of genera, as well as simple presence/absence.

Results and discussion

The generic composition of the medium crowned forest of the lowlands of the Adelberts was very similar to that of surrounding areas, forming a group with the Gogol-Ramu area, Sepik, Aitape (near the Torricellis) and other north coastal areas. This group is sister to the Huon region, and together they are different from a central/south group, a eastern peninsular group, and a large group of northern islands (New Ireland). This analysis indicates that the lowland-hill forests of the north coast are fairly homogeneous. Two important caveats exist, however: first, this analysis was not performed on the lower montane composition, which might be more variable (not all areas had significant amounts of lower montane forest), and second, endemism will be more obvious at the species level: turnover in species between areas would not register in this analysis if the species were congeners.

8.2 New Guinea-wide Edaphic/Climatic Comparison

Placing the Adelberts in the context of New Guinea as a whole permits us to begin to assess the regional conservation significance of the area. While New Guinea-wide databases are beginning to be assembled for some groups of organisms, none were available or suitable for use in this assessment. However, Earl Saxon and Stuart Sheppard have recently produced a model of climatic and edaphic diversity on the island, which can be used as a proxy for biological composition and diversity. Their model gives the spatial distribution of 500 clusters in climatic and edaphic multi-dimensional space (Fig. 19). We compared the classes from this model within each of the ecoregions defined by the WWF ecoregion project (Fig. 18).

Methods

The 500-cluster raster layer was loaded into the GRASS GIS system, and a JPEG of the WWF ecoregions was orthorectified to the 500-cluster layer. The northern ecoregions (Table 5) were extracted as separate raster layers and used as masks for the 500-cluster layer. The number and class composition of pixels in each ecoregion was summarized in tables, and these composition data were loaded into the R statistical system. The regions clearly varied greatly in size, and we corrected for this in two ways. First, by simply dividing the number of classes in each region by the number of pixels. Second, by subsampling 1,000 pixels (without replacement) from each region (a standard method used in ecology for comparing the diversity of different sized plots).

Beyond comparing the diversity of classes, we assessed the similarity of each ecoregion using cluster analysis on the class-composition matrix. We used the composition of the 1,000 subsampled pixels, both $\log(x + 1)$ transformed and simple presence/absence. The results for both methods were very similar and only the presence/absence dendrogram is shown.

Results & Discussion

The Adelberts region was analyzed separately from the other North-coast hill regions, and was thus one of the smallest regions. Scaled by area, the Adelberts come out as one of the richest areas for climatic/edaphic diversity (Table 5). However, when the rarifaction method was used, the Adelberts dropped to a relatively low position. This is because of the strong spatial autocorrelation in pixel identity—pixels are not like tree species in this respect (despite the patchiness in tree distributions)—which leads non-spatial rarifaction of large areas to over-estimate the pixel diversity. The best comparison method would have been to sample large contiguous areas within the different ecoregions, a method approximated by the sliding window measurement of pixel class diversity (Fig. 20). Examining this map by eye indeed indicates that class diversity in the Adelberts is high, and similar to the other mountainous ecoregions.

The similarity analysis (Fig. 21) indicates that the Adelberts are most similar to the other Northern Hill regions (AA0116), that the hill regions generally cluster together and separate from the lowlands, and that the Huon penninsular is the most dissimilar region.

Taken together, these data suggest that the Adelberts are not unique in their physical characteristics, but that they are among the riches areas for their size. Thus, we can expect high medium-spatial-scale biodiversity driven by high diversity-density of physical characters, but that these physical characters do occur in similar combinations in the other Northern hills ecoregion sites. Any gross difference in biodiversity and composition between these sites will be driven primarily by historical, biogeographic reasons.

8.3 Collections

Ali and Webb (and others) collected over 200 fertile specimens, primarily from the Munsiamunat area (Section 13). These were reviewed by Wayne Takeuchi at Lae, and named where possible, and where time allowed. Wayne expressed disappointment that there were no outstanding new records among the specimens, most being repeats of specimens he collected in the Josephstaal in 2000 (Takeuchi 2000), or common species widely distributed in PNG. This impression reinforces our assessment of the Adelberts as being representative of widespread forest, but not containing high levels of endemism.

9 Conclusions and Recommendations

The Adelbert mountains are intriguing biologically and an exciting case study in truly community-based conservation. I found an acute awareness among locals of the importance of the forest, and this bodes well for the future. Most people were excited that outsiders should come and find their resources to be interesting, and again and again they expressed the desire for continued scientific interaction. I strongly recommend instituting a community-based plant collecting program. The skills were grasped immediately, and the infrastructure could be set up in a week or less. Specimens could be brought to Lae by local villagers, and they could work with botanists. The potential for developing amazing ‘para-taxonomist’ skills has been shown by the herbivory project in Madang. Given the low density of ‘scientific’ collecting in PNG, such village-based initiatives may be the only way to flesh out our rudimentary knowledge of plant species and their distributions.

The forests themselves, while apparently not particularly unique in composition, form a compact assemblage of many vegetation types, and thus offer an important conservation target. I recommend going ahead with an Adelberts-wide conservation assessment. The forests to the south-west have yet to be visited by a scientific team, and reaching the lower montane forest is also a priority (probably by walking through Kumbu, down, and up to the highest peak in the Adelberts). Establishing a series of vegetation plots throughout the forest types would be useful to provide a more quantitative understanding of species composition and turnover, while offering a tangible scientific investment that might be well received in the different conservation areas.

The overall prognosis for the conservation of the forest and biodiversity of the Adelberts are good. I see the primary threats to be i) slow degradation of closed forest through garden clearance, associated with an increase in population pressure, and ii) devastating wildfire. While I have no hard data on the former, casual questioning of villagers indicated that population levels were stable. Probably, migration to the cities is offsetting slowly increasing child survival with better health-care. As with other parts of the forested tropics, climate change and increasing areas of degraded forest are increasing the risk of huge forest fires (cf. East Kalimantan in 1982, and every year since). Fire-education strategies should be part of the village conservation officers' presentations. The risk from large-scale logging appears to have been averted for a while (cf. Josephstaal story), but as tropical forests around the world are inexorably reduced in area, the value of the standing timber in the Adelberts will increase. Being proactive about the threat, and perhaps even encouraging community-based sustainable logging, will be vital for the long-term conservation of the Adelberts.

10 Acknowledgments

We would like to thank the outstanding logistical support offered by the Madang Field Office, particularly Francis Hurahura, Francis Beibe and Warren Jano. In Port Moresby, Paul Lokani and Dominica Kamas were very helpful, as were staff at the National Mapping Bureau (especially Sebastian Hani and Wike Songake). Earl Saxon offered very helpful comments during meetings in Brisbane and Washington, DC, and kindly offered to share the 500-cluster edaphic/climatic data layer. In the field, we were welcomed at a number of villages, including Inbab, Swopim, Wadakinam, Yawera, Munsiamunat and Dudura. Thanks in particular to our companions on the road: Fidalis, Joe, Phillip, Tobias, Sylvester, Atok, Samuel, Willy, Caspar, Sarah, Cosmas, Rafael, Alois, Lazarus, Thomas, and many others. Also Moyang Okira of Keki Lodge. In all, CW has been tremendously impressed with the kindness and helpfulness of the residents of PNG. My apologies to those inadvertantly ommitted from this list.

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12 Electronic appendixes

1. Digital map. Arc shape file: `adel_veg`.
2. GPS waypoints from field surveys: `webb_waypoints.txt`.
3. Orthorectified raster layer of Land systems classification: `adel_landsys.zip`.

Table 2: Landforms common in the survey area, as noted by Robbins et al. (1976).

Name (no.)	Locations	Description	Vegetation
Atitau (4)	Summits	Rounded hill ridges above 700 m within the Gal LS; old uplifted Tertiary sediments	Hill forest and sub-montane forest with some stands of *Castanopsis*
Gal (4)	Interior	Rugged low mountains of greywacke with interbedded sediments and tuff; narrow steep-sided ridges	Hill forest
Bagasin (7)	Nothern 'slopes'	Steep, rugged sandstone and limestone hills to low mountains	Lowland forest with patches of alluvial forest in valleys
Morumu (11)	Western and Northern 'slopes'	Very strongly dissected hilly country on gently dipping Pliocene mudstone and siltstone with some limestone capping	Lowland forest, secondary forest
Anaimon (12)	Western 'slopes'	Hilly country with narrow alluvial valleys; Miocene/Pliocene mudstone and sandstone	Mainly secondary forest with alluvial forest in valleys
Sangan (13)	Eastern 'slopes'	Strongly dissected hilly country near coast; Gently dipping sandstone, mudstone of Miocene age	Secondary forest and grassland
Amele (14)	Coastal hills	Strongly dissected, hilly to 250 m near coast; soft marl, siltstone with uplifted coral reef	Lowland forest
Madang (24)	Coastal plains	Shallow coral limestone and alluvial soils	Plantations and grassland
Papul (29)	Western flats	Small alluvial valleys on fine-textured alluvium	Alluvial forest

Table 3: Cross-walk between vegetation classes observed and vegetation classes in map

Vegetation observed	Mapped vegetation
Submontane (A)	(1) Submontane
Upland forest (B)	(2) Upland forest
Castanopsis forest (C)	
Araucaria forest (D)	
Hill forest (E)	(3) Hill forest
Lowland forest (F)	(4) Lowland forest
Deciduous forest (G)	
Alluvial forest (H)	(5) Alluvial forest (small-crowned)
Swamp forest (I)	(6) Swamp forest
Liana tangle (J)	(7) Degraded forest (tall)
Secondary forest (tall) (K)	
Garden (L)	(8) Scrub/garden
Grassland (M)	(9) Grassland
Mangrove (N)	(10) Mangrove
Coconut plantation (O)	(11) Coconut plantation
Open soil (P)	
	(12) Urban

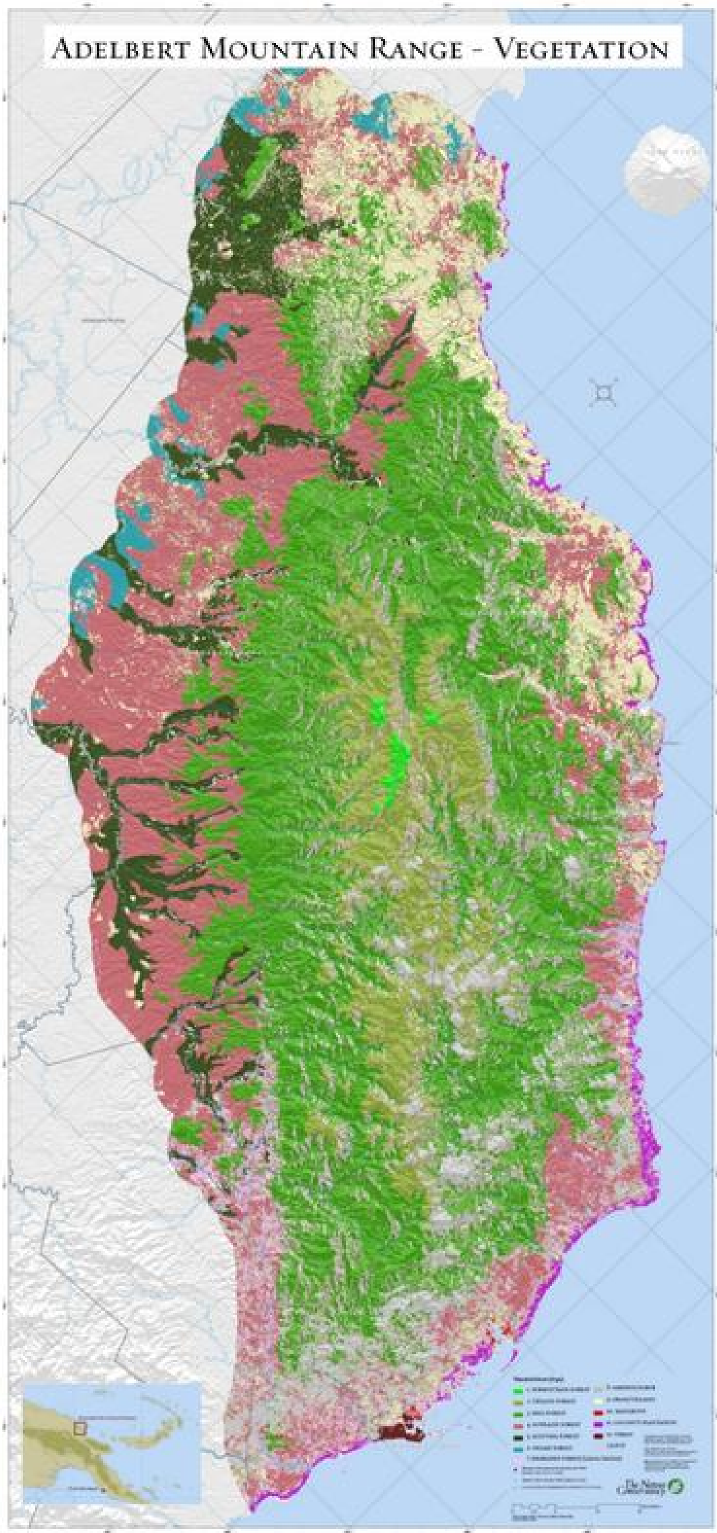

Figure 15: Vegetation map of the Adelbert mountains.

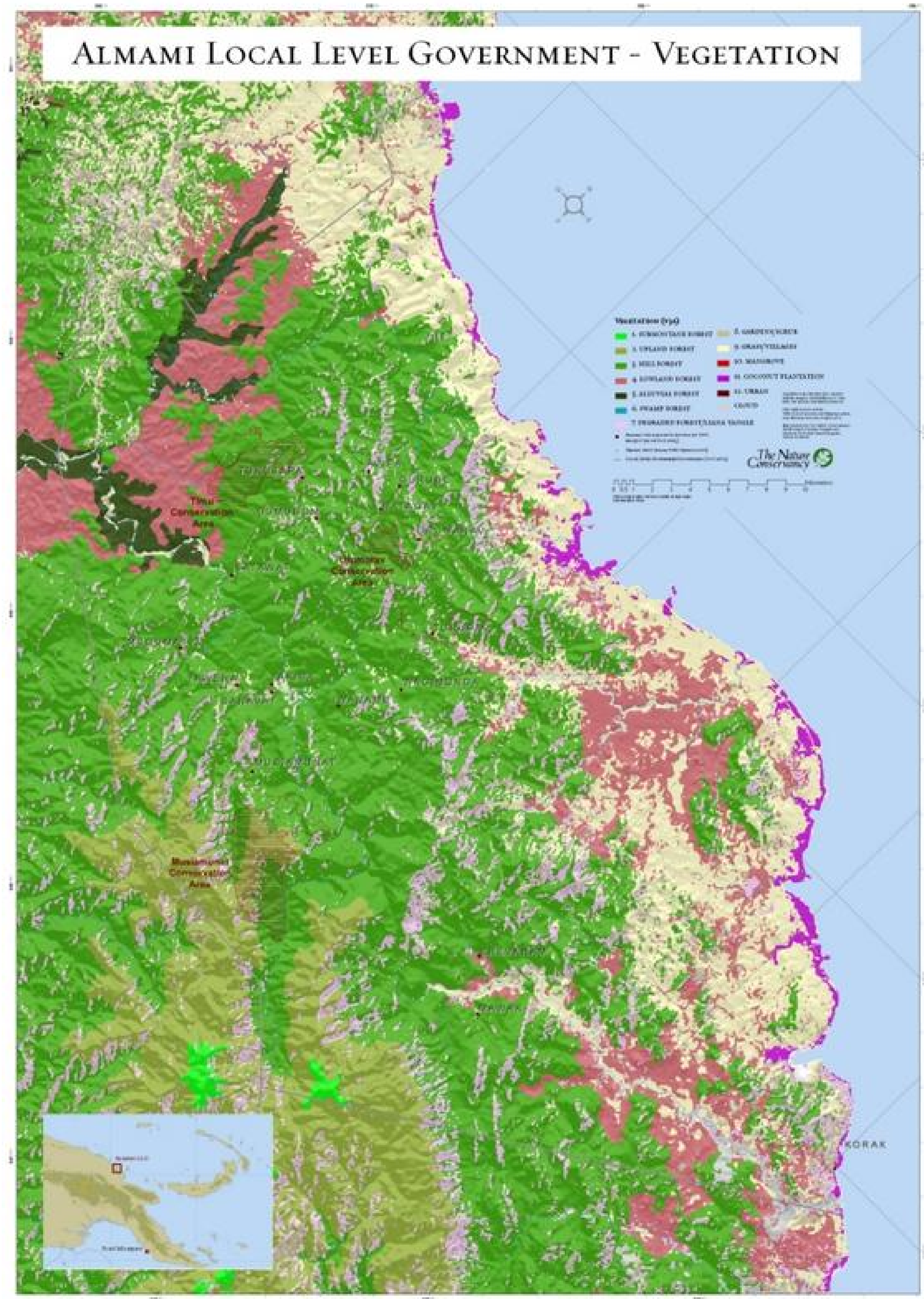

Figure 16: Vegetation map of the TNC northern Adelbert Almani region.

Table 4: Breakdown by area (ha) of vegetation types in the Community Conservation Areas.

	Timu (Turutapa) conservation area	Turutapa clan area	Musiamunat conservation area	Musiamunat clan area	Urumarav conservation area	Urumarav clan area
Submontane forest	0	0	0	0	0	0
Upland forest	0	0	616	14	0	0
Hill forest	793	683	799	788	231	1963
Lowland forest	60	3	0	0	0	0
Alluvial forest	0	0	0	0	0	0
Degraded forest/liana tangle	26	44	111	228	19	246
Gardens/scrub	1	1	4	105	2	26
Grass/villages	1	0	7	13	0	54
Total	*883*	*733*	*1538*	*1150*	*253*	*2290*

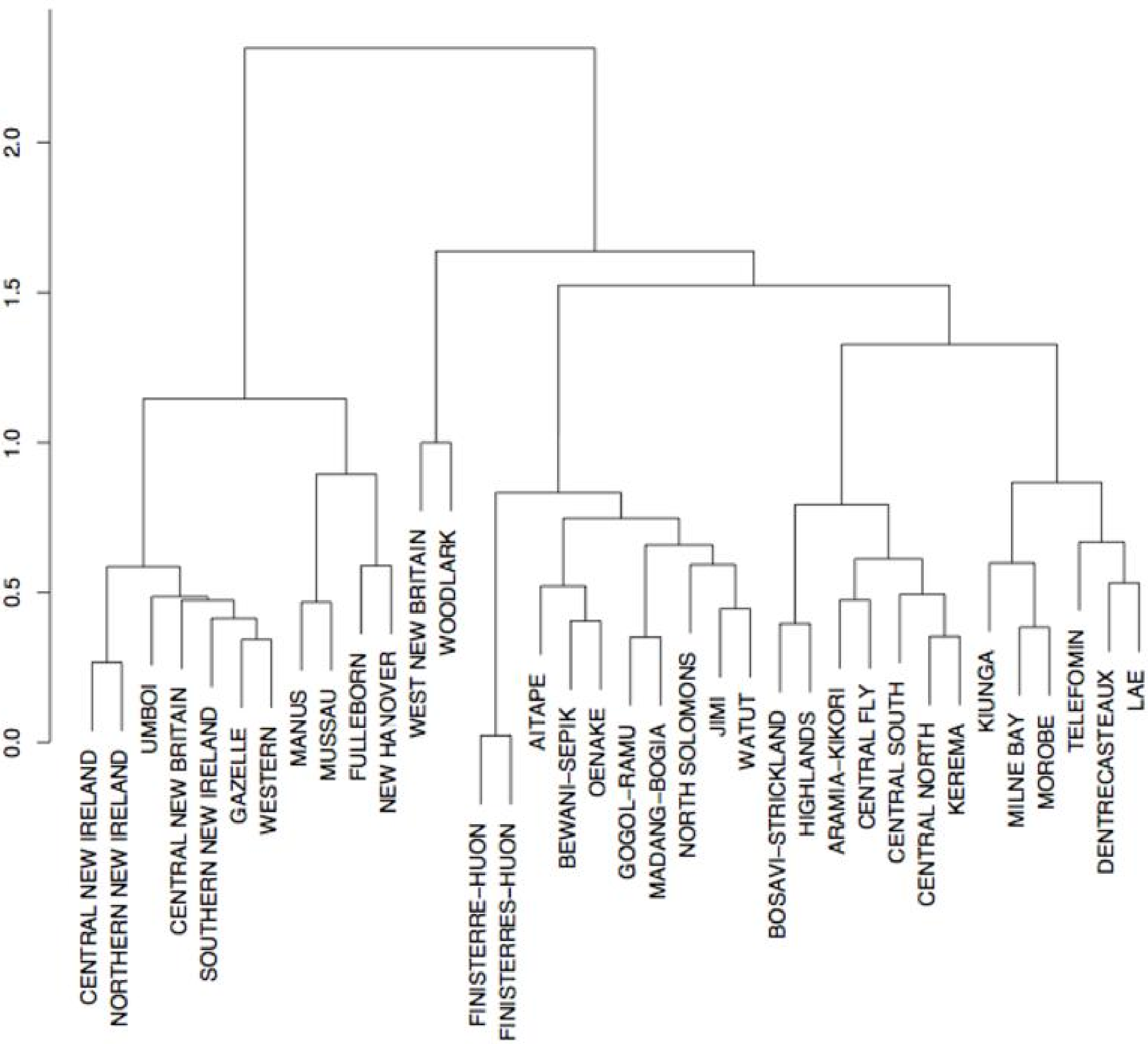

Figure 17: PNG forest compositional similarity using FIMS data. The Adelberts are represented by 'MADANG-BOGIA' (near center). See text for methods and details.

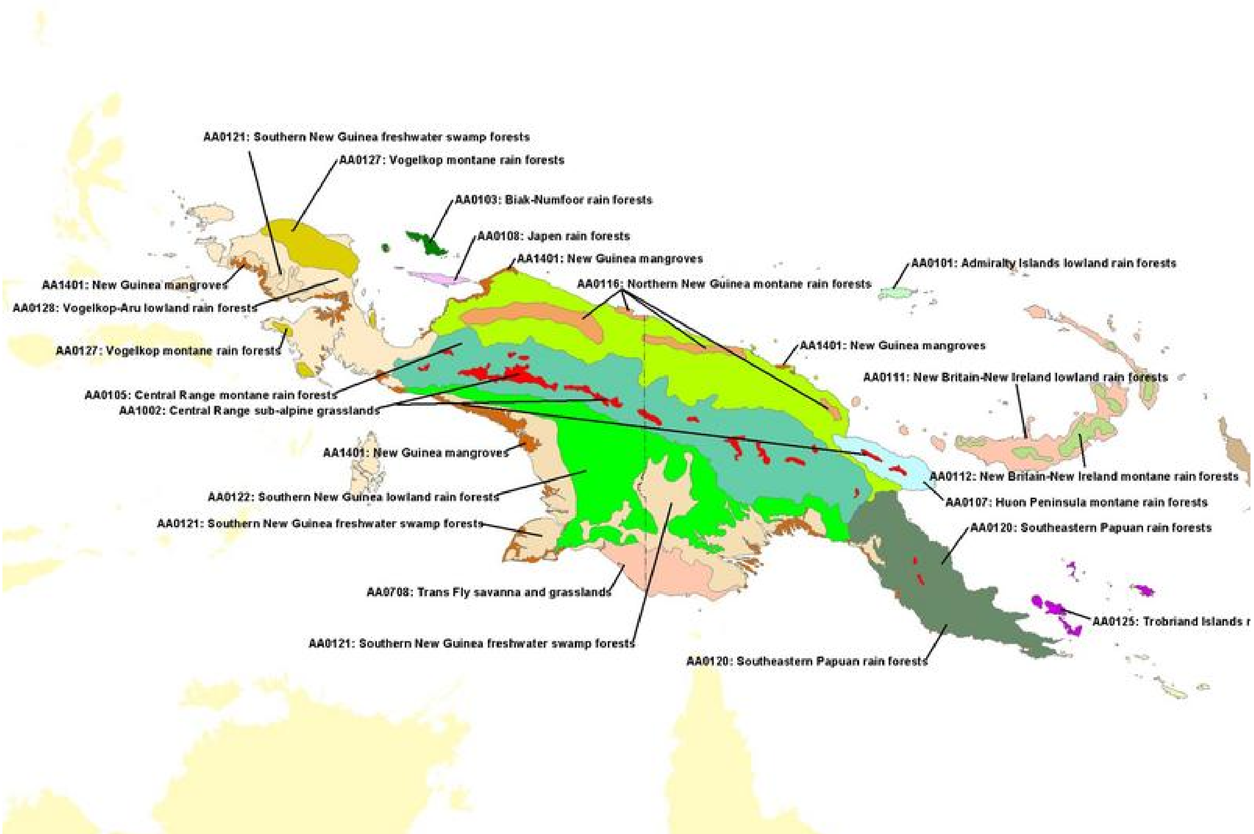

Figure 18: Ecoregions used in regional comparisons: Raja Ampat (islands west of Bird's Head), Bird's Head lowlands (flesh), Arfak mountains (straw), Northern lowlands (olive green), Northern hills (dark flesh; numbered '1,' '2,' '3,' 'Adelberts' from west), Huon region (pale blue; excluding mountains). Source: WWF ecoregions, via TNC GIS staff.

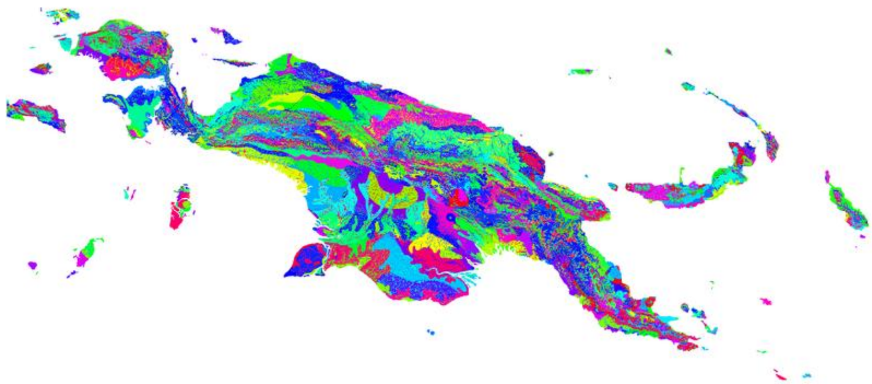

Figure 19: Saxon & Sheppard's 500 edaphic/climatic clusters in New Guinea. Colors are a random selection of 500, and simply indicate identity.

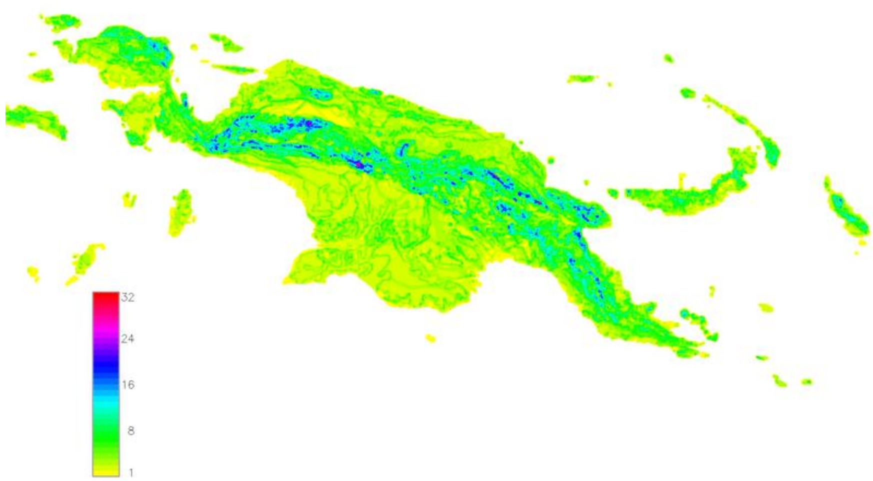

Figure 20: Diversity-density of Saxon & Shephard's 500 edaphic/climatic clusters: the value of each pixel is the number of different clusters in a square window (of sides 9 pixels) surrounding the focal pixel. The mountains stand out with the highest diversity because of the rapid change in climatic factors with horizontal distance. The Adelberts have a mean diversity of 8 classes.

Table 5: New Guinea-wide comparison of areas, based on edaphic/climatic units.

WWF ecozone	No. pixels	No. cluster-classes in zone	classes / pixel	rarefied no. classes
Adelberts	1,632	21	0.0128	20
Arfak Mtns	20,808	103	0.0049	75
Birds Head lowlands	64,745	133	0.0020	82
Northern hills 1	18,240	59	0.0032	43
Northern hills 3	1,550	29	0.0187	28
Northern hills 3	6,641	26	0.0039	22
Huon	18,163	144	0.0079	101
Northern lowlands	154,196	141	0.0009	76
Raja Ampat	8,219	55	0.0066	45

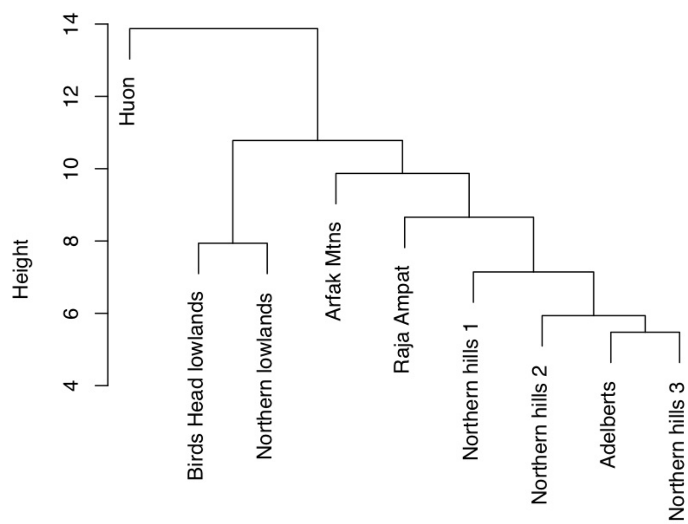

Figure 21: Cluster dendrogram of WWF ecoregions based on similarity (presence/absence, Euclidean, Ward's method) in 500-cluster space (see Fig. 19).

13 Appendix: Collections

No.	Determination	Family	Tok ples
1	*Pseuduvaria*	Annonaceae	wawairuv
2	*Fagraea woodiana* F. v. M.	Loganiaceae	
3	*Osmoxylon novoguineense*	Araliaceae	iperawitipav
4	*Chisocheton lasiocarpus*	Meliaceae	sakwerib
5	*Saurauia conferta*	Actinidiaceae	bebebe
6	*Dysoxylum variabile* Harms	Meliaceae	biburu
7	*Crytocarya*	Lauraceae	kuasanam
8	*Syzygium*	Myrtaceae	dadag
9	*Poikilospermum*	Urticaceae	yagididir
10	*Duabanga moluccana*	Sonneratiaceae	arenum
11	*Microcos*	Malvaceae	esdu
12	*indet.*	Apocynaceae	
13	*Macaranga*	Euphorbiaceae	savigorgor
14	*Gynotroches axillaris*	Rhizophoraceae	kidarakidara
15	*Dichroa sylvatica*	Saxifragaceae	wanapuakav
16	*Uncaria lanosa*	Rubiaceae	koropam
17	*Decaspermum bracteatum*	Myrtaceae	dadag
18	*Cyrtandra*	Gesneriaceae	reveriva
19	*Mallotus paniculatus*	Euphorbiaceae	kovera
20	*Elatostema*	Urticaceae	rupupuv
21	*Gouania*	Rhamnaceae	tanir
22	*Laportea decumana*	Urticaceae	irabisnadi
23	*Asplenium decorum* Kunze	Aspleniaceae	kanua
24	*Fittingia*	Myrsinaceae	amumavnasag
25	*Belvisia*	Polypodiaceae	wasina
26	*Microsorum*	Polypodiaceae	namstem-simisim
27	*indet. rhizomatous fern*	indet.	wasimiato
28	*Bolbitis heteroclita* (Presl) Ching	Lomariopsidaceae	emiridna

continued . . .

No.	Determination	Family	Tok ples
29	*Cyrtandra schumanniana*	Gesneriaceae	livarewa
30	*Psychotria phaeochlamys*	Rubiaceae	butonagarem
31	*Elatostema*	Urticaceae	lupupum
32	*Medinilla*	Melastomataceae	
33	*Ruellia*	Acanthaceae	saukivama
34	*Elatostema* cf. *macrophylla*	Urticaceae	
35	*Ophiorhiza*	Rubiaceae	bobogaram
36	*Rhynchoglossum obliquum*	Gesneriaceae	luknin
37	*Discocalyx*	Myrsinaceae	paipaiwap
38	*Steganthera hospitans*	Monimiaceae	marwabu
39	*Elatostema*	Urticaceae	tugutitilovo
40	*Amaracarpus*	Rubiaceae	bobogaram
41	*Cyrtandra*	Gesneriaceae	revarina
42	*Coix lachryma jobi*	Poaceae	matak
43	*Psychotria*	Rubiaceae	bobogaram
44	*Pilea*	Urticaceae	biarh
45	*Equisetum ramosissimum* Desf. ssp. debile (Vauch.) Hauke	Equisetaceae	kekir
46	*Ophiorhiza*	Rubiaceae	sibakukupat
47	*Decaspermum bracteatum*	Myrtaceae	tadak
48	*Psychotria*	Rubiaceae	bobogaram
49	*Agalmyla*	Gesneriaceae	sonojam
50	*Macaranga*	Euphorbiaceae	kinsar
51	*Procris frutescens*	Urticaceae	fakildidir
52	*Cypholophus*	Urticaceae	rubuwa
53	*Maesa haplobotrys*	Myrsinaceae	mongiem
54	*Sabia pauciflora*	Sabiaceae	
55	*Pueraria*	Fabaceae	bin diwai
56	*Cyrtosperma macrotum*	Araceae	obos diwa
57	*Alpinia*	Zingiberaceae	dare-dar
58	*Psychotria morobense*	Rubiaceae	bubagaram

continued . . .

No.	Determination	Family	Tok ples
59	*Phrynium*	Marantaceae	rusaim
60	*Casearia?*	Salicaceae	wawairuv
61	*Harpullia*	Sapindaceae	
62	*Cyrtandra*	Gesneriaceae	riveriwa
63	*Psychotria*	Rubiaceae	bubagaram
64	*Saurauia schumanniana*	Actinidiaceae	bebebe
65	*Oreocnide*	Urticaceae	idir
66	*Ixora 'cordata facies'*	Rubiaceae	subem
67	*Chisocheton pohlianus* Harms	Meliaceae	rueh
68	*Amaracarpus* sp., aff. '*attenuatus-heteropus* group'	Rubiaceae	
69	*Pilea*	Urticaceae	yagidir-idir
70	*Leea indica* (Burm. f.) Merr.	Vitaceae	abav
71	*Melicope* '*triphylla* facies'	Rutaceae	isiwar-noba
72	*Freycinetia*	Pandanaceae	rageragem
73	*Aglaia*	Meliaceae	muarasob
74	*Perottetia alpestris*	Celastraceae	sibagarom
75	*Tabernaemontana orientalis* R. Br.	Apocynaceae	kakawa
76	*Chionanthus ramiflorus* Roxb.	Oleaceae	uberam-dura
77	*Ardisia*	Myrsinaceae	badag
78	*Mackinlaya* '*schlechteri* facies'	Araliaceae	puarer
79	*Pittosporum sinuatum* Blume	Pittosporaceae	
80	*Archidendron*	Mimosaceae	was-uram
81	*Dolicholobium*	Rubiaceae	
82	*Ixora* '*cordata* facies'	Rubiaceae	subem
83	*Ardisia*	Myrsinaceae	
84	*Phyllanthus rubriflorus* J. J. Sm.	Phyllanthaceae	puaepuewav
85	*Geniostoma rupestre* J. R. & G. Forst.	Loganiaceae	uberam-durar
86*A*	*Harpullia*	Sapindaceae	
86*B*	*Lasianthus*	Rubiaceae	kedara-kedara

continued . . .

No.	Determination	Family	Tok ples
87	*Amaracarpus grandifolius* Valeton	Rubiaceae	
88	*Geniostoma rupestre* J. R. & G. Forst.	Loganiaceae	
89	*Cordyline fruticosa* (L.) A. Chev.	Agavaceae	arag
90	*Aphanamixis polystachya* (Wall.) R. N. Parker	Meliaceae	saya
91	*Begonia pseudolateralis* Warburg	Begoniaceae	rupupuv
92	*Cayratia geniculata* (Blume) Gagn.	Vitaceae	sisi
93	*Aglaia*	Meliaceae	saya
94	*Psychotria leptothyrsa* Miq. var. *leptothyrsa*	Rubiaceae	bubagaram
95	*Psychotria pseudomaschalodesme* Takeuchi	Rubiaceae	bubagaram
96	*Phrynium pedunculatum* Warburg	Marantaceae	muajao-weregav
97	*Myristica*	Myristicaceae	sigua
98	*Elatostema*	Urticaceae	yaga-diribua
99	*Cerbera floribunda* K. Schum.	Apocynaceae	ubug
100	*missing specimen*		wasuram
101	*Saurauia schumanniana*	Actinidiaceae	bebebe
102	*Lasianthus chlorocarpus* K. Schum	Rubiaceae	wawairub
103	*Goodyera*	Orchidaceae	rakaraka
104	*Astronia*	Melastomataceae	muga-ubegav
105	*Cyrtandra*	Gesneriaceae	reveriva
106	*Smilax calophylla* Wall. ex DC	Smilacaceae	taemara
107	*Archidendron*	Mimosaceae	wasuram
108	*Ixora* ‘*cordata* facies’	Rubiaceae	subem
109	*Amaracarpus*	Rubiaceae	
110	*Phrynium*	Marantaceae	mumadi
111	*Begonia papuana* Warburg	Begoniaceae	rupupuv

continued . . .

No.	Determination	Family	Tok ples
112	*Lasianthus chlorocarpus* K. Schum	Rubiaceae	kedara-kedara
113	*Versteegia cauliflora*	Rubiaceae	subem
114	*Alpinia*	Zingiberaceae	kurikurik
115	*Alpinia* '*oceanica* facies'	Zingiberaceae	isiwar-gurib
116	*Riedelia*	Zingiberaceae	manuwura
117	*Alpinia*	Zingiberaceae	daredar
118	*Spiraeopsis*	Cunoniaceae	
119	*Schuurmansia henningsii* K. Schum.	Ochnaceae	yageguar
120	*Parastemon versteeghii* Merr. & Perry	Chrysobalanaceae	
121	*Litsea*	Lauraceae	soinaro
122	*Gonocaryum*	Icacinaceae	kidara-kidara
123	*Aglaia*	Meliaceae	saya
124	*Cryptocarya laevigata* Bl.	Lauraceae	muaia
125	*Urophyllum*	Rubiaceae	isiwar muaia
126	*Dendrobium bracteatum*	Orchidaceae	yagadiribua
127	*Pilea*	Urticaceae	
128*A*	*Aristolochia schlechteri* Laut.	Aristolochiaceae	
128*B*	*Vittaria elongata* Swartz	Vittariaceae	
129	*Geniostoma rupestre* J. R. & G. Forst.	Loganiaceae	wasimigor
130	*Dysoxylum variabile* Harms	Meliaceae	
131	*Trichomanes*	Hymenophyllaceae	biburu
132	*Antrophyum alatum* Brack.	Vittariaceae	simi-simi
133	*Microcos*	Malvaceae	ujeuja
134	*Huperzia phlegmaria* (L.) Rothm.	Lycopodiaceae	mapuav
135	*Asplenium cuneatum* Lamk	Aspleniaceae	esdua
136*A*	*Aglaia*	Meliaceae	
136*B*	*Pronephrium*	Thelypteridaceae	nam pupun
137	*Lindsaea*	Lindsaea Group	kanua

continued . . .

No.	Determination	Family	Tok ples
138	*Ficus*	Moraceae	wasimi
139	*Dendrobium bracteatum*	Orchidaceae	nanag
140	*Oplismenus*	Poaceae	sabebar
141	*Ficus megalophylla* Diels	Moraceae	nagam
142	*Curcuma* cf. *australasica* Hooker f	Zingiberaceae	rakaraka
143	*Atractocarpus sessilis* (F. Muell.) C. F. Puttock	Rubiaceae	muado
144	*Ficus*	Moraceae	urawigar
145	*Aglaia*	Meliaceae	muarasob
146	*indet.*	Icacinaceae	puasar
147	*Ternstroemia cherryi* (F. M. Bail.) Merr.	Theaceae	
148	*Semecarpus brachystachys* Merr. & Perry	Anacardiaceae	sovekam
149	*Aglaia rimosa*	Meliaceae	saya
150	*Flacourtia inermis* Roxb.	Salicaceae	
151	*Macaranga quadriglandulosa* Warburg	Phyllanthaceae	kadim
152	*Antiaropsis decipiens* K. Schum.	Moraceae	anenag
153	*Aglaia sapindina* (F. v. M.) Harms	Meliaceae	saya
154	*Melastoma cyanoides*	Melastomataceae	eav
155	*Fissistigma*	Annonaceae	navi
156	*Ardisia*	Myrsinaceae	
157	*Callicarpa*	Verbenaceae	bemu
158	*Octamyrtus pleiopetala* Diels	Myrtaceae	dadag
159	*Piper macropiper* Pennant	Piperaceae	imeimuarav
160	*Syzygium*	Myrtaceae	dadag
161	*Medusanthera laxiflora* (Miers) Howard	Icacinaceae	kedara-kedara
162	*Alstonia*	Apocynaceae	umapu sipir

continued . . .

No.	Determination	Family	Tok ples
163	*Pisonia longirostris* Teijsm. & Binn.	Nyctaginaceae	tumuavi
164	*Phyllanthus*	Phyllanthaceae	suaretag
165	*indet.*	Cucurbitaceae	inukum
166	*Bambusa*	Poaceae	ugariv
167	*Ardisia*	Myrsinaceae	puaepuaevav
168	*Sabia pauciflora* Blume	Sabiaceae	tuy
169	*Ficus*	Moraceae	widom
170	*Melothria*	Cucurbitaceae	
171	*Callistopteris apiifolia* (*Trichomanes*)	Hymenophyllaceae	kanua ato
172	*Argostemma*	Rubiaceae	
173	*Argostemma*	Rubiaceae	rupupuv
174	*Begonia pinnatifida* Merr. & Perry	Begoniaceae	pudun
175	*Schizaea dichotoma* (L.) Sm.	Schizaeaceae	
178	*Cotylanthera tenuis* Blume	Gentianaceae	
179	*Cotylanthera tenuis* Blume	Gentianaceae	
180	*Phyrnium bracteata*	Marantaceae	
181	*Canarium vitiense* A. Gray	Burseraceae	
182	*Cryptocarya* (myrmecophilous)	Lauraceae	
183	*Alocasia lancifolia*	Araceae	
184	*Ficus*	Moraceae	
185	*Gonocaryum montanum*	Icacinaceae	
186	*Syzygium goniopterum*	Myrtaceae	
187	*Dysoxylum*	Meliaceae	
188	*Alangium villosum*	Alangiaceae	
189	*Myristica subulata*	Myristicaceae	
190*A*	*Haplostichanthus longirostris* (Scheffer) van Heusden	Annonaceae	
190*B*	*Gonocaryum*	Icacinaceae	
191	*Pseuduvaria*	Annonaceae	
192	*Microcos*	Malvaceae	

continued . . .

No.	Determination	Family	Tok ples
193	*Cryptocarya*	Lauraceae	
194	*Piper pseudoamboinense* C. DC.	Piperaceae	
195	*Ficus* cf. *subulata*	Moraceae	
196	*Osmelia philippina* (Turcz.) Benth.	Salicaceae	
197	*Pisonia longirostris* Teijsm. & Binn.	Nyctaginaceae	
198	*Syzygium*	Myrtaceae	
199	*Litsea*	Lauraceae	
200	*Psychotria dipteropoda* Laut. & K. Schum.	Rubiaceae	
201	*Rinorea horneri* (Korth.) O. K.	Violaceae	
202	*Calycacanthus magnusianum* K. Schum.	Acanthaceae	
203	*Ficus*	Moraceae	
204	*Morinda umbellatum*	Rubiaceae	
205	*Blumea arfakiana*	Asteraceae	
206	*Bolbitis*	Lomariopsidaceae	
206	*indet*	Orchidaceae	
208	*Melothria*	Cucurbitaceae	
209	*Lemmaphyllum accedens*	Polypodiaceae	