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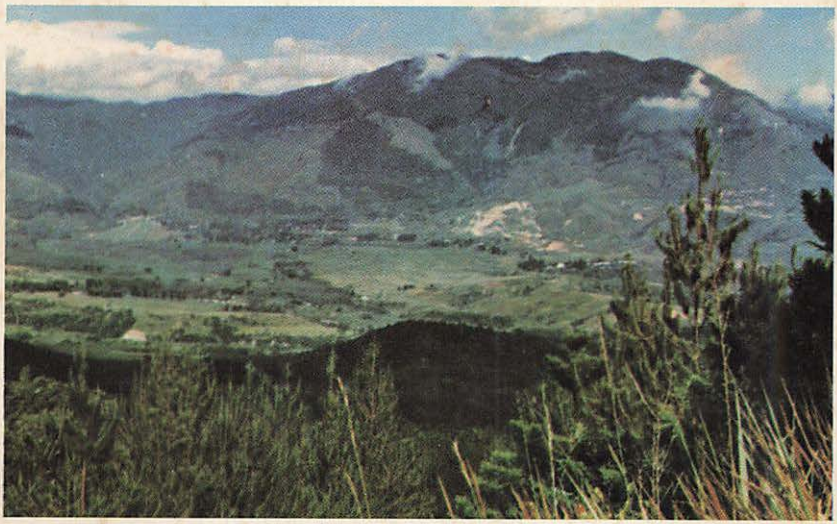
GUIDE TO MT KAINDI

BACKGROUND TO MONTANE NEW GUINEA ECOLOGY

By J. L. Gressitt and Nalini Nadkarni

Illustrated by Margaret Gressitt



WAU ECOLOGY INSTITUTE

HANDBOOK NO. 5

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BACKGROUND TO MONTANE NEW GUINEA ECOLOGY

By

J.L. Gressitt and Nalini Nadkarni

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ILLUSTRATIONS

INTRODUCTION

This work brings together data basic to an understanding of the ecology of Mt Kaindi, a representative mid-montane environment in northeastern New Guinea. Much of the information presented here is preliminary or fragmentary, but an immediate need exists for a teaching base and a reference point for visitors and researchers. Thus, available information is given here, recognizing that it is incomplete and requires more detailed documentation. The clarification of food-chains, nutrient cycles, and other basic ecological processes, for instance, is still in the future, but the material here presented may facilitate initiation of some of these lines of investigation.

Accumulation of various types of data has been undertaken for different periods of time and by different people. Therefore, the information is not balanced for different phases and taxonomic groups and there are many critical gaps. The greatest concentrated effort directed toward understanding various basic aspects of Mt Kaindi was made during July and August 1977 when 2 EARTHWATCH teams spent 3 weeks each documenting varied information in quadrats along a transect from the summit to the foot of the mountain. The data from that exercise comprise the core of this handbook. To that base is added information gleaned over longer periods of time. Publication of results of much research, completed or in progress, is anticipated. Certain reports have been published, and some of these are cited in the bibliography. Many taxonomic papers including species from Kaindi have been published in *Pacific Insects* (Bishop Museum) or elsewhere.

It is hoped that this publication may serve as a model for ecosystem and transect surveys in this country, and as a text for appropriate field ecology methods. It should likewise serve as a source for general information about the montane New Guinea environment and as a base-line documentary for comparisons with similar environments in other areas and for comparisons with other types of environments.

Mt Kaindi was chosen for this intensive survey because of its proximity to WEI, its easy access, the extent of research already carried out there, and the longer term data base already at hand relating to climate.

SCOPE

This work covers biological, physical and historical information relevant to Mt Kaindi, and especially in terms of its relevance to ecology and conservation. The more detailed transect studies took place from the summit to the foot of the mountain, on the NE side, mainly parallel to the electric power line. A small amount of data is presented for the Bulldog Road northern incline, south of Edie Creek, for partial comparison with the situation on the summit of Kaindi. The Bulldog Road, south to the pass and nearby peak at E end of Ekuti Range, forms the continuation to higher altitude of the study transect, just as the road to Lae forms the

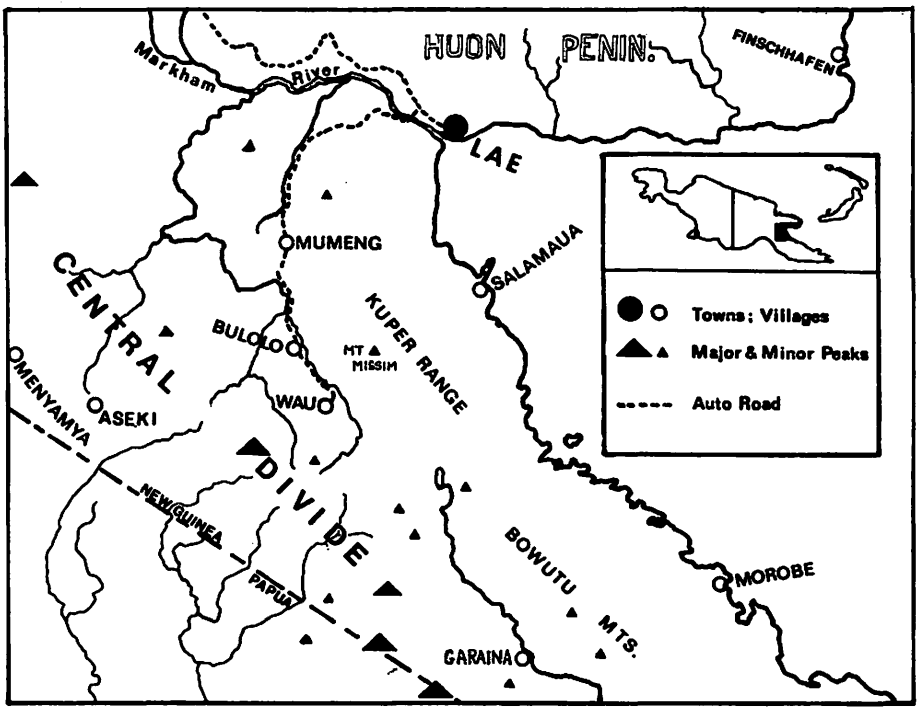
downward continuation to sea level. It is hoped to document these extensions later on to give a complete N slope overview for this part of New Guinea.

Edie Creek is considered as part of Kaindi. The general Wau-Bulolo area is included in the background discussions of geology and history.

The attempt has been made to include as much information as possible based on Kaindi, even some "raw data," partly as examples of types of information that need to be collected. Studies in progress should later permit refinement and more stable conclusions. A full plant-list is not included, partly because of our emphases, as well as work in progress by others.

SETTING

Mt Kaindi is situated at latitude 7° 24' S and longitude 146° 44' E. It is located on the S side of the Wau Valley, through which flows the upper portion of the Bulolo River. With a slight dip on the SW to about 2000 m altitude, the mountain connects with a ridge extending south and gradually rising to join the Ekuti Dividing Range, near its E end. This range is the main divide of the island in this section. The connecting ridge forms the



1. General map of Wau-Lae area.

route of the northern half of the war-time Bulldog Road, the only road every built across the island of New Guinea. The road rises to 2900 meters altitude where it crosses the end of the range and then drops more rapidly toward the S coast along the Lakekamu River.

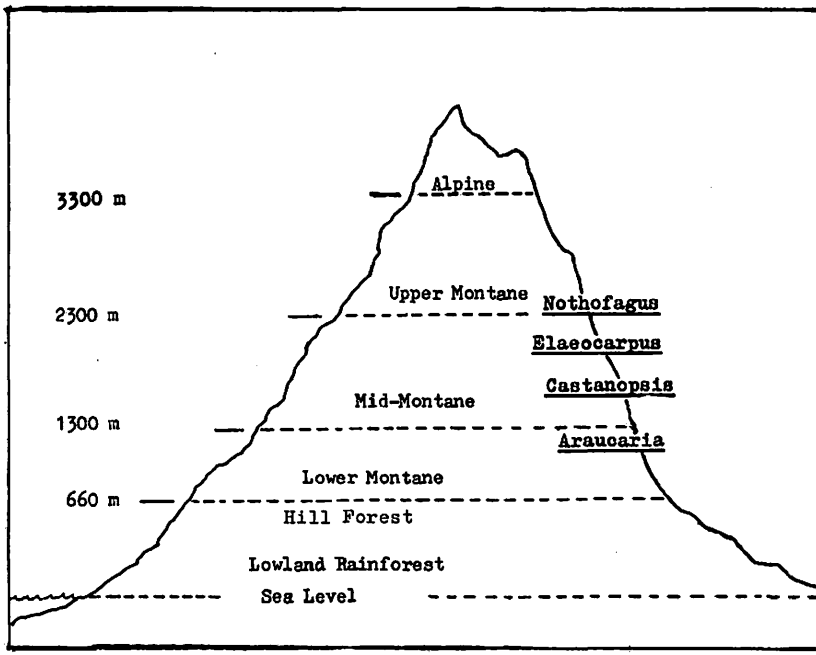
Across Wau Valley from Kaindi is Mt Missim (2839 m) of the Kuper Range. Lying between Kaindi and the Huon Gulf, this range shelters the valley and Kaindi from the NE trade winds. As mountains to the E, S and W of Wau and Kaindi are mostly even higher, the area is well protected from all directions, including from the SE trade winds by the Owen Stanleys and intervening mountains.

From the summits or upper slopes of Kaindi a great deal of this portion of New Guinea can be seen in clear weather. To the SE, beyond the Kuper Range, are the Bowutu Mts N of Garaina, mountains between Wau and the Owen Stanley Mts, and Mt Strong and other peaks of the W end of the Owen Stanleys to the SSE. Then to the S the Ekuti Range encompasses a very wide span of the view. The highest peak of the range, Mt Amungwiwa (3278) is considerably to the W, and large areas of alpine grassland can be seen around it and beyond, under suitable lighting conditions. The large Upper Watut Valley lies between the S rim of the Edie Creek Basin and the Ekuti Range, and its upper end is to the immediate W of the Bulldog Road just before it starts to round the E end of the Ekuti Ra. After a break at the W end of the Ekuti is Mt Leahy, and much farther to the W can be seen most of the N-S Kratke Mts of the Eastern Highlands. To the N of these to the NW, can be seen a distant mountain mass which is the Bismarck Range with Mt Otto and other lower mountains in between. To the NNW, but rarely seen, are the Finisterre Mts, and to the N parts of the Salawaket (Saruwaged) Range are often seen above Zenag pass (Lae road) and Mt Shungol, with the Markham Valley and Lae hidden behind these latter.

ENVIRONMENT

Mt Kaindi in many respects is typical of the mid-montane environment of northeastern New Guinea. The small mountain is also unique in several ways. The altitude span, from 1150 meters at its foot to 2362 at the summit, includes 4 principal vegetation subtypes, all mixed rainforest. The lowest zone is *Araucaria* mixed rainforest (in some places lower montane rainforest without *Araucaria*); second lowest is oak forest, often mixed and sometimes nearly pure; thirdly is the elaeocarp mixed rainforest; and on the summit ridge and upper lateral ridges is *Nothofagus* (Southern or Antarctic Beech) mixed semi-mossforest.

Unique aspects of Kaindi relate to its location and history. It is adjacent to the Edie Creek upper basin, the site of the greatest gold strike in Australasia. Some of the gold mines lie on the W slope of Kaindi, up to the middle of the summit ridge. Gold mining continues in the basin, as well as downstream for some distance, through the Edie and Bulolo gorges and farther down the Bulolo River. Moreover, the first telephone repeater



2. Altitudinal zones and main forest types (Mt Kaindi represented by *Araucaria* through *Nothofagus*).

station in New Guinea is situated on the S summit of Kaindi, where it was built about 1959, and rebuilt with new instrumentation in 1970. As a consequence of the gold mining and the repeater station, and all-weather road is maintained to the top, with a branch to Edie Creek. This ready access is a great advantage to scientists and students. Nowhere else in the country can one get from the coast to this altitude in just over 3 hours driving time (½ hour to summit from WEI). WEI also has a branch station at S summit. Thus, students can view the various altitudinal zones of the environment readily and researchers have a great advantage. As a result of research already accomplished, a great deal is known about the mountain, and many species have been founded with Kaindi as their type-locality. Therefore it is of great educational and scientific importance.

The environment of Mt Kaindi is a favourable one, supporting luxuriant growth of a huge variety of plants. These latter in turn help support a great variety of animals. The rainfall is not as high as in many parts of New Guinea which support rainforest. However, the fairly even distribution of rain throughout the year and the general lack of high winds provide a highly beneficial milieu. One example of the benign situation is the unusually great height of the trees on the summit ridge of the mountain, considering the altitude. Another example is the association involving many kinds of cryptogamic plants growing on the backs of large weevils,

with these plants in turn harboring several groups of animals, including protozoans, rotifers, nematodes, and phytophagous mites and insects. Apparently no comparable association has been found in other parts of the world. This phenomenon is not unique to Kaindi, but is shared with most upper mid-montane situations on the mainland of New Guinea.

CLIMATE

Kaindi has a climate similar to that of much of the New Guinea highlands. This is characterized by lack of distinct seasons, of moderate rainfall rather evenly distributed through the year, of weak wind, high humidity, considerable fog and limited temperature range.

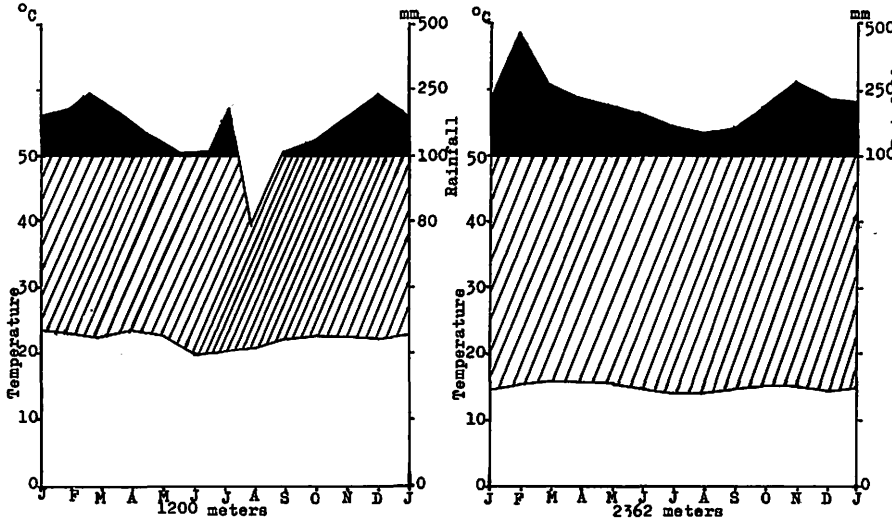
The diversity and luxuriance of the Kaindi forests are reflections of the benign climate and other favorable aspects of the environment. Thus adequate rain, lack of dry season, calm and damp air and moderate temperatures provide a setting conducive to continuous growth and activity together with rapid evolution. Regimes of rainfall, fog, humidity, wind and temperature are moderate but largely unpredictable. It is predictable, however, that humidity will be 100% every night. The increase in rain with decrease in temperature with altitude produces a variety of climatic types along the 1750-meter elevational transect stretching from WEI to the summit of Bulldog Road.

Wau Ecology Institute has maintained 3 principal weather stations, at 1200, 1800 and 2362 meters altitude, respectively (foot, middle and summit of Kaindi). The 1800 m station has not been operated as long as the other 2, and lacks wind gauge and solarimeter. Its records more closely approximate those of the summit than those of 1200 m. Incomplete stations (rain, temperature) are maintained near top of Bulldog Road (2864 m) and on side of Mt Missim (1600 m). Such stations were more recently established on summits of Mt Missim and Mt Amungwiwa.

Holdridge (1967) provides a useful method of climatic classification and McAlpine *et al.* (1975) provide comprehensive climatic tables for all of Papua New Guinea. Brookfield & Hart (1966) analyze rainfall patterns for the SW Pacific.

Rainfall: Monthly rainfall data for 1200, 2362 and 2864 m are shown in Table 1. Highest and lowest records are also shown as there is considerable year-to-year variation. Preliminary returns for 1800 m show a mean annual rainfall of 2250 mm. Rainfall generally increases with altitude although local topography may modify this pattern. The upper Edie Creek basin 300 m below the summit of Kaindi receives 2725 mm of rainfall as opposed to 2788.6 for the summit of Kaindi. Rainfall is generally more evenly distributed through the year at higher elevations, and the mean interval between rain-days is shorter. Also there is more fog-drip at higher altitudes. Most rain falls during afternoon or evening (about 70% at night).

The wettest period occurs from December to April when weather is dominated by the NE tradewinds. Moderate dry periods occur during June



3. Climate diagrams for 1200 and 2362 m, showing monthly mean temperature (below) and rainfall (above).

to mid-October or at other times when the SE tradewinds are dominant. Even during the drier period, there is generally at least some rainfall and fog each week. In 1977 there were only 20 days without rain during July–September and the longest period without rain was only 2 days. Fog-drip is difficult to measure, but is extensive and very significant. In other words, trees extract much water from fog so that actual precipitation is much greater than rainfall recorded in the open.

Humidity: Relative humidity varies in association with temperature, precipitation and the frequency of fog. Comparisons are difficult to make but mean annual humidity at 1200 m is ca 80% and at 2362 m, where temperatures are lower and fog more frequent, average relative humidity is ca 90%. Both stations are generally saturated at night. The moss forest at 2362 m may be saturated for most of the day. Bulldog Road (at 2850 m) is frequently foggy and relative humidity presumably varies little from saturation.

Temperature: Mean temperatures for different altitudinal stations are shown in Table 2. Mean annual temperature shows little annual variation. However, occasional short duration cool periods occur during June to September. Frosts are very rare at 2362 m (2°C is the lowest we've recorded so far), but may occur more frequently at higher elevations. Frost is usually associated with natural alpine grassland which is lacking on Kaindi and along Bulldog Road. As is generally true for the tropics, diurnal temperature variation is much greater than annual variation of mean minima and maxima. Diurnal temperature variation is greatest at 1200 m

Table 1. Rainfall (mm) for 1200 m (WEI), 2362 m (Kaindi) and 2864 m (Bulldog Rd). Means were calculated from 9-year records for 1200 m and from 4-year records for 2362 and 2864 m. The highest and lowest monthly and annual totals recorded during these periods are also shown. As the 2864 m readings were monthly, the figures are lower than they should be probably because of evaporation.

		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
	min.	55.6	73.7	69.7	55.4	67.6	44.2	40.1	25.1	57.6	66.8	86.0	113.5	1669.6
1200 m	mean	191.3	197.2	244.8	171.1	135.2	101.6	106.7	79.7	102.3	133.6	183.9	239.9	1887.2
	max.	289.8	377.5	398.8	327.2	259.3	297.1	198.1	160.3	209.8	332.3	297.2	400.3	2145.2
	min.	96.5	287.1	106.6	149.8	134.5	76.2	116.4	92.0	93.5	104.2	117.8	152.3	2575.4
2362 m	mean	230.8	448.9	274.2	228.6	213.3	180.2	162.0	134.2	146.1	183.1	262.5	239.9	3104.4
	max.	365.1	610.8	441.8	307.4	314.5	280.4	241.9	164.5	193.5	229.8	410.9	514.7	3775.0
	min.	164.2	169.8	219.1	222.1	118.6	75.0	77.5	110.9	115.3	214.1	119.1	163.2	2328.2
2864 m	mean	335.7	251.6	308.6	292.6	226.6	174.5	152.5	142.9	181.8	258.4	238.2	301.5	2861.6
	max.	598.1	372.7	401.5	337.2	283.4	259.3	200.8	212.2	237.2	311.5	354.8	397.7	3563.8

Table 2. Monthly and yearly temperature minima, means and maxima for 1200 m, 1800 m and 2362 m (Kaindi) and 2864 m (Bulldog Rd: no mean because data from max/min thermometer only).

		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year	Years on record
1200 m	min.	18.4	18.1	18.0	18.2	17.5	15.5	16.0	15.8	16.8	17.1	17.2	17.3	17.2	
	mean	21.8	21.7	21.4	22.0	21.3	19.5	19.6	20.2	21.3	21.6	21.6	21.5	21.1	9
	max.	27.3	27.5	26.5	27.5	27.1	25.4	25.4	26.7	27.5	28.4	28.7	28.1	27.2	
1800 m	min.	13.7	13.3	13.6	12.9	12.5	13.4	13.3	13.0	13.2	13.6	13.8	13.6	13.3	
	mean	16.7	16.2	16.2	16.2	16.0	16.4	16.1	16.4	16.6	16.9	17.0	16.8	16.4	3
	max.	21.6	21.0	21.0	21.5	21.4	21.3	20.8	21.4	21.7	22.0	21.8	22.1	21.5	
2362 m	min.	11.7	12.4	12.8	12.8	12.8	12.1	11.5	11.2	11.5	11.9	11.8	12.8	12.1	
	mean	14.5	15.3	15.5	15.5	15.4	14.5	13.8	13.9	14.2	14.9	14.9	14.2	14.7	6
	max.	18.8	19.6	19.5	19.3	19.4	18.2	17.0	17.9	18.5	19.3	19.5	19.0	18.8	
2864 m	min.	5	7	6	6	4	5	4	4	3	5	5	5	3	4
	max.	23	18	22	17	15	14	16	15	16	16	18	23	23	

and decreases with altitude (often only 4-5° inside the moss forest).

Wind: Wind velocity averages 3 km/hr at 1200 m and 5 km/hr or less at 2362 m. There is little annual variation. Wind direction was not recorded at 1200, but is variable. At 2362 m prevailing winds are from E and probably mostly produced by convective air rising from the floor of Wau Valley. Gusty conditions are infrequent and are usually associated with cyclones off northern Australia. The cyclone which devastated Darwin in December 1974 produced high winds in New Guinea.

GEOLOGY

Mt Kaindi consists mainly of schist, mudstone, clay and volcanic intrusions. The stratigraphic history may be summarized as follows (after Dow, Smith & Page 1974):

Mesozoic Papuan Ultramafic Belt: The oldest rocks in the general area, but only occur to E, on N slopes of Owen Stanleys proper.

Owen Stanley Metamorphics: Formed in Mesozoic and possibly also early Tertiary. Local low-grade metamorphics were named Kaindi Metamorphics, but are now considered part of the Owen Stanley Metamorphics. They contain fault wedges of higher grade here and there, make-up being:

Low Grade: Slate, phyllites, quartz-sericite schist, quartz-chlorite schist, Greywacke. Also, rare green metamorphosed tuff.

Higher Grade: Quartz-albite-sericite, quartz-albite-muscovite schist, and epidote-chlorite-actinolite schist with occasional alamandine and amphibole.

Less Metamorphosed areas: Include argillite, calcareous slate, coarse indurated greywacke, grit, conglomerate and re-crystallized limestone lenses up to 250 m thick which may have been reefs.

Upper Oligocene to mid Miocene Sediments, Intrusives and Volcanics: The sediments were deposited in shallow ocean. The granodiorite batholiths intruded in the Owen Stanley Metamorphics.

Upper Oligocene: Omaura Greywacke.

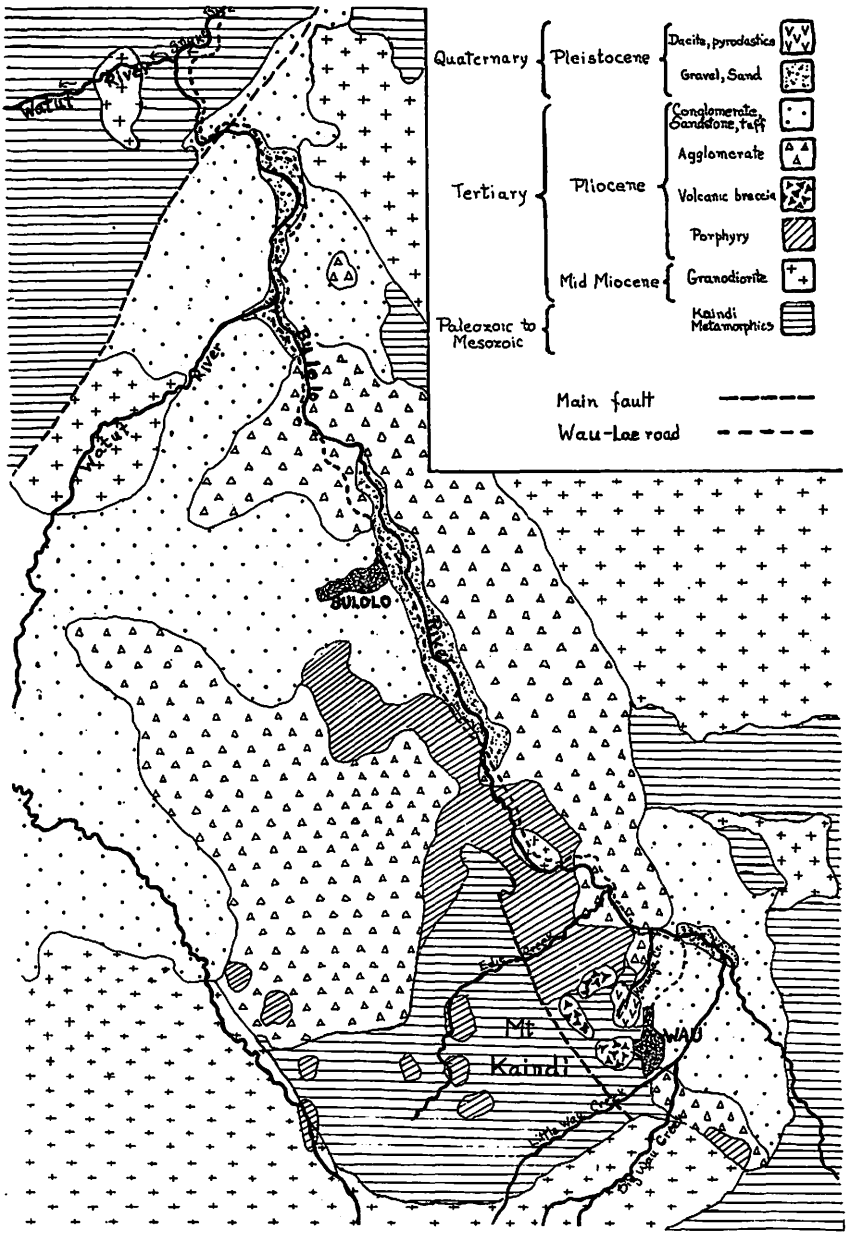
Mid Miocene: Langimar beds, with Foraminifera.

Upper Oligocene to Upper Miocene: Greywacke and siltstone, with marl, calcareous siltstone, argillaceous limestone, tuffaceous greywacke and pebble conglomerate.

Mid Miocene: Morobe granodiorite intruding the Owen Stanley Metamorphics and forming the Ekuti and Kuper ranges (each 600 km^2) plus a few other smaller areas. Age is 12 to 14.5 million years. Gold mineralization during this period (finer quality).

Upper Miocene, Pliocene sediments: These fringe the above sediments. Also lakes in the Watut-Bulolo area formed by intermediate volcanic activity and faulting in late Pliocene.

Upper Miocene: Marl, mudstone, etc with Foraminifera; mostly to S.



4. Geological map of Wau-Bulolo area.

Early Pliocene: Edie Porphyry: Biotite and hornblende andesite and dacite; porphyry stocks and dykes; fragments in the following. Consolidation of Edie Creek gold (less fine), 4-5 millions years ago.

Early mid Pliocene: Namie Breccia: Volcanic breccia of angular fragments of schist, dacite and andesite porphyry in black hydrothermally altered matrix.

Mid Pliocene: Bulolo Agglomerate: Dacite and andesite agglomerate and tuff, with rare obsidian.

Late mid Pliocene: Otibanda Formation (3-4 million years old): Lacustrine and fluviatile poorly consolidated sediments of tuffaceous sandstone and siltstone, and conglomerate and crystalline tuff, with vertebrate fossils. Latter included some extinct wallabies, thylacine (Tasm. wolf), an interesting rodent, and reptiles. Wau Lake damned by Bulolo Agglomerate; Watut-Lower Bulolo Lake by up-faulting Sunshine fault. The Wau lake was more fluvatile than lacustrine, and deposits were more schist and granodiorite and less volcanics. Koranga mine marks the spot where the ancestral Edie Creek debouched into the lake.

Late Pliocene: Poorly consolidated conglomerate, sandstone, mudstone, tuffaceous sandstone and dacite. Also andesite pyroclastics.

Quaternary: The present bottoms of Wau and Bulolo valleys are 2 million years old or much younger.

Pleistocene: Coarse, unsorted angular conglomerate torrentially deposited near Wau. Also unconsolidated gravel, sand and silt.

Pleistocene/Holocene: Dacite and andesite lava, crystalline tuff, agglomerate and obsidian. Mt Yelia near Menyamya: Last eruption less than 30,000 years ago; but a story suggests it may have been only about 35 years ago.

Holocene (Recent): Unconsolidated fluvial gravel, sand, silt and mud. Dacite lava, agglomerate and crystalline tuff, between Koranga and Upper Ridges (Golden Ridges). Last, abortive, activity in 1967, when temperature rose to 700°C and several million m^3 of unstable clay slumped into old Koranga mine area and the cliff-face below the Golden Ridges Road doubled in height. The throat of the Wau volcano penetrated the Otibanda Formation. The latter is also partly covered by alluvial fans from upfaulted Mt Kaindi.

GEOGRAPHY

The general characteristic of the country around Kaindi is of mountains with steep slopes, mostly with narrow valleys or gorges, but with a few wide and flat-bottomed valleys, some of them with hills here and there. In general, the rivers flow more or less in line with the island and main range – NW or SE, then changing course to flow to N or S coast. North of Kaindi the Bulolo River flows through the Wau Valley, the Bulolo Gorge, the Bulolo Valley and then joins the larger Watut River coming from the Upper Watut Valley on N side of main divide (Ekuti Dividing Range). The

Upper Watut turns and flows into the Bulolo at Sunshine. Shortly after, with the confluence of the Bulowat with the Snake River from opposite direction (Zenag and Mt Shungol), the enlarged Watut flows through a gorge into the Lower Watut and then into the Markham to the Huon Gulf at Lae.

SE of Wau, at the upper reaches of the Bulolo River, tributaries of the Biaru River interdigitate among hills, and these drain S through a gap between Mt Lawson (SE of end of Ekuti Range) and the western stepping stones to the main Owen Stanley Range. The Biaru then joins the Lakekamu River near Bulldog Village at S end of Bulldog Road. In general, the S slopes of the mountains, such as Ekuti Range, are steeper than N slopes. In the case of Mt Kaindi, the mountain actually forms the raised end of a branch ridge from near end of Ekuti Range, so its N slope is steeper and more extensive. Edie Creek Basin is bounded by a forking of that branch ridge and then continues to NW as the Watut-Bulolo Divide, gradually becoming lower to where the Watut River breaks through to join the Bulolo.

This general country, including the Kuper Range with Mt Missim (2839 m), N of Kaindi, is covered with rainforest, except for the bottoms of the Wau, Bulolo, Watut, Bulowat and Snake valleys, and some of the hills near Bulowat and Snake (mostly S side, Lae-Wau Road, between Bulolo and Zenag).

HISTORY OF DEVELOPMENT OF THE WAU/KAINDI AREA

During the period of German administration of the Territory of New Guinea (Kaiser Wilhelmsland), to 1914, little or no penetration took place in the Wau-Bulolo area.

Australian prospectors started searching for gold in Northeast New Guinea even before Australian administration superceded that of Germany. But gold was not discovered in this area until 1922 when alluvial gold was found by William (Sharkeye) Park in lower Koranga Creek in the lower part of the Wau Valley, near the Bulolo River. In January 1926 W. Royal and R. Glasson made a find of rich gold in the upper Edie Creek Basin on the west side of Mt Kaindi, and this had a profound effect on the area. There were 200 Australians working gold at Edie Creek by the end of 1926. There was considerable hardship suffered by them. The explorer Mick Leahy (who still lives at Zenag) in October 1926 got enough gold in 3 days to pay for a trip to Australia for medical treatment.

C.J. Levien was District Officer at Morobe on the coast to the east in 1923. He organized Guinea Gold No Liability (GGNL) between 1926 and 1929 and planned dredging of the Bulolo Valley. There was much dispute of claims and leases and in 1927 a Royal Commissioner (P.B. MacGregor) was appointed to the area.

Salamaua on the nearby coast was the main supply and transit point. It

was a walk of several days over the Kuper Range to Wau and Bulolo from Salamaua. In December 1926 GGNL took over the DH37 airplane of Salamaua Development Co. (pay-load 280kg), and started flights to Wau from Lae in April 1927. Flights were twice daily, 5 days a week flying the Markham, Wampit and Watut-Bulolo valleys to Wau. At that time there were still tall trees all around Wau airsttip, which has an average slope of 9%, with the upper half having nearly a 15% slope. In the first 6 months of the flying, 80,000 lb of freight and 150 passengers (at £33) were carried. Freight cost 1S6d/lb. At the end of 1927 Guinea Airways Ltd was formed, largely owned by GGNL and in 1928 it got 2 German W-34 Fokkers (800 kg load). Placer Development Ltd was formed in Bulolo in 1926 (based in Vancouver), and New Guinea Goldfields Ltd (NGG) was established at Wau in 1929 (home-base Sydney).

The possibility of a railroad to the coast was being considered, but was felt to be a government responsibility. As government did nothing, Placer started working on a road in 1929. It went as far as Sunshine by 1933. Bulolo Gold Dredging Co (BGD) was formed in 1930, as a subsidiary of Placer. BGD acquired 2 Junkers G-31 planes (8600 kg load) in April 1931 and a third plane in 1933. With these, huge gold dredges were brought in sections and reassembled. Dredge no. 1 started to operate in Bulolo Valley 21 March 1932; no. 2 in Bulolo November 1932; no. 3 in Bulowat (Sunshine) in 1933; no. 4, Bulowat, August 1934; no. 5, Bulolo, December 1937; no. 6, Wau, 1938; no. 7, Bulolo, July 1939 and no. 8 Bulowat, November 1939. Thus at end 1939 BGD had 8 dredges in continuous operation, with high financial return. Air freight rates dropped to 3d/lb in 1934 and the idea of a road to the coast was temporarily abandoned.

Electric power for the dredges was initially obtained through flumes and Swedish turbines in the lower Bulolo Valley, from 1932. Floods and other problems affected decision to build a power plant on Baiune Creek E of Sunshine. This involved Pelton wheels of 3200kg, brought by the G-31 planes, and operation was effected by November 1934. Some of the power was leased to NGG. The BGD dredge 6 in Wau was powered via NGG lines. The power line from Wau to Edie Creek was put in during 1935. In 1938 an additional power plant on the upper Baiune was constructed.

In 1937–38 Wau airstrip was the busiest in the world, with more landings per day than any other airdrome, and more cargo per year than total for all Australia airports combined.

Coffee planting commenced in the Wau Valley on a small scale in late 1927. Most present plantations were planted in the early 1950's following on vegetable market gardening. A photograph taken in 1936 from Edie Creek Road at mid-level of present WEI shows nearly half of the floor of Wau Valley still covered with tall dense rainforest, and the clearing done in wide oblong N-S swaths. The track from Wau to Edie Creek became a vehicle road commencing in 1928.

In the first Japanese air raid on Bulolo, 21 January 1942, all 3 of the Junker planes were destroyed. Prompt evacuation of Europeans was

ordered. Air transport was not available, and dependents and men unfit for military service were evacuated by foot from Wau via Kudjeru to Bulldog, the Lakekamu River and Port Moresby, February 1942. This helped spur the idea of a military road across New Guinea.

The Japanese landed at Lae and Salamaua 8 March 1942 and in August the local Australian Army Colonel ordered dynamiting of all airstrips, roads, bridges and facilities. This included the dredges and power plants. The town of Wau was burned. It was then larger than the present town of Wau. The Japanese Army crossed the Kuper Range and reached Wau airstrip late January 1943 and held the east side of the strip till February, when Australian troops, constantly brought in by American DC-3 planes, annihilated them. An Australian machine-gun nest is on a hill on the lower part of the WEI grounds west of the airstrip. A photograph of an Australian fighter plane bombed and burning on Wau airstrip (Anon. 1974) during this period shows the grassy area on the side of Mt Kaindi above present WEI to have appeared in 1943 much as it did when WEI started to plant trees on the steep slope in 1970.

The Bulldog Road, from Edie Creek across the east end of the Ekuti Range and down to Bulldog on the Lakekamu River, was built by Australian Army engineers with some American participation. After very difficult surveying starting July 1942, the extremely difficult construction commenced early in 1943, and the first procession of jeeps went from Wau to Bulldog on 23 August 1943. The Bulldog Road beyond Edie Creek was only used for several months, as retaking of the airfields on the north side of the mountains rendered air transport cheaper than maintenance of the road through the high, steep and wet country, where even natural landslides are frequent. The highest point of the road is at over 2900m in constantly wet and foggy mossforest.

The Australian military put through the first road from sunshine to the Wampit River and to Labu, across the mouth of the Markham River from Lae, after the Wau-Sunshine portion had been repaired. Connection with Lae was by barge between Lae and Labu. On 3 March 1944 a jeep went from Labu to Bulldog, the first complete crossing of New Guinea by vehicle. This was only possible for a very short time, with abandonment of Bulldog Road. By 14 April 1944 the Labu – Bulolo/Wau road was improved and in active use, though the next night heavy floods caused wash-outs and delayed traffic a week. The Army maintained the road until 1946, and then BGD had to do the road maintenance and operate the Lae – Labu barges until civil administration was organized to take over.

The facilities destroyed during the war were gradually repaired or replaced and gold mining resumed. Power from the new Upper Baiune generators was ready November 1946, with more generators added there in 1947 and then 2 at Lower Baiune. These gave total output of 5500 KW. Dredge 1 resumed February 1947, no 2 in April 1947; 5 and 7 were last to return to service, February 1949. Six dredges were in service for all of

1947–48. No. 5 was out of commission 1959–62. As the gold was rapidly depleted for profitable operation, dredges gradually closed down: no. 1 in 1949, 3 and 6 in 1951, 8 in 1953, 2 in 1955, 7 (sunk) in 1956, 4 in 1957 and 5 in 1965. Nos. 1 and 2 were used for spare parts; 3 and 4 were sold and shipped to S. America. No. 6 remains in lower mid Wau Valley, 5 and 7 in upper Bulolo Valley and 8 at Bulowat.

Commonwealth New Guinea Timbers (CNGT), a subsidiary of Placer, was formed in 1947 and in 1949 commenced testing for plywood and produced excellent quality from *Araucaria*, mainly klinkii (*A. hunsteinii*), but also hoop (*A. cunninghamii*). Production started in 1955, and was up to 7 million super feet in 2 years and later to 12 million or so per year. The supplies of large trees of both *Araucaria* species are expected to give out by 1980 for plywood, but the planted stands are already being thinned and can be used for timber and possibly for pulp.

In 1957 a wooden bridge was built across the Markham so one was able to drive from Lae to Wau. (The Lae Highlands Highway was not yet put through.) A new concrete bridge was constructed at the same point in 1975.

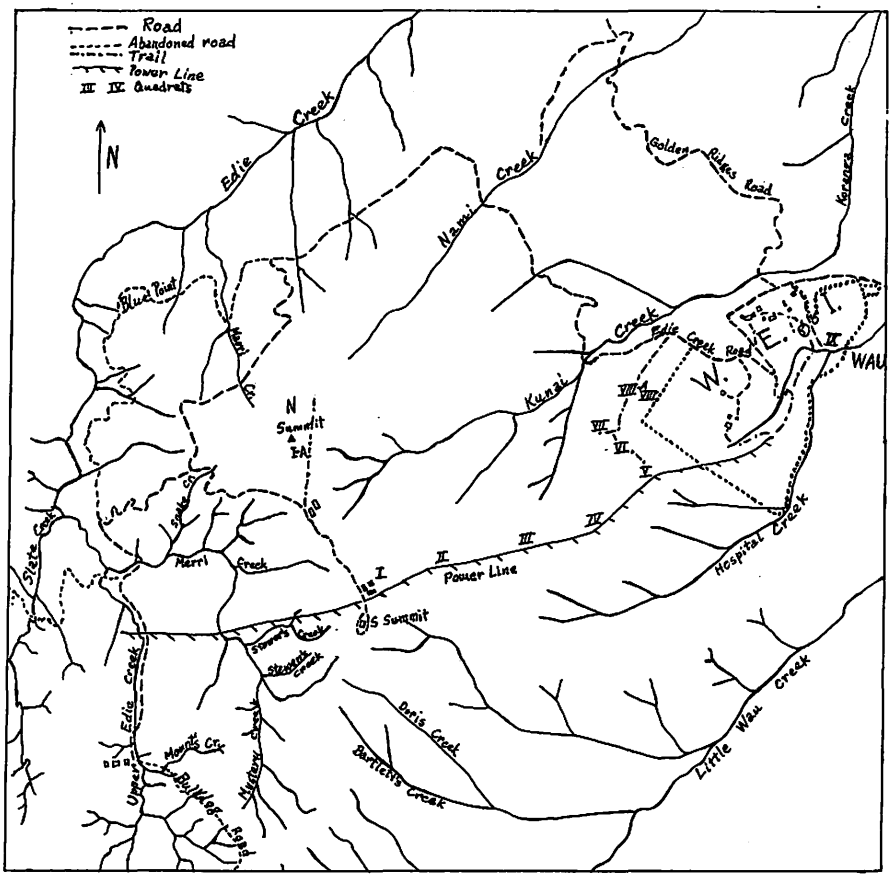
Dr Carl Gunther was medical officer for BGD both before and after the war. Before the war he did important research on scrub typhus and after the war on malaria and dysentery.

In 1959 the first repeater station for telephone calls radioed across New Guinea was constructed on the summit of Mt Kaindi. This involved construction of a road from the Edie Creek Road, within Edie Basin, to the south summit of Mt Kaindi. At this time, and partly during earlier periods of the gold mining and installation of the power line, many of the tall trees from the summit ridge, and all but one on the south summit, were felled. In 1966 work on a more modern-equipped repeater station was started, and new enlarged areas were bulldozed, both at the end of the road and beyond the old repeater station. But the single tall *Nothofagus* tree was not harmed, and still remains today, although some branches have died and fallen (a major branch fell just after Margaret Gressitt sketched the tree for the background painting in the main exhibit in the new Szent-Ivany Laboratory in 1975). The new repeater station was completed in late 1970, and following this WEI was able to purchase the 3 buildings of the old repeater station from the government for token sums. These were then moved and re-erected on the north side of the power line and east side of the road, to form the present Kaindi branch station of WEI.

In late mid-1970 the landslide at Blue Point above the waterfall in the Edie Gorge (opposite the taller and steeper landslide, dating from 1930's) finally defeated the Public Works Dept and decision was made to close the Edie Creek Road at that point and start bulldozing a detour route from the point on the road, at 1800 meters, facing the waterfall, the opposite landslide, and the silhouette of the ridge just before Blue Point landslide. The new road is in part very steep, crosses Maori Creek well above the

Kabwum village, turns above the subsidiary peak among *Nothofagus grandis* above Blue Point, and crosses the main ridge not far north of the north summit, then descends a bit to rejoin the old road from Edie to Kaindi. By this change the distance by road from Wau to Kaindi summit was reduced from 22 to 17 km and that from Wau to Edie increased from about 20 to 25 km.

Areas that were bulldozed in 1966 at the south summit, now in 1978 have trees 5–8 meters tall, and the composition of this second growth is very much like that of the climax forest on the north summit. This suggests that there is not a great difference between 2nd growth and climax forest in this zone. However, some clearings west of S summit abandoned in 1975 now have a great majority of 2–3 m high *Homalanthus* trees plus some *Rubus* and *Ficus*. The earliest colonizers around the south summit were *Eurya* and *Macaranga*, but many Elaeocarpaceae, Cunoniaceae,



5. Local map of Kaindi, showing transect.

Rutaceae, Saurauiaceae, *Nothofagus, Vaccinium, Rubus, Archiboldiodendron, Scaevola,* etc. are also on the fringe.

The goldminer Omas Genora built his house on the gap above his west-slope mine between north and south summits in 1961 extending the clearing on both sides of the summit ridge. He started his mine in 1960. A small house was built in a new clearing on the east side of road between Omas' house and south summit late in 1974. This was abandoned a year later and the forest is rapidly coming back in the clearing. A clearing made in 1973 within the forest on the same side and below the WEI branch station has also been abandoned and forest is coming back. Another clearing made early in 1974 below the power line, also on east side, was likewise abandoned and is growing back. These clearings represented unsuccessful efforts to find gold on upper NE slope of Kaindi. The rapid and natural re-growth suggests that the area is quite viable as nature sanctuary if further tree-cutting is halted.

The area of the north and east sides of Kaindi plus summit areas still under forest is about 2,200 hectares. WEI has been planting trees on the Kunai areas of these slopes for a few years. The 2 western ones (above Edie Creek Road) represent areas of former mining leases; the middle one, just above the road crew compound was made in 1972–3 by David of Wau Trade Store; the one above the institute is old and may represent a large landslide of a century or 2 ago, with old forest re-growth above the present coffee; and the eastern one, above Wau town, was cleared 1960–72 by Goilala settlers.

WEI commenced in the form of Bishop Museum New Guinea Field Station in June 1961 with rental of what is now house 2 and the area of laboratories, office and upper part of arboretum. This was purchased in 1963 when tree-planting was started, and then gradually the nearby properties were added as circumstances permitted, until the area reached 80 ha in 1977. The 40 ha coffee plantation and remnant forest above it were purchased in 1971. The "lower arboretum" below zoo and Allison Road was obtained as kunai in 1971 and then planted with many trees in 1971–2. The zoo and demonstration garden area was obtained in 1975 and planted to trees 1975–6. The Allison property, with the remnant forest near Hospital Creek, was obtained in 1977.

TRANSECT ANALYSIS PROCEDURE

The transect analysis carried out in July and August of 1977 by staff of the Wau Ecology Institute and participants in EARTHWATCH teams I and II was of pioneeringly wide scope. The goal of the study, to provide a backround of integrative ecological information about the mountain for visitors and scientists, involved collection of vegetation, soil, insect, and descriptive data at regular intervals. The results and interpretations presented here are only the immediate conclusions. The quadrats established for this project are permanently marked and will be used for future study and examination of the many biological questions that remain.

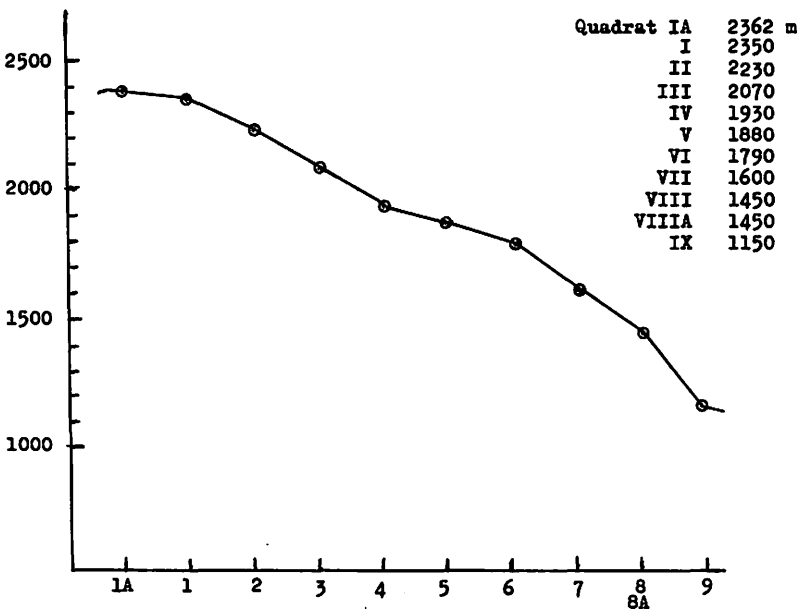
PHYSICAL DESCRIPTION

The altitudinal transect of Kaindi, from the S summit (2362 m) to the lower level of the institute (at 1150 m), was laid roughly parallel to the powerline that runs the length of the NE face of the mountain. Below 1800 m, the transect diverges from the powerline, follows the Kunai Ridge, drops into Kunai Creek Basin and then returns to the middle one of the 3 branch ridges above WEI. A kunai area on E side of latter ridge is included for comparison. Though not continuous with the transect line itself, a representative *Nothofagus* forest on the N summit was sampled for tree representation and forest structure.

METHODS

No other study of this scope has been carried out in this environment, and the quadrats originally inventoried (10 x 10 m^2) by EARTHWATCH Team I proved to be too small for significant statistical analysis. EARTHWATCH Team II sampled adjacent quadrats at the same elevations 4 times that size (20 x 20 m^2).

The position of each quadrat was marked by flagging tape. Beginning from the S peak, at 450-m intervals, the lower corner of each quadrat was set at a 90° angle to the powerline cut, 20 m to the left of the forest/ powerline interface. To define the exact boundaries, 20-m ropes, marked at 1-m intervals, were stretched around the borders of the quadrat during



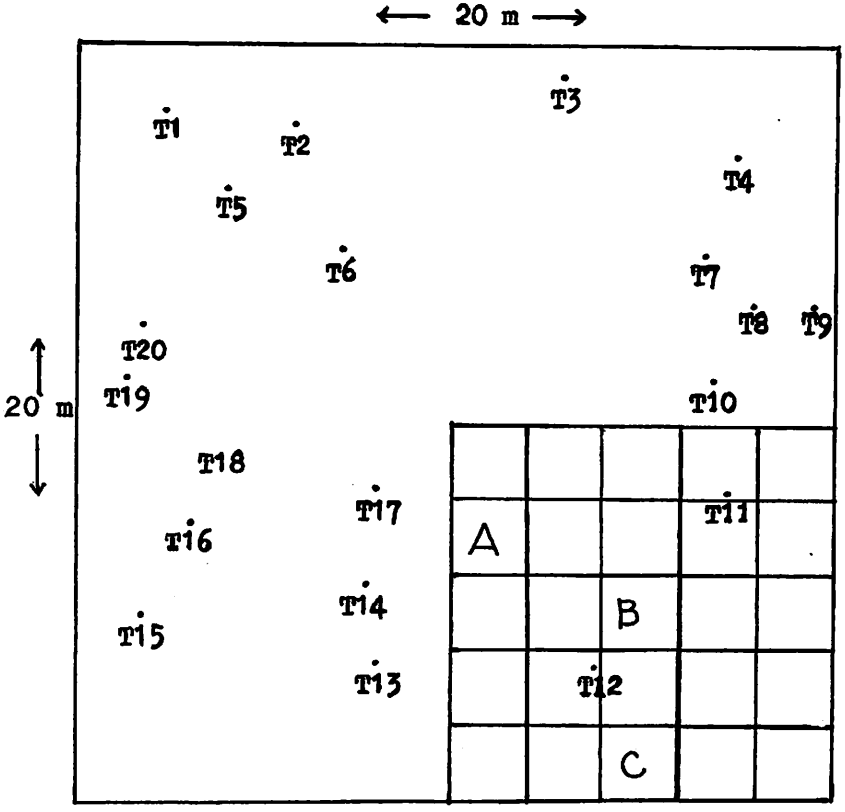
6. Transect, showing altitudes of quadrats.

the sampling process. Attached to these outer lines were ropes delineating a 10 x 10 m square, and within this area was set a "mini-grid" of squares 2 x 2 m in size for sampling surface vegetation.

Sampling of trees, surface vegetation, soils, insects, and filling out 2 *pro formas* took a team of 4 to 7 fieldworkers about 3 hours.

VEGETATION

Trees, being the dominant vegetation for all stations except the Kunai, were of course of primary interest. All specimens within the 20 x 20 m boundary with a breast-height diameter (DBH) of over 10 cm were mapped on graph paper and wherever possible, field identified. Twig, flower and fruit samples were taken and recorded. Because tree-cutting and rifle shooting (standard tree-sampling methods) are discouraged on Mt Kaindi for conservation reasons, samples were taken by tree-climbing.



7. Sample of a quadrat map (Quad VI, 1800 m). Maps and field notes for all quadrats sampled on transect are on file in WEI library.

The surface vegetation was inventoried by collection of all plants under 1 m in height in 3 different 2 x 2 m mini-quadrats. The choice of mini-quads was decided by random numbers to insure that "easy" quads were not favored over less accessible ones. These samples were labelled, with data on height and growth form recorded in field notebooks. Later, these specimens, along with the tree samples, were pressed, dried and stored in the Wau Ecology Institute herbarium.

Much of the plant material is unfortunately sterile, i.e., without distinguishing flowers and/or fruits. This makes positive identification to the species level nearly impossible. However, almost all of the specimens have been determined to at least the generic level by Forestry College and Lae Herbarium botanists.

SOILS

Soil characteristics were examined at each quadrat. A soil sample of one liter volume was collected from 20 cm deep for later analysis. A field soil-testing kit was used for the upper quadrats, but the results proved inadequate for our purposes. Soils from each elevation were analyzed by the University of Technology Analysis Laboratory for pH, calcium, magnesium, sodium, phosphorus, potassium, cation exchange capacity, nitrogen, and organic matter content.

Soil temperatures were taken at each elevation at the depth of approximately 15 cm with a mercury-bulb thermometer. Three readings were taken, and the time of measurement was recorded.

INSECTS

The insect fauna was a major focus of the transect analysis. An inventory of insect numbers and diversity as well as distribution due to altitudinal factors was an important question explored. Four methods were used to extract the huge variety of insects from their environments: pitfall traps, Berlese funnels, Malaise nets, and light-trapping at night.

1) Three pitfall traps, consisting of plastic buckets containing 0.5 liter of formalin to kill and preserve the insects were sunk in each quadrat with the lip of the bucket level with the leaf litter. They were covered against rainfall and remained in place for at least 48 hours. This method captured insects and other invertebrates that are mobile in the soil and leaf litter.

2) Berlese funnels extracted live insects from the upper layer of the soil ecosystem. A one-liter volume of leaf litter was subjected to light bulb-engendered heat at the large end of the funnel, forcing the negatively phototropic invertebrates down the funnel to an alcohol catch-bottle at the narrow end.

3) Gressitt traps (Gressitt & Gressitt 1962; Thomson & Holmes 1977), large nets stretched across an open area in the quadrat, were set up for a minimum of 48 hours and captured flying insects of the

area. The cyanide bottles at the peak of the net killed and preserved the lepidopterans, beetles, and miscellaneous flying insects.

4) Light-trapping, both with a mercury-vapor light and a black light, was carried out at 3 elevations: at the branch station on the summit (2362 meters), at Mid-Camp (1880 meters) near Quadrat V, and at WEI (1200 meters), near Quad IX. The intense light attracts flying insects of the immediate area as well as luring non-local species. Samples of the diverse and numerous insects were killed with cyanide or ethyl acetate (acetic ether gas), and spread in the field and laboratory.

OTHER ANIMALS

Arthropods other than insects were sampled by some of the preceding 4 methods, but especially in the pitfall traps and Berlese funnels. Some other animals, also, were taken in small numbers by those means; for instance snails, frogs or skinks. However, very few spiders were obtained by any of the above techniques.

Sampling for other groups of animals also has to be done by various means. Spiders and some other groups must be searched for visually. Frogs can be listened for and searched or dug out. Reptiles may be found by searching, and by chance. Birds and mammals are recorded by observation, or by trapping, netting or shooting. However, no specimens of birds or mammals were taken or tried for in this survey.

DESCRIPTIVE ANALYSIS

One other facet of the transect study was explored by the use of a *pro forma* to analyze the physiognomic-structural features of Mt Kaindi and its vegetation. This method of vegetation analysis, developed by L. Webb and J. Tracey of CSIRO, is designed to facilitate collection of data by non-botanists. The *pro forma* consists of a questionnaire type format. The occurrence of features is assessed by presence/absence, or on a 4-point scale or by measurements. (See Webb, Tracey & Williams)

Four *pro forma* sets were filled out at each quadrat, each by a different person. Factors noted in the form provide a rapid method of structural analysis. This system shows promise for classifying tropical vegetation for which floristic data are not usually available. However, computer processing of our Kaindi data did not produce striking results, which may be attributed to insufficient briefing of participants plus the extreme complexity of the mid-montane New Guinea vegetation.

RESULTS OF TRANSECT SURVEY

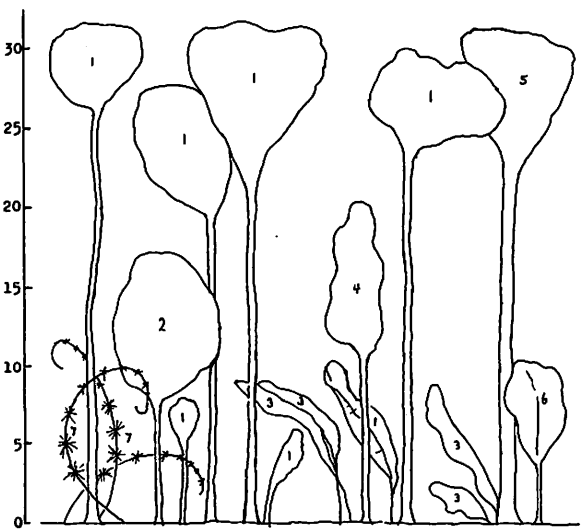
The various results of the survey, mainly coming from the work with the EARTHWATCH teams, is presented below. Time did not permit full identification of many of the taxa, but some of this has been achieved by others. Material resulting from earlier partial surveys, mostly at foot and

summit of Kaindi, is still unfortunately to a great extent unstudied, although some studies are in progress. Among these are very extensive light trap and Gressitt trap material at Bishop Museum, light trap material assembled by P. Hebert, R. Harmsen and colleagues, and Berlese funnel and/or pitfall material processed by T. Tigner, J. Balogh and P. Lehtinnen.

DESCRIPTION OF QUADRATS

QI – (Fig. 8) This highest of the regular series of quadrats is on a north-facing slope just below the WEI branch station, at 2351 m altitude. It is situated 20 m to left (NNW) from start of the trail paralleling the Wau-Edie Creek powerline which crosses Kaindi just N of the S summit. The WEI branch station is by the powerline and the road. The quad is thus below and E of the road, which is partly on the ridge but mostly on its E side. Slope is c 35°. The quad is characterized by slender immature trees of small crowns and broken canopy. The majority are *Nothofagus*. Ground cover is largely dense moss. The irregular lower stratum consists mostly of *Vaccinium, Rapania* and young *Nothofagus*. The slender bamboo-vine, *Nastus*, is abundant, as is *Palmeria*. Canopy height is 22–30 m with some emergents to 32 m. A few trees had recently been cut.

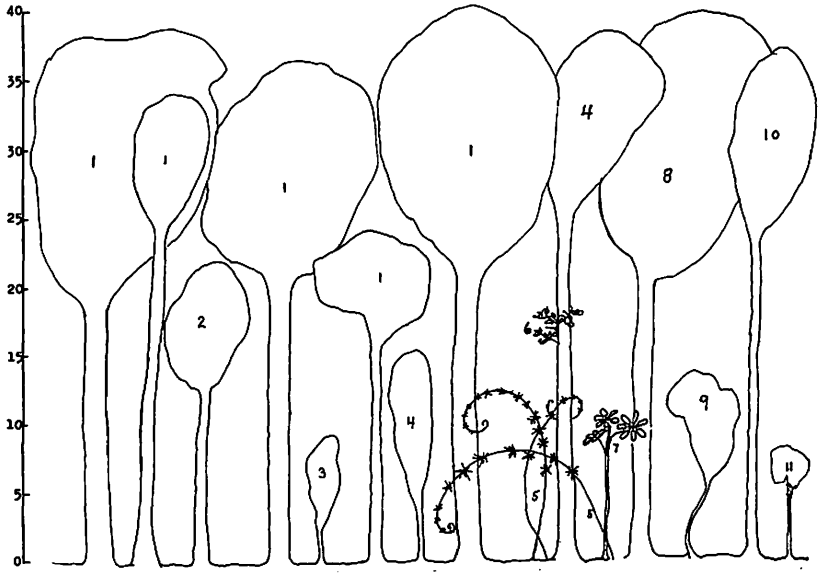
I-A – (Fig. 9) This supplementary short transect goes through some of the climax *Nothofagus* forest on the N summit, at 2360 m. It consists of a straight line with 10 m radius circles at 30 m intervals, and then 5 m radius circles at 20 m intervals, going N from left side of trail starting 50 m



8. Quadrat I. 1, *Nothofagus carrii* Steen.?; 2, *Cryptocarya* sp.; 3, *Vaccinium* sp.; 4, *Ilex* sp.; 5, *Macaranga* sp.; 6, *Calophyllum* sp.; 7, *Nastus productus.*

from Omas' parking area in the saddle. This forest is tall, luxurient and diverse, and many of the large trees are *Nothofagus pullei* (about 40% of the biomass). These, in particular, are heavily loaded with epiphytes of many sorts, including moss, hepatics, ferns, orchids, rhododendrons, and other epiphytic trees and shrubs, as well as vines. *Nastus*, *Palmeria* and other vines are abundant. The canopy is fairly well closed, but with occasional gaps from tree-falls. Canopy height is as great as 38 m. Soil temperature (10:00) was 14.5° C. Trees on this transect not sampled on the main transect included *Dacrycarpus imbricatus; Melicope* (Rutaceae), 20 cm DBH; *Micromelum* (Rutaceae), 12 cm DBH; and *Casearia* (Flacourtiaceae), 17 cm DBH, and *Phyllocladus* (QIV-VII), *Syzygium* (QIV, V, VII) and *Calophyllum* (QIV) are also here. Between QI and QII there is considerable Nothofagus forest, with *Prunus, Sapindus, Bubbia,* and with *Dimorphanthera, Rhodomyrtus*, etc, on fringes.

QII – (Fig. 10) This quad is somewhat more mature and diverse than 1, with dense canopy and deep shade. Slope is 35–45° and somewhat irregular. *Nothofagus* is still present, but it is *N. grandis* here instead of *N. pullei. Elaeocarpus* becomes more dominant. Moss is less dense and thick than in QI and there are more ferns. There are still no very large trees, which suggests earlier natural landslide. There are considerable areas of



9. Transect I-A, profile diagram; heights in metres. 1, *Nothofagus pullei* Steen.; 2, *Macaranga* sp.; 3, *Rapania vaccinioides* Kan. & Hats.; 4, *Elaeocarpus* sp.; 5, *Nastus productus*; 6, *Rhododendron* sp.; 7, *Schefflera* sp.; 8, *Evodia* sp.; 9, ?*Terminalia* sp.; 10, *Melicope* sp.; 11, unknown. Branches of larger trees have masses of epiphytes.

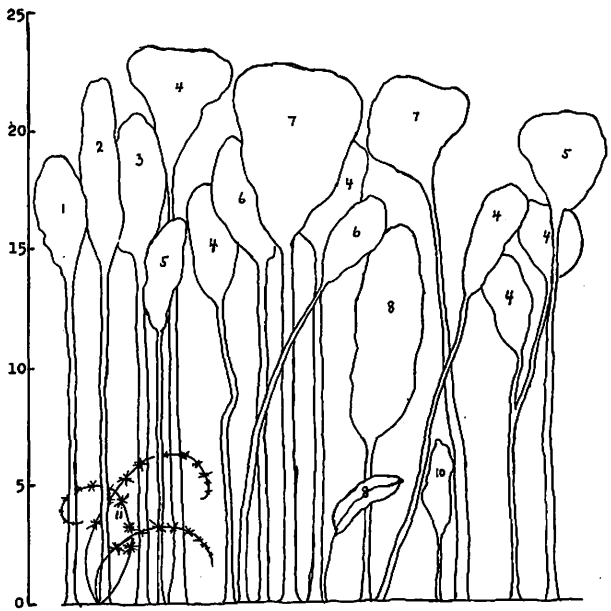
dead leaves on ground. Moss is partly 7.5 cm thick on stumps and old logs, which were not cut, but fallen and rotten. Considerable *Nastus, Selaginella* and small tree ferns; also *Freycinetia*. Canopy height is up to 24 m. Altitude 2230 m.

Between QII and QIII along powerline are *Macaranga, Ficus, Sericolea, Spiraeopsis, Planchonella, Rhodomyrtus, Homalanthus, Albizia, Trimenia, Elaeocarpus, Scaevola, Rubus* and *Cayratia.*

QIII – (Fig. 11) More mature forest than QI and QII, with larger and straighter trees. There are overlapping strata, largely of different species, and ages. Much of the canopy consists of *Castanopsis* and *Elaeocarpus*, although the former was not expected quite this high on the mountain. Slope is 25–45° and less steep in lower portion. There is a thick layer of fallen leaves and scattered clumps of moss and ferns, on ground; also moss, as well as ferns, on tree trunks. There is less *Nastus* than higher up; but various other slender vines. Most of the trees are mature or young to 2/5 grown. Canopy height is up to 33 m. Altitude 2070 m.

Between QIII and QIV there are some *Nothofagus grandis* seedlings.

QIV – (Fig. 12) This quad partly has a more disturbed appearance than the others, reflected in a great abundance of a 25 mm diameter bamboo, which grows obliquely instead of suberect or strictly vine-like (no *Nastus*).

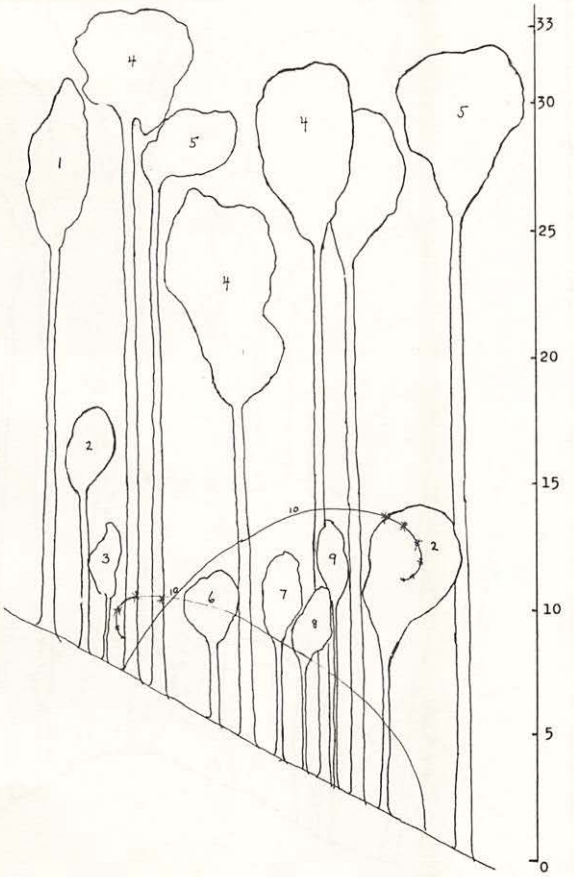


10. Quadrat II. 1, *Syzygium* sp.; 2, *Polyosma* sp.; 3, Rubiaceae (no.89); 4, *Elaeocarpus* sp.; 5, *Macaranga* sp.; 6, *Quintinia altigena;* 7, *Nothofagus grandis;* 8, *Cryptocarya* sp.; 9, *Eurya* sp.; 10, *Gordonia* sp.; 11, *Nastus productus.*

There is 1 very large tree, and others of various heights. Quad is situated along a slight ridge, quite narrow, with 20° slope to SE and 60° slope to NW. The ground is covered with bamboo leaves or other leaves. Some of larger tree trunks have filmy ferns and moss < 10 mm thick. Canopy height is up to 32 m. Altitude 1930 m.

Between QIV and QV there are large bamboos, *Elaeocarpus, Sericolea, Adinandra, Albizia, Macaranga* and *Homalanthus.*

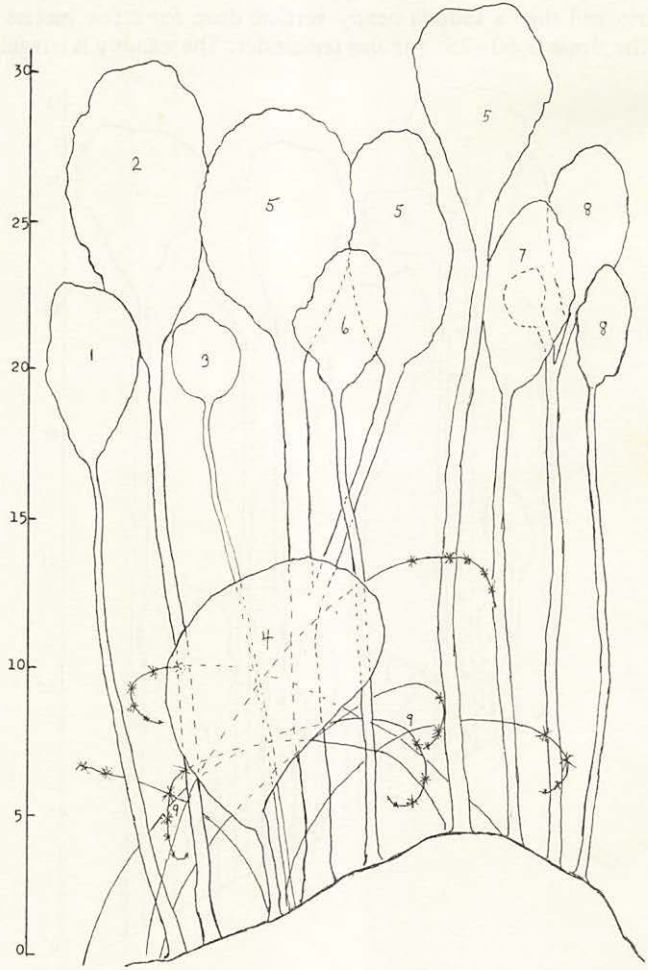
QV – (Fig. 13) Situated on edge of steep slope bordering Kunai Creek basin, slightly down from ridge. Upper portion of quad includes a narrow level strip and then a sudden nearly vertical drop for a few meters below which the slope is 60–75° for the remainder. The canopy is irregular and



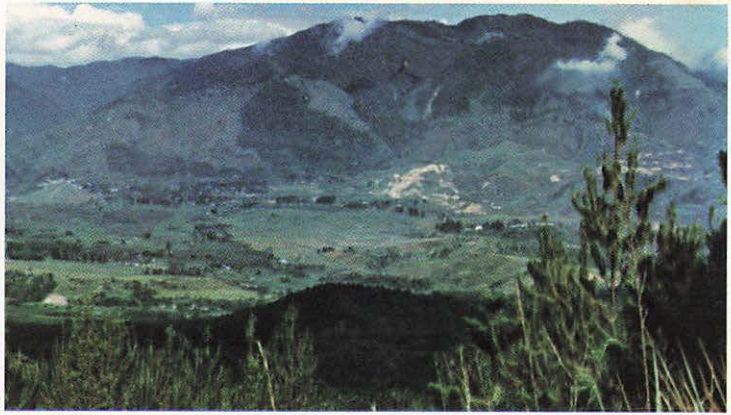
11. Quadrat III. 1, *Evodia* sp.; 2, *Astronia* sp.; 3, *Timonius* sp.; 4, *Castanopsis acuminatissima;* 5, *Elaeocarpus* sp.; 6, *Phyllocladus hypophyllus;* 7, *Fagraea* sp.; 8, *Kibara* sp.; 9, *Polyosma* sp.; 10, *Nastus productus.*

the trees diverse, with an *Albizia* the largest. There are a number of young or low trees and plants, including *Planchonella, Phyllocladus, Schefflera,* other araliads, *Pandanus*, a small rattan (*Calamus*), gingers, a large-leaved *Palmeria* vine, *Cissus*, a large *Selaginella*, etc. A few trees had been cut not long before. Ground cover consists mainly of leaves, with patches of moss or ferns. Canopy height ranges up to 27 m. Altitude is 1880 m.

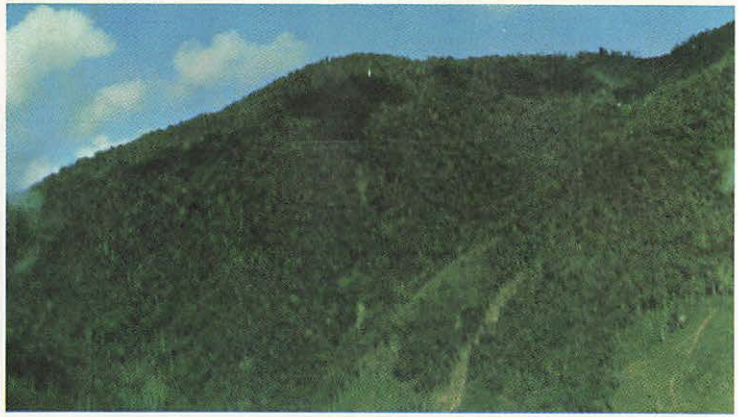
Along the forest fringe between QV and QVI there is abundant bracken



12. Quadrat IV. 1, *Galbulimima* sp.; 2, Lauraceae; 3, Rutaceae; 4, *Acronychia* sp.; 5, *Elaeocarpus* sp.; 6, *Cinnamomum* sp.; 7, *Castanopsis acuminatissima;* 8, *Macaranga* sp.; 9, *Bambusa* sp.



a



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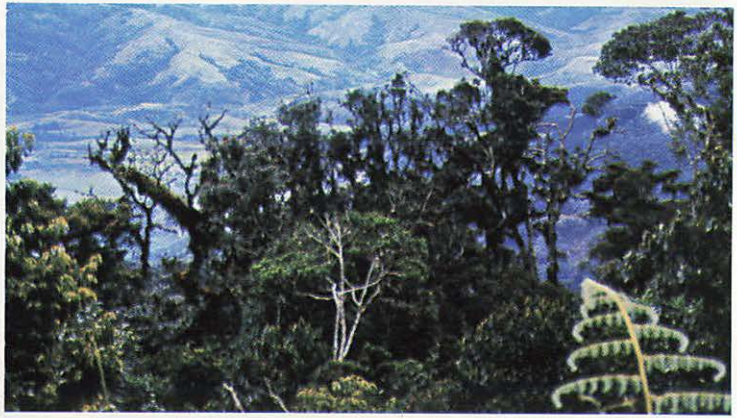
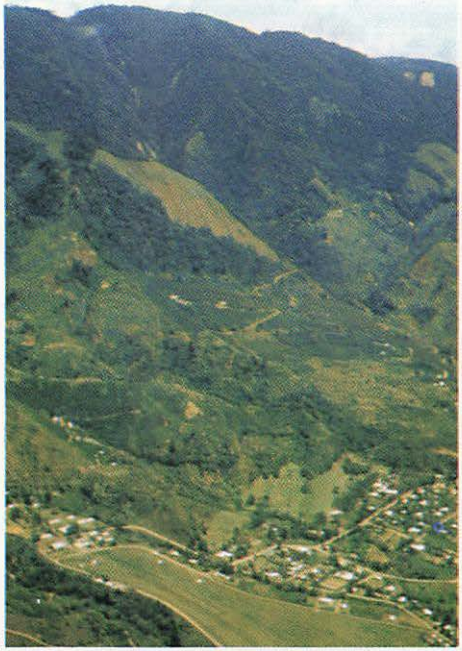
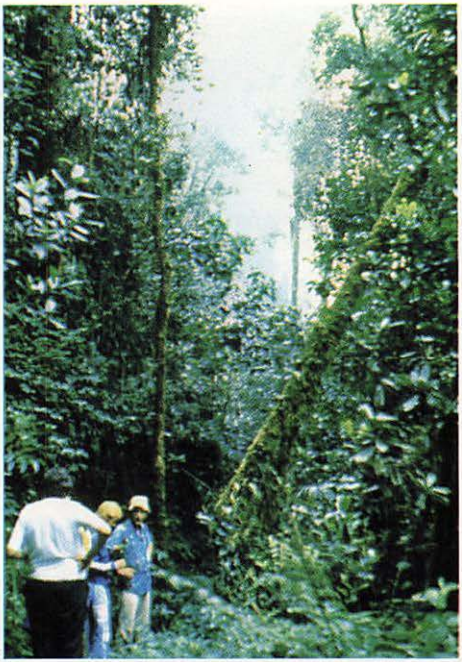


d

Plate I. a, View of Mt Kaindi from SE slope of Mt Missim, June 1978; b, Part of Kunai Creek drainage, NE slope of Kaindi; Edie Creek Road in lower right corner (from airplane, June 1978); c, Much of upper half of Kaindi transect on right: powerline cut in upper middle, turning to right middle (airplane view, June 1978); d, Edge of forest near S summit, looking toward Wau Valley and foot of Mt Missim; 1976 (all by L. Gressitt).



a



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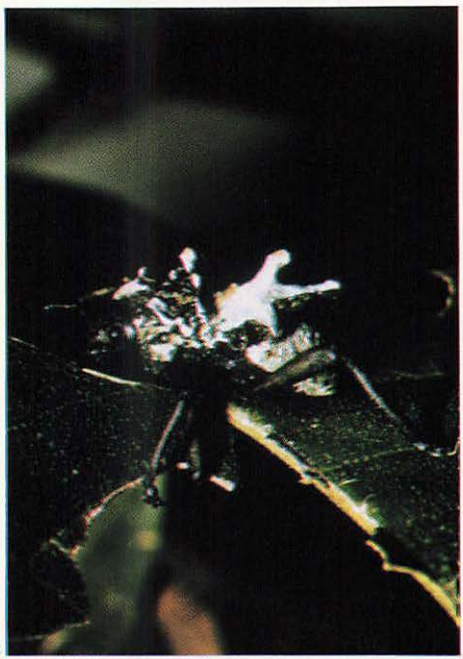

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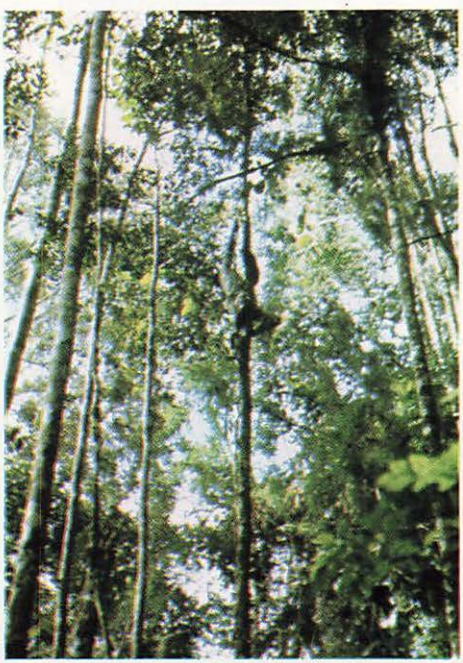


d

Plate II. a, N summit of Mt Kaindi, top left; steep tree-planting slope, upper center; WEI grounds, middle; Wau and Wau airstrip, foreground (from airplane, June 1978, Gressitt); b, Contour nature trail, 2200 m, E of S summit; 1977 (V.N. Kisling, Jr); c, *Pantorhytes lichenifer* Gressitt weevil with lichens on back, Kaindi summit, 1967 (R. Straatman); d, Grey Ateng climbing tree for identification material, Quadrat III, 1977 (V.N. Kisling, Jr).

and other ferns, including a slender Gleichenia, as well as *Pandanus, Phyllocladus, Schefflera, Mearnsia, Trimenia, Engelhardtia, Vaccinium,* etc.

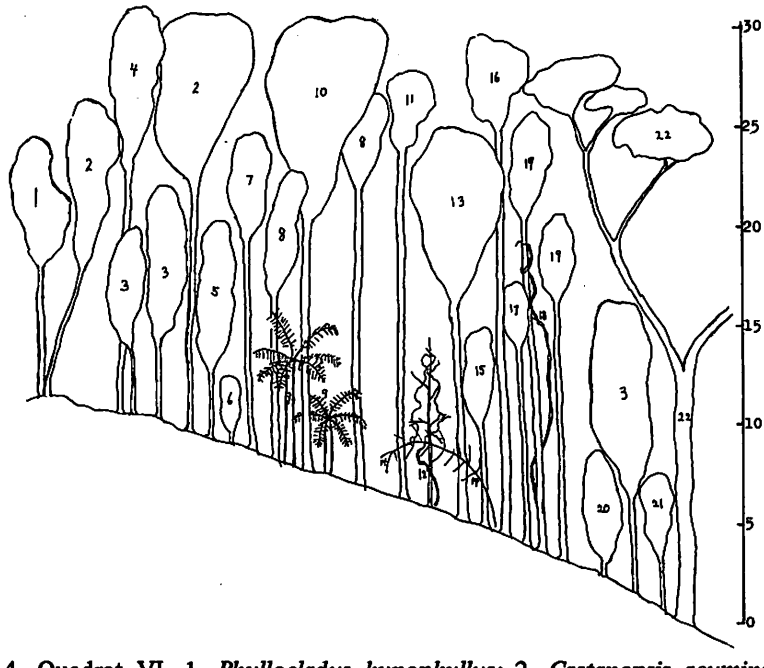
QVI – (Fig. 7, 14) Nearby, and partly in this quad, are some extensive tree-falls. Slope is about 50° average. The diversity of trees of larger size is fairly great. Trees are of all heights and the canopy irregular and partly broken. There are relatively few lianas, and no *Nastus*, but hanging *Usnea* lichen is abundant in taller trees, and there are small vines, and low climbers such as *Cissus*. Epiphytes are relatively few. Ground cover includes leaves, ferns, moss, young seedlings (where canopy is open). Canopy height ranges up to 29 m. Altitude is 1790 m.

Between the altitudes of QVI and QVII, in the kunai – unburned for more than 8 years at this spot – the natural regrowth includes *Eurya, Spiraeopsis, Wendlandia, Vaccinium, Ficus, Symplocos, Planchonella, Homalanthus,* etc. as well as brackens, other ferns, and grasses. In the forest at this altitude is *Adinandra, Casuarina papuana, Elatostema, Gardenia,* etc.

13. Quadrat V. 1, *Decaspermum* sp.; 2, *Pandanus* sp.; 3, *Cinnamomum* sp.; 4, *Elaeocarpus* sp.; 5, *Schefflera* sp.; 6, *Polyscias* sp.; 7, *Cryptocarya* sp.; 8, Araliaceae; 9, *Albizia* sp.; 10, *Galbulimima* sp.; 11, *Prunus* sp.; 12, *Planchonella* sp.; 13, *Daphnandra* sp.

QVII – (Fig. 15) This is situated inside the upper Kunai Creek basin, which is deep and shady much of the time. The forest in this quad is tall and dense, with fairly complete, though uneven, canopy, except at lower edge where a rock slide and tree-fall lets in some light. Tree diversity is fairly great. Slope is about 48° average and the ground is rocky and partly loose (decomposing schist), and soil is uneven and partly very shallow. There are large lianas and other vines, but fewer miscellaneous epiphytes than higher up. Canopy is about 40 m and altitude 1600 m.

QVIII – This is fairly typical kunai, consisting of the grasses *Saccharum, Themeda* and *Imperata*, except that it has not been burned for 7 years at this point, and volunteer trees are starting to appear, in addition to *Vaccinium* which has been there for some time. Slope is 50–55° and ground cover is mostly dead kunai. Altitude is 1450 m. The kunai is gradually being replaced by molasses grass (*Melinis minutiflorus*), in lower portion and areas being planted.

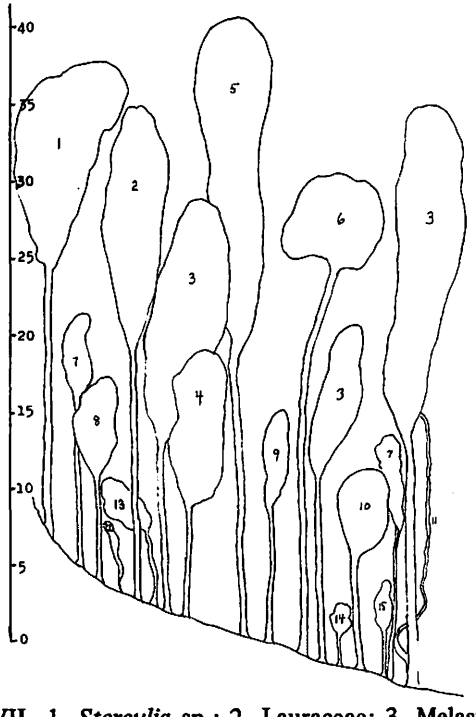


14. Quadrat VI. 1, *Phyllocladus hypophyllus;* 2, *Castanopsis acuminatissima;* 3, *Planchonella* sp.; 4, *Gastonia* sp.; 5, *Garcinia* sp.; 6, *Syzygium* sp.; 7, Araliaceae; 8, *Galbulimima* sp.; 9, *Cyathea* sp.; 10, Lauraceae; 11, *Gordonia* sp.; 12, Dead sapling & vines; 13, *Daphnandra* sp.; 14, *Calamus* sp.; 15, *Cinnamomum* sp.; 16, *Caldcluvia* sp.: 17, Araliaceae; 18, Lianas; 19, *Elaeocarpus* sp.; 20, *Acronychia* sp.; 21, *Lithocarpus* sp.; 22, *Albizia* sp.

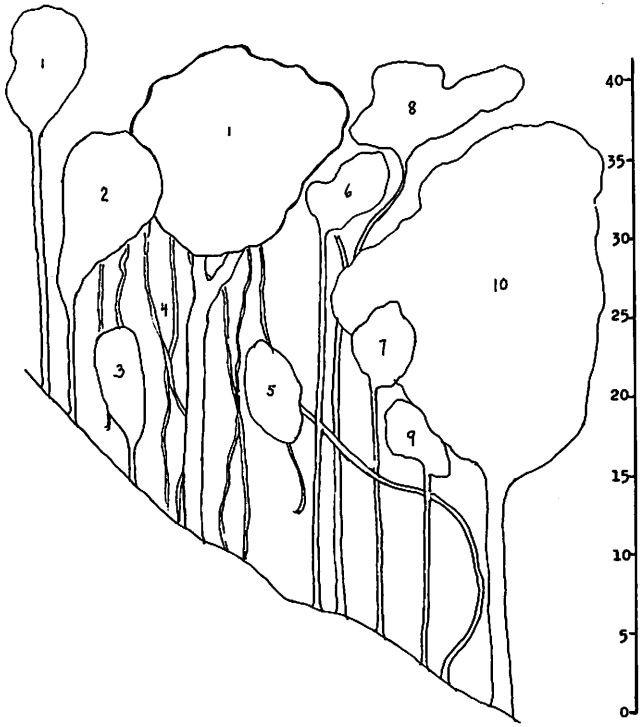
QVIII-A – (Fig. 16) This is oak forest, fairly typical but not pure, with large *Castanopsis* and *Lithocarpus* trees, but also tall trees of other genera, such as *Albizia, Alstonia, Vernonia,* etc. Canopy is dense and understory is sparse and irregular, with some *Vaccinium* and young trees. There are several long lianas. Ground cover is mostly dead leaves, with some ferns and moss. Slope is about 50° and canopy up to 38 m. Altitude is also 1450 m, the quad being situated opposite the kunai/forest interface from QVIII and inside the Kunai Creek gorge.

Second growth in the kunai below QVIII, partly shaded by forest edge, includes *Vaccinium, Macaranga, Semecarpus, Castanopsis, Geniostoma, Litsea* and a few *Araucaria cunninghami*. Some of these, and others, including *Banksia, Casuarina, Leea, Araucaria hunsteini* and *Pinus*, have also been planted there by WEI.

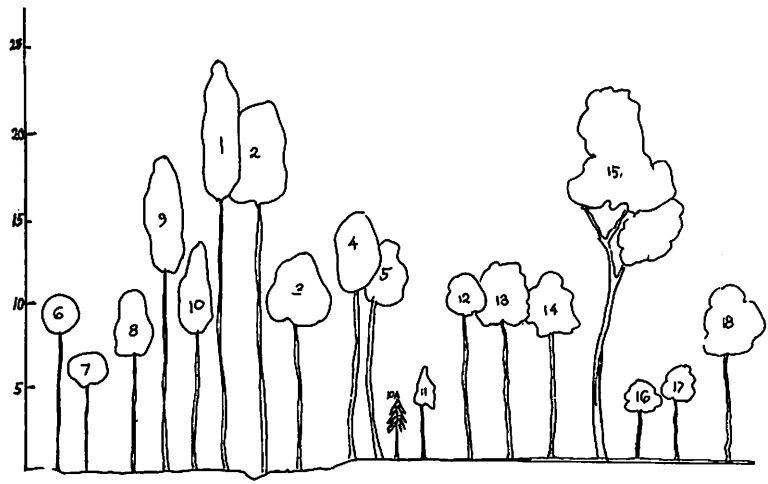
QIX – (Fig. 17 a–c) This lowest quad, in the lower end of the WEI grounds, was not one of the formal series chosen by the prescribed impartial formula, but was added to complete the lower end of the altitudinal



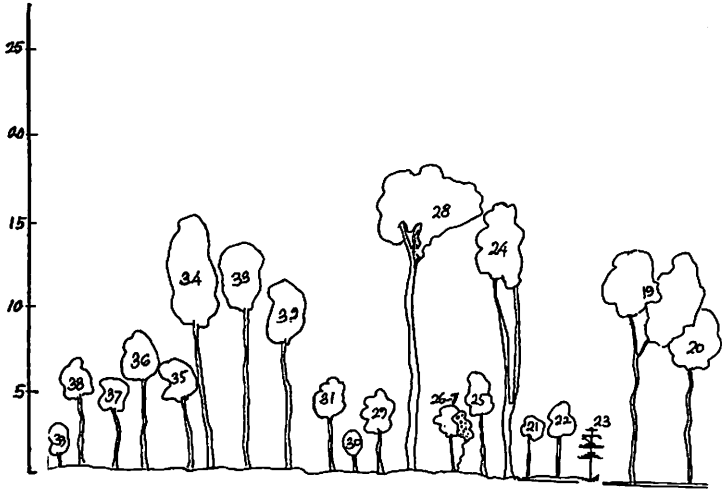
15. Quadrat VII. 1, *Sterculia* sp.; 2, Lauraceae; 3, Melastomataceae; 4, *Myristica* sp.; 5, Celastraceae; 6, *Dendrocnide* sp. 7, *Elaeocarpus* sp.; 8, *Xanthophyllum papuanum;* 9, ditto; 10, *Lithocarpus* sp.; 11, Liana; 12, Monimiaceae; 13, Unknown; 14, *Cyrtandra* sp.; 15, *Macaranga* sp.



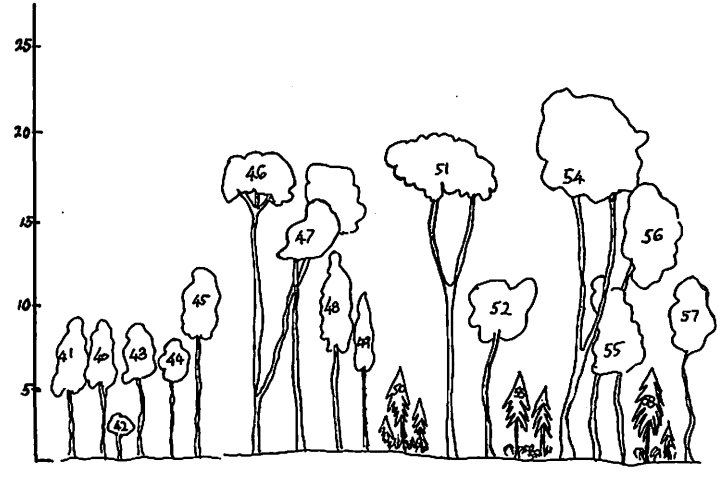
16. Quadrat VIII-A. 1, *Lithocarpus* sp.; 2, *Wendlandia* sp.; 3, *Saurauia* sp.; 4, *Lianas;* 5, *Vaccinium* sp.; 6, *Vernonia* sp.; 7, *Rhus taitensis;* 8, *Albizia* sp.; 9, *Alstonia* sp.; 10, *Castanopsis acuminatissima.*



17. Quadrat IX and subtransect. (a) 1, *Alstonia brassi;* 2, *Toona sureni;* 3, *Carpodetus* sp.; 4, *Ficus* (orange fruit); 5, *Toona sureni;* 6, *Ficus* sp.; 7, *Geijera* sp.; 8, *Toona sureni;* 9, *Lithocarpus* sp.; 10, *Pandanus* sp.; 11, *Litsea* sp.; 12, *Ficus* (red bark); 13, 14 unknown; *15, Anthocephalus cadamba;* 16, *Ficus* sp.; 17, *?Moraceae;* 18, *Ficus* sp.



(b) 19, *Ficus* sp.; 20, *Ficus* sp.; 21, unknown; 22, *Lithocarpus* sp.; 23, *Semecarpus* sp.; 24, *Ficus* sp.; 25, *Eugenia* sp.; 26, *Ficus* sp.; 27, *Piper* sp.; 28, *Toona sureni;* 29, *Sterculia schuurmaniana;* 30, *Litsea* sp.; 31, *Ficus* (small leaves); 32, *Ficus* (= 24); 33, *Sloania* sp.; 34, *Toona sureni;* 35, Moraceae; 36, *Toona;* 37, *Ficus* sp.; 38, *Dysoxylum* sp.; 39, *Cryptocarya* sp.



(c) 40, *Ficus* sp.; 41, *?Ficus* sp.; 42, *Persea americana;* 43, *Carpodetus* sp.; 44, ditto; 45, *Cryptocarya* sp.; 46, *Polyscias* sp.; 47, *Sterculia* sp.; 48, *Alstonia scholaris;* 49, ditto; 50, *Pandanus* sp.; 51, *Sloania* sp.; 52, *Carpodetus* sp.; 53, *Pandanus* sp.; 54, *Ficus* sp.; 55, *Carpodetus* sp.; 56,57, *Toona;* 58, *Pandanus* sp.

range of Kaindi, in the only remnant stand of original forest roughly in line with the transect. It contrasts with all the other quads in several respects, but especially in soil characteristics. There is some raised marine limestone here, and an underground stream and spring. Also, the slope is not steep as with the other quads, but is gently sloping in average, although quite rocky and up and down, with boulders. The forest is also quite different, with a definite lower montane aspect. Though within the *Araucaria* zone, there is no clear evidence that *Araucaria* occurred naturally in this spot (it is planted outside the forest). Many of the larger trees are *Ficus* of various species, but other tall ones include *Alstonia, Anthocephalus, Sloania* and *Lithocarpus*. Although this quad was surveyed by EARTHWATCH in the same manner as the other quads, a tree transect had been surveyed earlier, mainly by Allen Allison and Tola Gulaga, and their diagrams are used here. Ground cover consists of leaves, roots, rocks, ferns and introduced *Commelina diffusa*. Altitude is 1150 m.

SOILS

The physical and chemical properties of soils have a great effect on the vegetation and animal life it supports. Because of the extremely high rainfall levels, tropical soils are generally "leached," the nutrients such as Ca, Mg, K, and Na not available in the soil, but instead stored in the vegetation itself.

The results of soil ananlysis by the University of Technology Analysis Laboratory show that, in general, the samples of Mt Kaindi had:

a) very low pH
b) virtually no exchangeable Ca and Mg
c) extremely high Cation Exchange Capacity (C.E.C.)
d) high concentration of organic matter

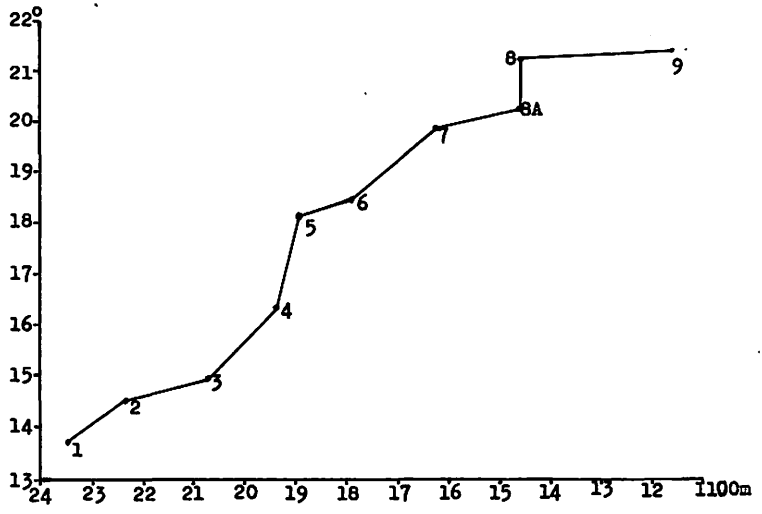
Brief comments by the soil interpretor at the Agriculture Research Centre in Bubia are as follows:

QI:	very acid; P, Ca, Mg and K low
QII:	very acid; P marginal; Ca, Mg, and K low
QIII:	very acid; P particularly high; C.E.C. and N high, Ca low
QIV:	very acid; P marginal
QV:	very acid; P, Mg, K, Ca low
QVI:	very acid; P high; Ca low
QVII:	acid; P low, C.E.C. and N marginal
QVIII:	slightly acid; P, Ca, Mg and K low
QVIII-A:	acid; P and K very low
QIX:	slightly alkaline; Ca fairly high

Sample IX differs greatly from the others and appears fairly fertile, possibly due to volcanic intrustions and limestone. The higher-altitude samples are well-leached and consequently acid to very acid. The C.E.C. in most samples are high probably because of high organic matter content due to the forest cover.

Diurnal temperature regime: In deep shade the temperature varies

rather little during the 24-hour cycle. In the moss forest at the top of Kaindi there is rarely more than 6 degrees difference between maximum and minimum air temperature during most weeks. In Quadrat 9 (1150 m) below ground cover but above ground surface, temperature varied from 17.0 to 22.8°C. Under ground (20 cm deep) the temperature only varied from 17.9 to 20.2°C (IX. 1977). Thus the temperatures recorded in the various quads, at different times, may actually be fairly representative (see Fig. 18).



18. Soil temperatures at transect quadrats. Temperature reading upward at left; altitudes indicated in hundreds of metres, decreasing to right.

Table 3 WEATHER DURING EARTHWATCH TRANSECT SURVEY PERIOD

Period	RAINFALL (mm)			Rainless Days		WIND (av. speed km/hr)	
	1200 m	1800 m	2360 m	1200 m	2360 m	1200 m	2366 m
27.VI-4.VII	93	66	69	–	–	1.5	1.9
4-11.VII	43	226	51	3	–	1.6	0.5
11-18.VII	13	20	45	2	1	1.6	0.5
18-25.VII	28	23	20	3	5	1.2	2.8
24.VII-1.VIII	17	30	74	2	1	1.9	4.1
1-8.VIII	100	55	113	–	–	1.6	3.9
8-15.VIII	17	25	74	3	–	1.9	(3.0)
15-22.VIII	14	60	89	2	–	1.7	(3.0)
22-29.VIII	38	45	47	2	–	1.8	2.7
29.VIII-5.IX	59	50	63	3	–	1.7	2.0

TEMPERATURE (°C)

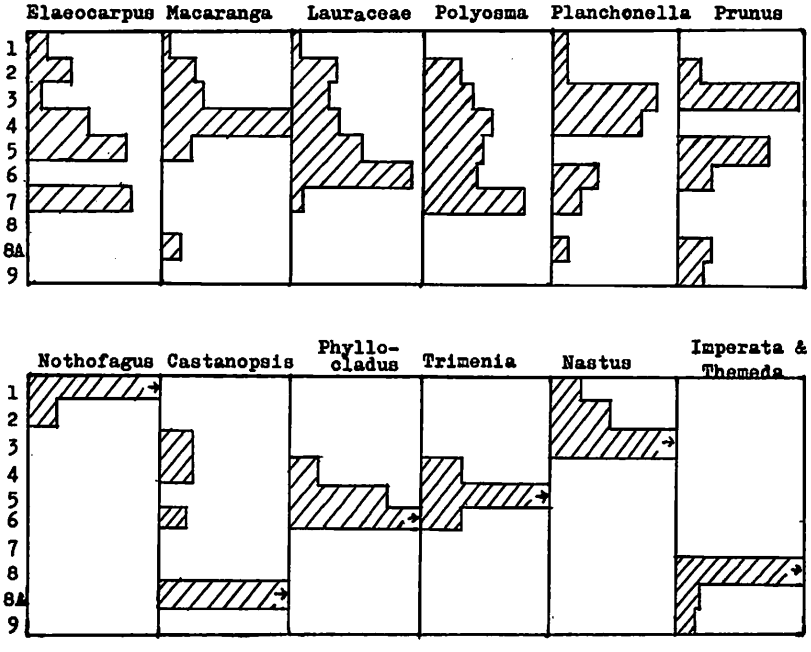
	1200 m		1800 m		2350 m (forest)		2360 m	
	min	max	min	max	min	max	min	max
27.VI-4.VII	15	25	12	23	10	15	10	19
4-11.VII	15	27	13	23	11	16	12	20
11-18.VII	14	26	13	23	10	15	11	21
18-25.VII	14	27	12	23	9	15	10	20
25.VII-1.VIII	14	26	13	22	9	15	10	19
1-8.VIII	15	28	12	23	10	15	11	21
8-15.VIII	16	27	12	23	10	16	11	21
15-22.VIII	15	29	12	24	10	18	10	21
22-29.VIII	15	28	12	23	9	10	11	20
29.VIII-5.IX	16	26	13	21	11	13	11	20

PLANTS

Over 1000 plant specimens were collected from the 10 quadrats along the EARTHWATCH transect. Nearly all of these were identified to at least the generic level, the list of which is recorded on the following pages. Fifty-eight families of spermatophytes (seed plants, including trees, shrubs, grasses, and herbs), comprised of 118 genera, are represented. The samples of Pteridophytes (ferns) included 17 genera. The Bryoflora (mosses and hepatics) was diverse, but identification to even family of these and microflora level was not attempted.

One of the goals of the transect analysis was to discern patterns of tree and surface vegetation in relation to elevation. However, the extremely complex and diverse nature of the mid-montane rainforest made even this extent of sampling insufficient to give statistically significant results. It will take a great deal more field research with more specific focus to answer the question of abundance and distribution of plants in relation to altitude and other environmental factors.

Fig. 19 shows a graphical representation of the distribution of 10 groups of plants. This histogram illustrates the relative abundance of a single family or genus over the entire altitudinal range of the transect. Each bar represents the percentage in a single quadrat of the total number of the group sampled, e.g., *Nothofagus* is found only in the high-elevation quadrats (QI, QII), while *Polyosma*, with a wider altitudinal range, is found from Quadrat II through QVII. As with other data, more research remains to be done to complete the altitudinal analysis.



19. Altitudinal distribution of 10 plant groups (quadrat data only: percentage in each quadrat of total in all quadrats; total length of a horizontal bar = 40%; arrow pointing right signifies more than 40%).

Table 4 CHECKLIST OF PLANT GENERA IN QUADS

	I	II	III	IV	V	VI	VII	VIII	VIIIA	IX	TOTAL
ALANGIACEAE											
Alangium							3				3
ANACARDIACEAE											
Semecarpus										*	
APOCYNACEAE											
Alstonia						1				1	2
Alyxia	1	1		1			1		12		16
Neuburgia							1				
AQUIFOLIACEAE											
Ilex		5			3	1					9
ARACEAE											
Pothos							2		3		5
Alocasia							1				1
ARALIACEAE											
Polyscias					1					*	1
Schefflera				1	9	7					17
ASTERACEAE											
Crassocephalum								11			11
Erigeron								3			3
BIGNONIACEAE											
Tecomanthe		4									4
BURSERACEAE											
Canarium					2	1					3
CELASTRACEAE											
Perrottetia					1		1				2
COMMELINACEAE											
Commelina										15%	

	I	II	III	IV	V	VI	VII	VIII	VIIIA	IX	TOTAL
CUNONIACEAE											
Spiraeopsis			1	1							2
DICHAPETALACEAE											
Dichapetalum				6	1						7
ELAEOCARPACEAE											
Aceratium			3	1	6						10
Dubouzetia				2							2
Elaeocarpus	4	6	2	9	14	13					48
Sericolea		2	1	2			4		1	2	12
Sloanea		6			1				154		161
ERICACEAE											
Dimorphanthera		1									1
Vaccinium		2				12		4	1		19
ESCALLONIACEAE											
Carpodetus										*	
EUPHORBIACEAE											
Acalypha									3	5	8
Aporusa						3	15				18
Breynia									1		1
Cleidion								1			1
Macaranga	2	9	8	24	3			3			49
Phyllanthus								1			1
FAGACEAE											
Castanopsis			1	1		1			14		17
Nothofagus	23	2									25
Lithocarpus		1							1	*	1
GESNERIACEAE											
Aeschynanthus		1									1

* – On older transect at IX

	I	II	III	IV	V	VI	VII	VIII	VIIIA	IX	TOTAL
Cyrtandra		1	2				13				16
GOODENIACEAE											
Scaevola								8			8
GRAMINAE											
Imperata								20%			
Nastus		3	9								12
Themeda								10%			
Bambusa				11							11
GUTTIFERAE											
Calophyllum				1							1
Garcinia			1								1
HIMANTANDRACEAE											
Galbulimima				3	11	3					17
ICACINACEAE											
Gomphandra								16			16
Platea				3							3
LABIATAE											
Coleus								1			1
LAURACEAE											
Cinnamomum		1	2	2	2	3	1				11
Cryptocarya	1	5	2	4	6	19				*	37
Endiandra							1				1
Litsea										*	
Neolitsea							1				1
LEGUMINOSAE											
Desmodium								5			5
Lupinus								14			14

	I	II	III	IV	V	VI	VII	VIII	VIIIA	IX	TOTAL
LILIACEAE											
Dianella	1		2		3						6
Smilax							6				6
Donax			3								3
LOGANIACEAE											
Fagraea			1	1							2
MARANTACEAE											
Donax											
Maranta							1				1
MELASTOMATACEAE											
Medinilla	3	1	15		2		2				23
Memecylon	1	1					1				3
Astronia			1				1				2
MELIACEAE											
Aglaia					1					2	3
Dysoxylum									6	2	8
Toona										*	
MONIMIACEAE											
Dryadodaphne	1			1							2
Kibara			1				1				2
Palmeria	1		5	3	3		1				13
Leviera					1		2				3
Trimenia				1	6	1					8
MORACEAE											
Ficus							3			13	16
Streblus	1			1	3	1	3				9
MYRISTICACEAE											
Myristica							1				1

* – On older transect at IX

	I	II	III	IV	V	VI	VII	VIII	VIIIA	IX	TOTAL
MYRSINACEAE											
Ardisia	1						1				2
Maesa		2									2
Rapanea	5	1	6		3						15
MYRTACEAE											
Acmena				1							1
Decaspermum	2								1		3
Eugenia			3							*	3
Rhodomyrtus			1	3							4
Syzygium				4	8		6				18
Xanthomyrtus	1										1
Octamyrtus		2			1						3
Metrosideros						2					2
OLEACEAE											
Linociera				1			1				2
ORCHIDACEAE											
Dendrobium		1									1
Glossorhyncha		2									2
Spathoglottis					1						1
PALMAE											
Caryota										1	1
PANDANACEAE											
Freycinetia		1	2	3	31		4				41
Pandanus			2	4	9					9	24
PIPERACEAE											
Piper		1			1		14				16
PODOCARPACEAE											
Phyllocladus				1	4		7				12
Podocarpus					1						1

	I	II	III	IV	V	VI	VII	VIII	VIIIA	IX	TOTAL
POLYGALACEAE											
Polygala								1			1
PROTEACEAE											
Helicia	1			7	2						10
ROSACEAE											
Prunus	1	15		8			1		1		27
RUBIACEAE											
Anthocephalus										*	
Canthicum							1				1
Hedyotis								7			7
Lasianthus						1					1
Ophiorrhiza									5		5
Psychotria	1			2	6		2				11
Timonius						2	1				3
Neonauclea							1				1
RUTACEAE											
Acronychia	2			2	3	3					10
Evodia			8								8
Evodiella	1										1
Geijera										*	
SAPINDACEAE											
Cupaniopsis				2					1	4	7
Dictyoneura				10	2	1				3	16
Harpullia							1				1
Mischocarpus	2	1									3
SAPOTACEAE											
Planchonella	1	1	8	7	2	1	1				21
SAXIFRAGACEAE											
Polyosma		2	2	3	2	2	7				19

	I	II	III	IV	V	VI	VII	VIII	VIIIA	IX	TOTAL
Quintinia						1					1
STERCULIACEAE											
Sterculia							3			*	3
SYMPLOCACEAE											
Symplocos			1	1		1					3
URTICACEAE											
Pouzolzia								3		1	4
VITACEAE											
Cayratia	1	2	1	2							6
Cissus			3	10	7	1					21
WINTERACEAE											
Bubbia		5									5
Drimys	1					6					7
ZINGIBERACEAE											
Alpinia			7	3							10
Riedelia	1		15	4		9		1			30
											974

Total number of flowering plants recorded (excluding I-A and old transect at IX)

	I	II	III	IV	V	VI	VII	VIII	VIIIA	IX	TOTAL
PTERIDOPHYTES (FERNS)											
Athyrium					4						4
Arachnides									1		1
Cyclosorus										2	2
Dicranopteris						1	1	15			17
Humata							2				2
Hymenophyllum	5	14									19
Hynodendron			5				1				6
Hypolepis			1				29		21		51
Lindsaea			4		1		1				6
Microsorium									4		4
Nephrolepis							1		13	1	15
Pteridium								9			9
Pteris							2		30	2	34
Stephania							1				1
Thelypteris	3	1		2							6
Trichomenas	2	1		4							7
										Total	184

INSECT SAMPLING RESULTS

Following are tabulations of the numbers of specimens of major groups of insects and other arthropods, or other animals, sampled by various methods in the formal transect survey. Much greater numbers of specimens have been taken at other times, mainly at top and bottom of Kaindi. Lists of some species from the overall studies follow under "Faunal analysis" The tables here are given partly as examples of types of data collected. The information is only partly summarized here.

Examination of tables 8–11 will show that different groups of arthropods, and different proportions also, are provided by the different trapping means. This shows that all types of trapping is required for a comprehensive survey. However, it must not be assumed that these 4 systems will provide a full sample of the fauna of a quadrat or transect. Many groups are quite inadequately sampled by these means and very many species will be totally lacking. Not only would these methods have to be used continuously or repeatedly throughout the year, but some species will only be found by careful and protracted searching in the appropriate niches.

Tables 5–7 condense and summarize information in tables 8 and 9. However, in the condensing, and in the grouping of quadrats, much significant information is hidden and the complete data must be examined to obtain more accurate pictures of the situations as demonstrated by those methods of sampling.

FLORA AND VEGETATION

Kaindi has a rich and diverse flora, and it cannot be adequately characterized here. No estimate is made of the number of species involved, but it would be a least a few hundred species of woody plants alone. It is hoped later to publish a flora of Mt Kaindi. The plants illustrated and noted here represent only some of the more common woody plants from the S summit area of Kaindi. Many groups were excluded by chance from the transect survey because of the limitations of size of quadrats. These were limited partly because of the steep and difficult nature of the terrain to be surveyed. As an example, the araliad *Polyscias* is abundant in second growth around the S summit, yet was lacking in quadrats I, I–A and II–IV. Some other species completely lacking in the quadrats, such as rhododendrons, low melastomes, gesneriads, *Rubus* and other plants growing on forest fringe, are among those illustrated here. The latter include a number of those to be seen from the clearings and trails.

Mt Kaindi demonstrates considerable vegetational differences from Mt Missim across the Wau Valley. There is relatively less *Nothofagus* on Missim, and much of the *Castanopsis* forest has a different aspect in that on Mt Missim it has an understory of a broad-leafed bamboo not noted on Kaindi. Also, no *Banksia* or *Grevillea* savanna has been found on Kaindi, whereas there is some in at least one spot on the S slope of Missim, and considerable in the upper portion of Wau Valley (with *Rhododendron aurigeranum* and *Nepenthes*). There is also some on the N side of Bulolo

Table 5. Percentages of animals sampled by 4 methods, by altitude groupings.
(Figures in columns are percentages of catches for each grouping of quadrats)

	PITFALL			BERLESE			GRESSITT TRAP			LIGHT TRAPPING					
											M.V.			U.V.	
	1–3	4–6	7–9	1–3	4–6	7–9	1–3	4–6	7–9	1	5	9	1	5	9
Acarina	1.1	1.7	2.1	25.7	22.6	40.4									
Other Arachnida	8.0	7.1	9.2	4.2	4.6	4.9									
Crustacea	4.3		0.7	1.5		1.0									
Chilopoda		0.6	0.3	3.2	1.3	1.0									
Diplopoda	2.1	0.3	1.9	3.2	0.4	4.1									
Symphyla	0.5		0.2		0.2	0.8									
Insecta	(84.0	90.1	85.1	62.2	70.9	47.8	–	100%	–		–	100%	–	–	100% –)
Collembola	9.1	21.4	15.6	7.9	3.7	7.0									
Orthoptera	1.6	3.7	3.9	0.6	0.4	1.3	1.1	0.2	0.3			3.7		1.2	9.2
Homoptera	0.5	4.4	0.5	1.8	0.4	1.6	2.9	3.1	2.8	3.6	1.0	1.6	14.9	2.0	9.8
Heteroptera	0.5	2.7	1.4	0.7	0.9	–	0.9	1.7	0.7	2.9	6.8	2.9	1.3	4.2	12.9
Lepidoptera															
larvae	4.8	3.4	1.4	6.8	8.8	3.9									
adults	1.6						28.9	18.8	31.5	77.7	48.5	68.2	24.5	28.0	38.5
Coleoptera	39.0	32.7	35.0	28.8	25.4	10.9	4.0	8.5	5.2	5.1	20.2	5.7	4.8	34.2	13.7
Diptera	20.9	12.9	10.5	5.5	7.0	15.5	54.5	55.9	51.4	2.2	16.7	11.8	47.8	27.7	10.2
Hymenoptera															
parasitic		2.0	2.1	0.9	0.2	0.3	4.5	5.4	6.9	1.3	4.4	1.6	4.8	1.8	2.8
ants	3.7	5.1	6.9	6.4	23.2	16.9	1.4	1.7	0.7	0.3		0.8			1.4
aculeates							0.2	4.7	0.5		1.5			0.2	
	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Table 6. Percentages of major groups in pitfall and Berlese Collections
(Figures in colums are approximate percentages of catches for each grouping of quadrats)

	PITFALL			BERLESE		
Quads :	1–3	4–6	7–9	1–3	4–6	7–9
Arachnida	9	9	10	30	29	34
Collembola	9	21	14	8	4	5
Orthoptera	2	4	4	1	1	1
Lepidoptera	6	4	1	6	9	3
Coleoptera	39	34	31	29	25	16
Diptera	20	13	14	5	7	12
Hymen. : ants	4	5	25	20	23	17
	100	100	100	100	100	100
Total coll'n	187	294	529	455	456	512

Note : This information (extracted from tables 8–9), which could be presented in a histogram (as Fig. 19), hides some significant facts. For instance, it does not show that the kunai (Quad 8) had very few soil animals, and that most of those few were ants.

Table 7. Percentages of major groups of Coleoptera represented in pitfall and Berlese lots.

	PITFALL			BERLESE		
Quads :	1–3	4–6	7–9	1–3	4–6	7–9
Carabidae	2	0	0	3	4	0
Hydrophilidae	2	5	8	3	10	5
Staphylinidae	20	23	43	17	30	13
Nitidulidae	53	27	10	6	5	7
Ptiliidae etc	0	13	7	11	1	6
Tenebrionidae	2	6	2	2	2	2
Curculionidae	3	15	8	14	2	0
	100	100	100	100	100	100
Total spec. Coleopt.	64	94	166	131	112	84

Table 8. PITFALL TRAP RESULTS
(Numbers of specimens of different groups taken in the various quadrats)

		1	2	3	4	5	6	7	8	8A	9	Total
ARACHNIDA:	ACARINA		1	1	3		1	2		4	3	14
	PHALANGIDA				1		1					2
	ARANEIDA	3	1	11	8	7	4	4	2	5	31	76
CRUSTACEA:	AMPHIPODA	4										4
	ISOPODA		1	3							4	8
CHILOPODA					1		1		1		1	4
DIPLOPODA				4			1	2			9	16
SYMPHYLA				1					1			2
INSECTA:	COLLEMBOLA	5	7	5	44	15	4	10	21	23	35	169
	THYSANURA			1	1							2
	PSOCOPTERA			1	4					1		6
	BLATTARIA		1			6			1	4	4	16
	ORTHOPTERA											
	Tetrig, Acrid.		1		2				1			5
	Gryllidae		2		3	6		6	1	4	6	28
	HOMOPTERA											
	Aphid, Coccid.				1						1	2
	Cicadel., Fulgor.			1		1	1				1	4
	HETEROPTERA											
	Pentatomidae				1		1					2
	Lygaeid., Mirid.		1		5	1		1	1		2	11
	Aradid., Reduvi.				3						3	6
	LEPIDOPTERA											
	adults			3	1							4
	larvae	1	7	1	5	5				1	5	25

		1	2	3	4	5	6	7	8	8A	9	Total
	COLEOPTERA											
	Carabidae		1									1
	Staphylinidae	4	5	4	10	8	4	5		10	57	107
	Hydrophilidae		1		5				6		7	19
	Nitidulidae	7	15	12	14	11		4	6		7	76
	Ptiliidae, etc				7	2	3			5	6	23
	Tenebrionidae			1	4	2			1		2	10
	Chrysomel, Scarab.		1	1		1		1		1	3	8
	Curculion.		2		10	1	3	5		2	7	30
	miscell.	2	8	5	5	3	1	6	2		17	49
	larvae			4		2			1	4	4	15
	DIPTERA											
	Nematocera	1	5	9	4	7	2	7	1	3	22	61
	acalyptrate	6	7	9	11	7	7	7	2	7	23	86
	muscoid, larv.		1	1						1	2	5
	HYMENOPTERA											
	parasitic				4	1	1		2	7	2	17
	ants		3	4	3	6	6	1	103	4	25	155
MOLLUSCA:	slug			1								1
AMPHIBIA:	frog		1									1
REPTILIA:	skink					1						1
	Totals	33	71	83	160	93	41	61	153	86	290	1071

Table 9. BERLESE FUNNEL SAMPLES OF FOREST FLOOR LITTER
(Numbers of specimens of various groups taken in the quadrats)

	Quads:	1	2	3	4	5	6	7	8	8A	9	Total spec.
ARACHNIDA:	Acarina	93	17	7	92	10	61	111		4	41	443
	Pseudoscorpion.											
	Araneida	1	11	7	14	7	13	12		1	6	72
CRUSTACEA:	Amphipoda		4					2		1		7
	Isopoda	1	2							2		5
SYMPHYLA					1		6	2		1	1	11
DIPLOPODA			4	11		2		14		6	1	38
CHILOPODA			15		3	3		3			2	26
INSECTA:	Protura											
	Collembola	24	10	2	15	2	21	11		7	9	101
	Thysanura		1					1			1	3
	Psocoptera			1	1			2			2	6
	Elattaria				1							1
	Orthoptera											
	Gryllidae			1				1				
	Dermaptera		2							2		4
	Thysanoptera	1		2	1		3	3			1	11
	Homoptera											
	Coccidae	1	7	2	6		2				3	21
	Cicadellidae?		5		2			2		1		10
	Heteroptera											
	Pentatomidae								1			1
	Lygaeidae, Mir.				1				1		1	3
	Aradidae		2		3		1					6
	Reduvidae							1	1			2

		Quads:	1	2	3	4	5	6	7	8	8A	9	Total spec.
	Lepidoptera												
	Larvae		13	12	6	40		2	5	1	3	7	89
	Coleoptera												
	Carabidae			4		1	4						9
	Hydrophilidae			1	3	1	10		1		2	1	19
	Staphylinidae		4	12	6	23	10	9	1	4	1	5	75
	Nitidulidae		2	1	5	5	1	11	3			3	31
	Ptiliidae, etc		2	5	7	1		6	3			2	26
	Tenebrionidae			1	1	2		1			2		7
	Scarabaeidas				1		1						2
	Curculionidae		15	3		2		10					30
	miscell.		6	12	3	12	3	2	7		2	9	56
	larvae		21	10	6	31	3	7	8	1	13	15	115
	Diptera												
	Nematocera		4	1	2	7		2	3		5	1	25
	acalyptrate					1		2					3
	larvae		3	9	6	19	1	24	20	1	12	19	94
	Hymenoptera												
	parasitic		1		3			1	1	1			8
	ants		6	5	18	54	50	42	47	15	9	17	263
MOLLUSCA:	Gastropoda								1				1
	Totals		198	156	101	339	107	202	264	26	74	148	1625

Table 10. GRESSITT TRAP RESULTS
(Number of specimens of various groups taken in the quadrats)

Quads:	1	2	3	4	5	6	7	8	8A	9	Total spec.
ACARINA		1									1
ARANEIDA										1	1
INSECTA											
PSOCOPTERA	1	2			1						4
HOMOPTERA											
Cicadellidae		18		1	4	4		26	4	9	66
Cercop., Fulgor.		4	3			7	2	5		1	22
HETEROPTERA											
Pentatomidae	2									1	3
Lygae., Mirid.		1	3	3		2	1	9	3		22
BLATTARIA		1				2					3
ORTHOPTERA											
Acrid., Tettigon.		1	1					2			4
Gryllidae				1	1			1	3	2	8
DERMAPTERA		1									1
THYSANOPTERA			2		1						3
EMBIOPTERA								2			2
ODONATA											
Zygoptera			2								2
NEUROPTERA											
Chrysopidae								1			1
TRICHOPTERA					1			1		1	3
LEPIDOPTERA											
micros	24	3	20	18	7	17	2	160	21	39	313

Quads:	1	2	3	4	5	6	7	8	8A	9	Total spec.
Pyral., Tortric.	57	3	12	10	9	8	5	34	46	28	112
Geometridae	40		1	3		22	9	2	11	10	99
Noctuidae	27			1		3		3	4	4	42
butterflies										2	2
COLEOPTERA											
Staphylinidae	1									4	5
clavicorns, etc.			3	3	4	2	2	2		5	21
Heteromera			1		1	1	1	1			5
Chrysomelidae	3	6	5	4	5	7	7	5		1	43
Curculionidae	1	1				3	1	2	1		9
miscell.	3		1	3	1	10	2	4	2	2	28
DIPTERA											
Nematocera	101	60	133	170	33	35	32	220	175	70	1025
acalyptrates	7	28	6	15	9	7	6	15	3	4	100
muscoids	2	13	2	3	2	11	2	2			37
Trypetid, Syrph.				1	2			5			8
HYMENOPTERA											
parasitic	10	9	10	16	8	4	6	140	28	5	236
ants		2	7	5	1	3	1	15	2	1	37
Vespoidea					16			1			17
Sphecoid., Apoid.			1	1	1	2		3	1		9
Totals	279	154	213	258	107	150	79	667	305	184	2273

Table 11. LIGHT TRAP RESULTS

(Numbers of specimens in various groups, taken in quadrats 1, 5 and 9)

	1 (2360 m)		5 (1875 m)		9 (1200 m)		
	M.V.	U.V.	M.V.	U.V.	M.V.	U.V.	Total
ORTHOPTERA							
Tetrigidae				3	5	31	39
Tettigoniidae				4		9	13
Gryllidae				2		5	7
MANTODEA		2			3	3	8
DERMAPTERA		1					1
HOMOPTERA							
Cicadidae	7			4	1	27	39
Cicadellidae	12	33	4	11	3	21	89
Cercopidae	3	2					5
HETEROPTERA							
Pentatomidae	13	1	23	22	4	12	75
Reduviidae			1			1	2
Lygaeid., Mirid.	18	2	2	8	3	14	32
Pyrrhocoridae				2		36	38
Coreidae					1		1
NEUROPTERA							
Chrys., Hem.			1	3		2	6
TRICHOPTERA	1		1		1	1	4
LEPIDOPTERA							
micros	37	23	11	18	8	15	112
Pyralidae	91	4	51	46	22	26	240
Tortricidae	22	10	5	28	22	16	103

	1 (2360 m)		5 (1875 m)		9 (1200 m)		
	M.V.	U.V.	M.V.	U.V.	M.V.	U.V.	Total
Geometridae	106	11	25	20	26	24	212
Noctuidae	191	3	45	54	58	64	422
Arct., Lyman., Lasioc.	14	5	40	18	13	12	102
Saturniidae, Drepan.	10		3	13	8	8	42
Uraniidae	6			1	1	1	9
Sphingidae	14		5	14	9	22	64
COLEOPTERA							
Carabidae			3	12		3	18
Tenebrionidae, Lagri.	3	1	2	8	1	9	24
Coccinellidae			18	108			126
Cantharoidea	2			35		14	51
clavicorns, etc.	3	4	8	25	2	12	54
Chrysomelidae	10	5	37	36	3	4	95
Dynastinae, Melolonth.		1	2	5	8	5	21
Cerambycidae	2		3			2	7
Curculionidae	10		4	30	10	18	72
DIPTERA							
Nematocera	10	109	38	200	26	36	419
acalyptrates	3		13	8	1	9	34
Otitidae			13	2	2	5	22
HYMENOPTERA							
parasitic	8	11	17	14	4	14	68
ants	2				2	7	
aculeates			6	2			8
Totals	584	228	381	756	245	488	2674

Table 12. RHODODENDRON SPECIES NATIVE TO, OR PLANTED IN, KAINDI AREA

	Natural Occurrence (m)				Planted on
	Bulldog	Edie Creek	Kaindi	Upper Wau Valley	S. Summit Kaindi
	2800±	2000±	2340±	1300±	2362
Pseudovireya (subsec.)					
nummatum J. J. Sm.	X	X	X		
lindaueanum Koord.	X	X	X		
invasorium Sleum.	X	X			
Siphonovireya (subsec.)					
herzogii Ward.	X	X			
Phaeovireya (subsec.)					
superbum Sleum.	X	X			
rarum Schltr.					X
phaeochitum F.v.M.	X	X	X		X
dielsianum Schltr.					X
leptanthum F.v.M.		X	X		X
konori Becc.	X	X	X	X	X
solitarium Sleum.	X		X		
Albovireya (subsec.)					
yelliotii Warb.	X				
Solenovireya					
maius Sleum.	X				
cruttwellii Sleum.	X				
pleianthum Sleum.	X				
Euvireya (subsec.)					
Linnaeoidea (ser.)					
anagalliflorum Wernh.	X				X

	Natural Occurrence (m)				Planted on
	Bulldog 2800±	Edie Creek 2000±	Kaindi 2340±	Upper Wau Valley 1300±	S. Summit Kaindi 2362
gracilentum F.v.M.	X	X	X		
Stenophylla (ser.)					
purpureiflorum J. J. Sm.	X				
Buxifolia (ser.)					
vitis-ideae Sleum.	X				X
alticolum Sleum.	X		X		X
luteosquamatum Sleum.	X	X			X
inconspicuum J. J. Sm.	X	X			X
commonae Foerst.					X
Javanica (ser.)					
christi Forst.	X				
macgregoriae F.v.M.	X	X	X	X	X
culminicolum F.v.M.	X				
aurigeranum Sleum.	X	X	1500	X	
zoellerii Warb.					X

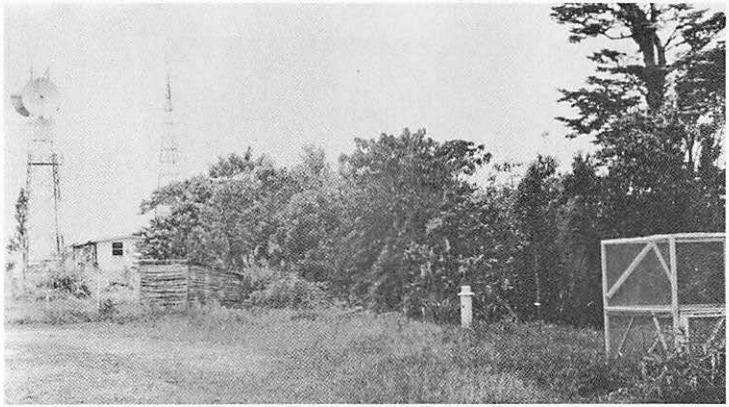
Valley and also in the middle Upper Watut Valley. *Cycas revoluta* grows in some of these kunai areas below 1200 m. A few plants of *Banksia* have been planted on the steep kunai slope above WEI. Other vegetation types lacking on Kaindi include *Eucalyptus* and *Melaleuca* savanna, alpine grassland and lowland vegetation.

The general structure of montane rainforest is not very different between here and Hawaii, but there is no *Acacia* parkland, dry forest or open bog on Kaindi (see Doty & Mueller-Dombois).

Kunai grasslands: Kunai is a natural form of grassland occurring in New Guinea. It usually consists of an association of 3 genera of grasses: a *Saccharum* (wild sugar cane), a *Themeda* and an *Imperata*. This grassland usually develops where vegetable gardens are abandoned away from the forest edge, and where the grass is burned annually. In the shade of small clearings natural forest soon regenerates, but where grassy areas are frequently burned, the forest is prevented from regenerating. As a result of lumbering of *Araucaria*, clearing, road-building, gold mining and vegetable cultivation and abandonment, a number of kunai areas have developed on the lower slopes of Kaindi N side over the years. Some of the grassy areas coincide in extent with the boundaries of former gold leases. In addition, the steep kunai slope above the Institute grounds had already been mentioned. This is apparently old, but not old enough to have naturally occurring *Banksia*. These kunai areas are being planted with trees by WEI. As great difficulty was experienced in planting to native rainforest trees, a number of exotics were planted, including *Pinus, Leucaena, Datura,* poinsettia, as well as natives such as *Eucalyptus, Banksia, Cycas,* bananas, gingers, *Heliconia* and *Rhododendron*, to help produce shade and humus for rainforest trees. In the more disturbed areas, the kunai is being rapidly replaced by molasses grass (*Melinis minutiflora.*)

Rhododendrons: New Guinea is notably rich in rhododendrons, with more than 100 species, and is second only in numbers to the Himalayan area. They occur primarily at high altitudes. A number of them are pioneers on landslides and similar situations. As a result of this, a large concentration occurs along the upper portions of the Bulldog Road. This is demonstrated in Table 12, which lists the species of the Wau-Bulldog area. This information has been kindly supplied by Paul Kores, who conducted a project on rhododendrons under a grant to WEI from the Stanley Smith Horticultural Trust (1974–78). A rhododendron garden was developed beside the WEI hostel and also a special nursery. Plants blossoming in the garden are mainly *R. aurigeranum*, which occurs naturally at slightly higher altitude in the grasslands in the upper Wau Valley. A number of the other species grow as epiphytes on tall moss-forest trees. Some of the species have very large flowers. Table 12 also indicates species planted by Mr Kores at edge of the parking area at Kaindi S summit. These also include the hybrids *gracilentum* x *leptanthum* and *macgregoriae* x *inconspicuum.*

Southern beech: Three species of *Nothofagus* occur on Kaindi:



a

b

c

d

Plate III. a, S summit, Kaindi: Repeater Station, orchid house, 15 to 18-year-old 2nd growth of *Nothofagus, Homalanthus, Macaranga, Evodia, Acronychia*; part of tall *Nothofagus*, rain gauge and weevil cage at right, May 1978; b, 10-year old *Nothofagus carrii*, and *Rhodomyrtus novoguineensis* NE corner S summit cleared area, May 1978; c, Young *Nothofagus* with *Homalanthus*, ferns and ginger, near Repeater Station, May 1978; d, *Dimorphanthera, Palmeria*, as epiphytes, near summit ridge, 1976 (all by L. Gressitt).

a

b

c

d

Plate IV. a, Two species of *Evodia*, with *Rubus* and *Dicranopteris* (*Gleichenia*); b, *Homalanthus* with *Polyscias* at top left center; c, *Saurauia* sp. (a-c at S summit, May 1978); d, Epiphytes, S summit contour trail, 2200 m, 1976 (all by L. Gressitt).

N. carrii Steen. and *N. pullei* Steen. on summit; *N. grandis* Steen. 2000–2200 m zone. Several other species from other parts of New Guinea are planted near the WEI branch station on S summit. These were donated by Ross Hynes who studied the ecology of New Guinea southern beeches. (See Appendix: Guide to nature trails).

COMMON WOODY PLANTS OF KAINDI SUMMIT AREA

First-time visitors to Mt Kaindi's moss forests frequently express disappointment at seeing so few pretty flowers. There are in fact exquisite flowers, but they tend to be small and are hard to see at first. There are, however, multicolored leaves on many of the woody plants, and these can be just as pretty as flowers. Many of these plants have a special grace and beauty of form, especially some of the vines, mosses and ferns. The elfin woodland glens are enchanting.

It is hoped these sketches and informal notes will help you see more than you would unaided. The phenology list (Table 13) indicates when you can expect to find individual species in bloom. Some of the following identifications are tentative.

FAGACEAE Beech Family (Oak; beech)

This family is the most important on the Kaindi summits because of the dominance of Southern beech trees; and *Castanopsis* trees are dominant in Quadrat VIII-A (oak zone). Pl. 3b shows *Nothofagus carrii.*

ROSACEAE Rose Family

Three native species of *Rubus* (vines) are common in the open summit area. Two are obvious and are not illustrated: *R. moorei*, with yellowish green maple-shaped leaves (like the classic raspberry) and good-tasting red fruit; and *R. rosaefolius* with its dark green compound leaves (mainly trifoliate, and like rugose rose leaves). *R. fraxinifolius* (Fig. 20) has tiny leaves arranged like the pinnately compound leaves of the ash tree (*Fraxinus*). Its thorns are slender and spiny, being bunched together near nodes. In bloom and fruit most of the time, it is a pretty sight in red, white and green. Inside the forest is a maple-leaved *Rubus* with much larger fruits and flowers. A fifth one in the open area resembles *rosaefolius* but has smoother leaves.

RUTACEAE Citrus Family (Lemon; *Evodia*)

This family is well represented here. Many members can be recognized by lemon odor of crushed new leaves. See Pl. 4a for an *Evodia*.

EUPHORBIACEAE Spurge Family (poinsettia; rubber)

Homalanthus novaguineensis (Fig. 21) Newer leaves (especially on young plants) of this tree are purple or maroon on undersides; still younger leaves

can be entirely bronzy-purple; new shoots are enclosed in a long, sharp-pointed sheath which can be vivid red. Otherwise dark green. It is especially striking as early to come up in regrowth. The other common member of this family, *Macaranga*, is likewise prominent in regrowth.

RHAMNACEAE Buckthorn Family (buckthorn; cascara; jujube)

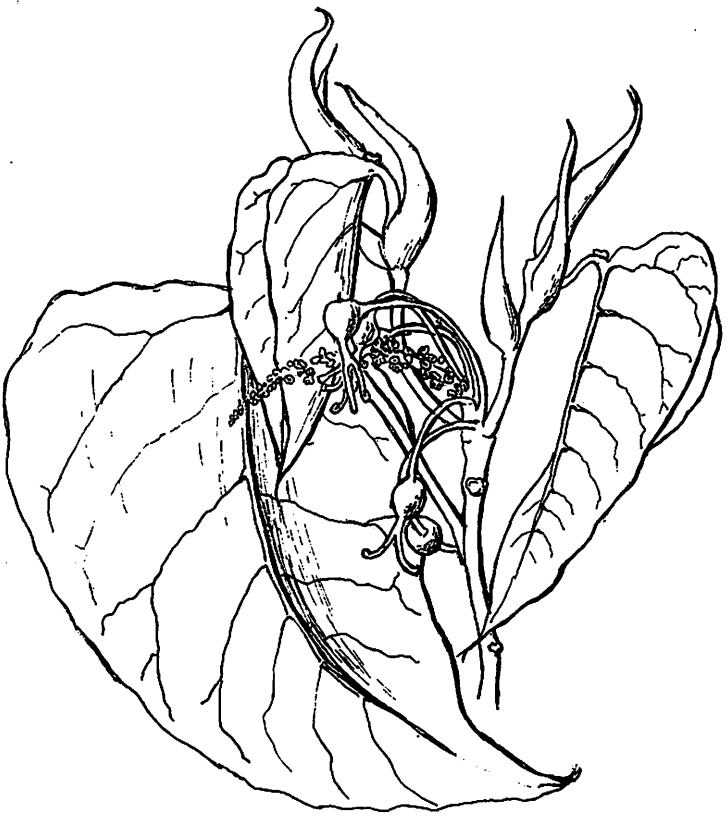
Alphitonia incana (Fig. 22) is a tree with sturdy dark green leaves that have a flannelly pale-rusty coating on undersides. The veins of the leaves are regular and conspicuous. The nut-like fruit persists a long time.

ELAEOCARPACEAE Elaeocarp Family

This family is sometimes included in TILIACEAE (Linden Family; includes jute) and shares a tendency to bear flowers and fruit on long slender stems. Kaindi elaeocarps usually have bell-shaped flowers, the petals sometimes fluted and usually deeply fringed at distal margins. One Kaindi species has clusters of flowers shading pale pink to white, with much cherry red on pedicels and sepals. Some species bear bright blue fruits like those of *Elaeocarpus grandis* of Australia, one of whose common names is blue marble tree. *Elaeocarpus* flowers are a favorite source of food for many honeyeaters and lories and the drupes likewise for green fruit pigeons.

Sericolea sp. (Fig. 23) is one of the prettiest Kaindi trees. Of a general blue-gray-green color, its leaves are slender, strongly tapered, tending to

20. *Rubus fraxinifolius* Poir.? sprig, fruit & flower (Rosaceae); x 1; detail x 2.



21. *Homalanthus novaguineensis* (Warb.) K.Schm. (Euphorbiaceae); flowers & fruit at center, leaf buds above; x 0.8.

curl. New leaves are satin-downy, and of a pale coppery gold color, looking like pale gold satin. The satin persists on undersides of young leaves as upper surfaces turn red-brown, chocolate brown, maroon, and finally green. When in fruit there is added charm of tiny round black or red berries. *Sloanea archboldiana* (Fig. 24) has large ovoid leaves. The flowers of this tree are fairly large creamy yellow bells, fluted and with a short fringe.

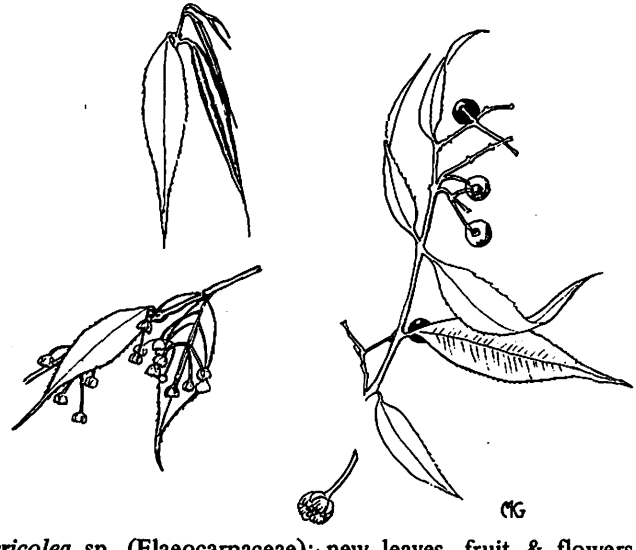
SAURAUIACEAE **Saurauia Family**

This family is significant in this zone. Some of these trees, like that illustrated in Fig. 25, have large leaves with sandpapery, and sometimes also buff-woolly, undersides. Other species have leaves of same length (20 cm ±) but narrower and quite smooth. Only the genus *Saurauia* occurs here.

THEACEAE **Tea Family** **(tea; camellia)**

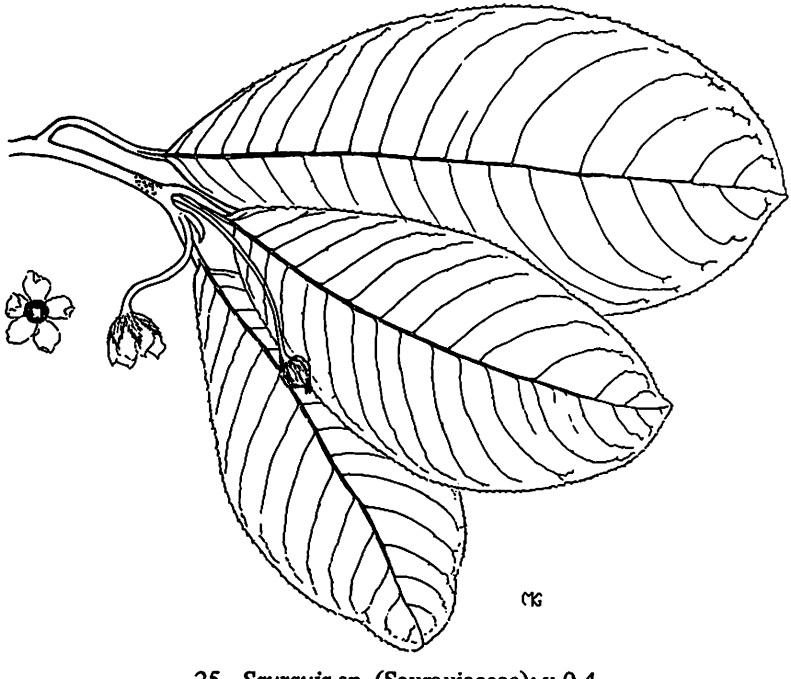
There are 2 striking representatives of this family on Kaindi S summit.

22. *Alphitonia incana* (Roxb.) Teys & B. ex Kurz. (Rhamnaceae); x 0.5; detail x 1.2.



23. *Sericolea* sp. (Elaeocarpaceae); new leaves, fruit & flowers; x 0.5; fruit x 1; flower x 1.5.

24. *Sloania forbesii* F. Muell. (Elaeocarpaceae); x 0.5.



25. *Saurauia* sp. (Saurauiaceae); x 0.4.

26. *Archboldiodendron calosericeum* (Theaceae), buds, flowers & fruit; x 0.4; detail x 1.0.

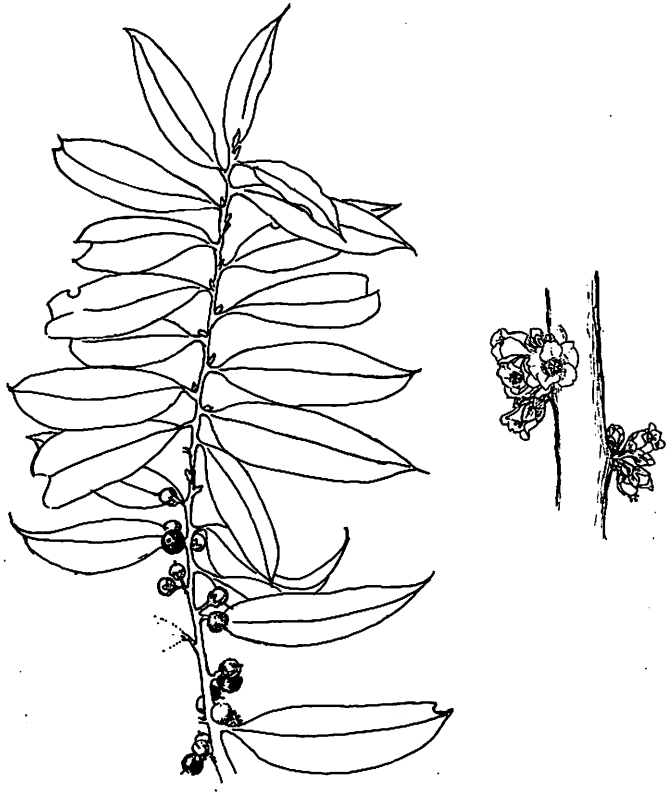
Rather rare is *Archboldiodendron calosericeum* (Fig. 26). Its long leaves retain longitudinal creases from having been tightly tucked into a spike-like sheath when still young. The buff downy spikes are conspicuous at branch tips. Undersides of leaves are varying shades of buff; uppersides dark green, with red midribs. Young leaves may be red. The sessile white flowers look like miniature tea or camellia (single) flowers. Flowers present year-round, along with nut-like fruit.

Much more abundant is *Eurya tigang* (Fig. 27). The genus is enough like tea to be called false tea in some areas. The tiny creamy white or greenish white flowers hug the branches, especially at leaf nodes, the stiff scaly sepals recalling camellias. The spherical fruits, developing at different times, vary from green through maroon to shiny black.

MYRTACEAE **Myrtle Family** **(eucalyptus, etc)**

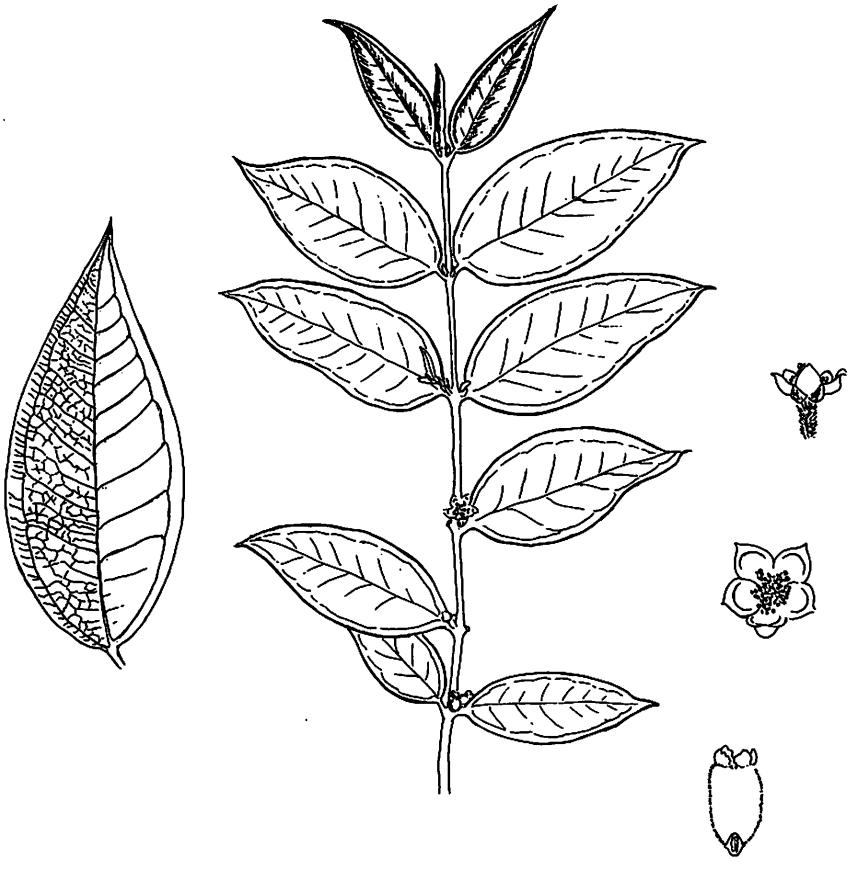
Metrosideros parviflora (Fig. 28) is enough like its Hawaiian cousin 'ohi'a lehua' to make visitors from there feel at home. It has same stiff, twisted gray-green leaves and flowers of same clear red, but more scanty, with fewer stamens (hence *parviflora*). It isn't common; one tree is near the small clearing at the hump on S-end trail, and another at N summit (Helicopter pad).

The Kaindi rose myrtle, *Rhodomyrtus novoguineensis* (Fig. 29), could be the commonest shrub; also one of the most beautifully colored. Young foliage is coppery to red plush or like brushed velvet, from rose at base to



27. *Eurya tigang* Laut. & K.Schm. (Theaceae), with flowers & fruit; x 0.25; detail x 1.0.

28. *Metrosideros parviflora* Wh. (Myrtaceae); x 0.5; detail x 1.4.



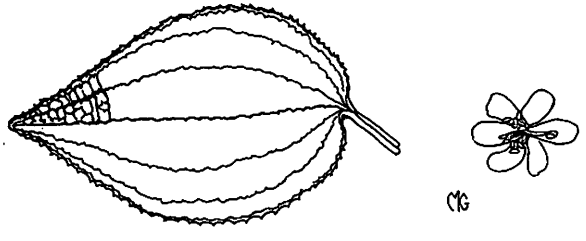
29. *Rhodomyrtus novoguineensis* Diels (Myrtaceae), with flowers & fruit; x 0.4; detail x 1.0.

green at tip. Older leaves are dark green to bluish green, with rusty bloom below and on petioles and twigs. The flowers are relatively inconspicuous but the 5 crisp white petals make a pleasing shape and the many stamens are yellow.

MELASTOMATACEAE **Melastome Family**

Among the few dicot plants whose leaves appear parallel-veined like those of monocots because large veins originate at or near base, are melastomes, pipers, vacciniums plus dimorphantheras, which might be confused with smilax, a true monocot. The first melastome shown here, *Medinilla crassinervis* (Fig. 30) is quite distinctive, indeed fantastic. The large smooth leaves of this shrub are vivid magenta beneath, where veins stand out. Large bracts enclose bases of each pair of leaves. Large maroon panicles bear small white flowers. Another kind, of related habit (probably *Poikilogyne*), has bright pink flowers with yellow stamens, and rugose leaf surfaces (Fig. 31).

30. *Medinilla crassinervis* Bl. (Melastomataceae), with flowers & fruit; x 0.25; detail x 1.0.

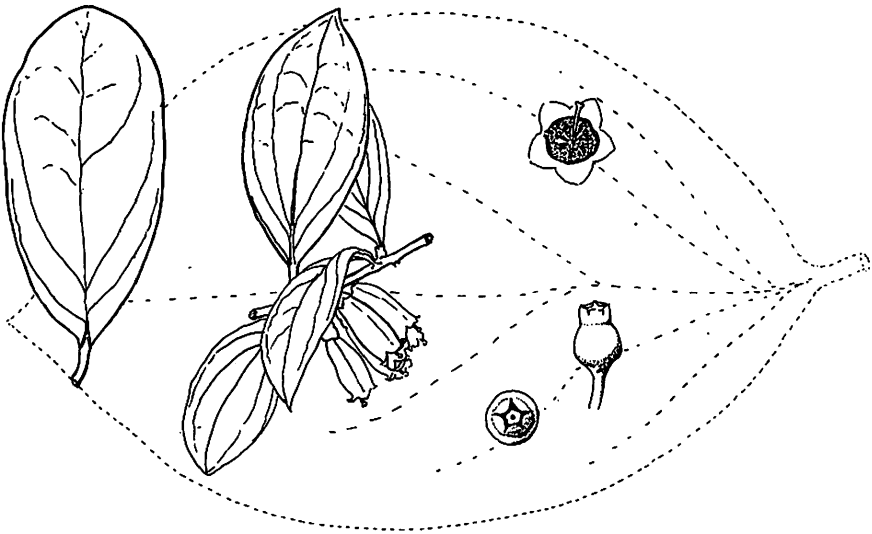


31. *Poikilogyne hirta* Noyer? (Melastomataceae), leaf x 0.5; flower x 1.0.

ERICACEAE **Heath Family** **(heather; blueberry)**

Drawings of 9 species of this family are included because they are among the most exciting flowers newcomers are likely to see in Kaindi summit area, with possible exception of orchids, which may be harder to find. Visitors familiar with azaleas, rhododendrons and vacciniums will recognize many of the following shrubs.

Starting with dimorphantheras, which have been called vacciniums, are some very large-leaved shrubs, sometimes almost vine-like. *Dimorphanthera denticulifera* (Fig. 32) has deep coral pink tubular blossoms, which are waxy and translucent. Leaves are conspicuously subparallel-veined and tend to curl. Petioles and new shoots may be reddish. Twigs bearing flowers are typically stout. Similar, and often growing intertwined with this is *D. ingens* (Fig. 33). Leaves of former are usually pointed and those of latter more often rounded at tips. Blossoms of *ingens* are pale green, with almost no tube, and fruits also differ (see figures). *D. amplifolia* (Fig. 34) drops



32. *Dimorphanthera denticulifera* Sleum. (Ericaceae); x 0.5; detail x 1.0.

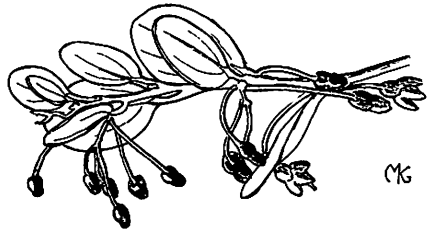
33. *Dimorphanthera ingens* Sleum. (Ericaceae), with flowers & fruit; x 0.5; detail x 1.0.

tiny rose-red corollas along trails, like 5-pointed stars. Calyxes, long pedicels and even twigs are deep crimson. Berries are crimson to black. Leaf is thick and pingpong-paddle shaped, smaller than 2 preceding and less prominently veined.

Vaccinium molle var. *mollissima* (Fig. 35) is common near repeater station. Its leaves are small, crowding up erect branchlets, overlapping like scales, pointed tipped and with margins folding under, and softly pube-

scent, grayish green when mature, rosy on newer shoots. Flowers creamy and fruit greenish. *V. reticulatovenosum* (Fig. 36) has thin leaves, dry and twisted when mature, strongly tapering. The subparallel veining is marked. Slender tubular flowers hang like miniature red bottles from slender pedicels, the pale-tipped tubes never fully open. Buds are distinctly pointed.

Rhododendron gracilentum (Fig. 37) our commonest rhododendron, is hard to see at first, its leaves are so small and slender. Once recognized, it's easily noted all along road cut, on high banks, starting below summit, upward. As with azaleas, the pointed leaves grow in whorls about rusty-looking stems, glossy green and sparsely hairy above, pale green and stippled below. The name is appropriate for the leaf whorls, the miniaturization and the bell-like coral pink blossom, which you will be lucky to see. Ideal for terrarium and dish garden. *R. leptanthum* (Fig. 38) is even more like an azalea in habit and color, though its rose-pink flowers are more tubular. Less common than *gracilentum*; but down power line in Wau direction, at about 3rd power standard, it flourishes on a stump to right of trail. Look and photograph, but do not disturb. *R. herzogii* (Fig. 39) has spectacular long-tubed flowers, white with a touch of brownish rose at base, and with distal petal lobes recurving. Leaves are thick, round and paddle-like, graceful in nearly flat whorls. *R. macgregoriae* (Fig. 40) also has recurved petal lobes; but the tubes are short, and the red pedicels are long and slender. Flowers cluster thickly like those of ixora, golden yellow to pinkish orange or salmon. Leaves tend to fold inward



34. *Dimorphanthera amplifolium* var. *stabilipes* F.v.M. (Ericaceae); with buds & flowers; x 0.7.

35. *Vaccinium molle* var. *mollissimum* Sleum. (Ericaceae); leaves, flowers & fruit; x 1.3.

36. *Vaccinium reticulato-venosum* Sleum. (Ericaceae), with flowers & fruit; x 0.5; detail x 2.0.

37. *Rhododendron gracilentum* F.v.M. (Ericaceae), with flowers & fruit, x 0.6.

38. *Rhododendron leptanthum* F.v.M. (Ericaceae), with flowers & buds; x 0.5.

39. *Rhododendron herzogii* Warb. (Ericaceae), with flowers; x 0.5; detail x 1.0.

40. *Rhododendron macgregoriae* F.v.M. (Ericaceae), with flowers; x 0.75.

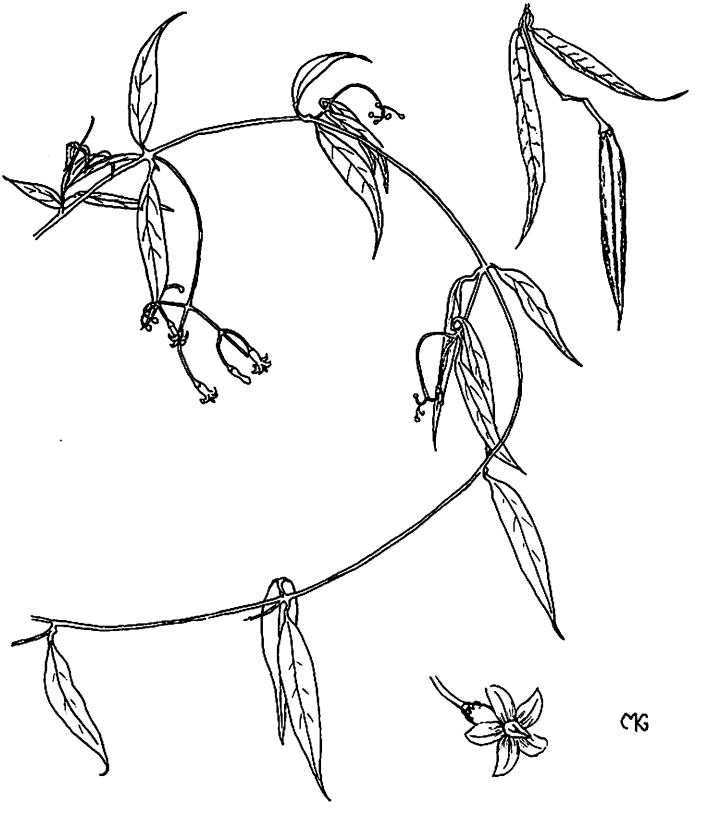
41. *Gaultheria pullei* Sleum. (Ericaceae), with flowers & fruit; x 0.5; detail x 1.0.

from midrib, like those of yellow grassland rhododendrons at lower altitude. Seed pods are long and slender and persist in twisted, untidy bunches long after seeds have scattered. The most sensational rhododendron on Kaindi, *R. konorii*, is not illustrated. It grows as an epiphyte in the tallest tree tops. But in season corollas (11 cm in width) may be found on road or trail – white to pale pink, with some deep rose streaking, carnation-like scent. Look in ditch at first bend in road above Edie Creek turnoff.

Gaultheria pullei (Fig. 41) is a wintergreen: smell a bruised leaf. Some gaultherias do produce commercial oil of wintergreen. Leaf margins are toothed, rare in this family locally. The shiny black fruit lacks the blueberry "crown."

Ericaceous plants seem to like each other's company – or are heavily competing for favorite niche: landslides or other opened-up areas. At edge

of repeater station clearing, on right approaching buildings, is a large *R. macgregoriae*. Around it, with its own progeny, are at least 5 young ericaceous species, including a pink vaccinium, and *V. mollei, V. reticulato-venosum, R. gracilentum* and one which may be a hybrid *gracilentum* x *leptanthum*; also possibly *D. denticulifera*, and others that look like the minute-leaved vacciniums. At the big stump (5) on contour walk are the pink vaccinium, and *V. reticulato-venosum*, and *D. denticulifera* and *ingens* intermingled. At the open area on the hump down the S-end trail (not on numbered walks) are *D. denticulifera, D. amplifolia* and *R. gracilentum* all in close association. *R. gracilentum* often occurs with a small orchid which has burnt orange blossoms that never fully open. If you learn to recognize its succulent rod-shaped leaves you can find additional members of this family not illustrated here.



42. *Parsonsia brassi* Mgf. (Apocynaceae), with flowers; fruit questionably associated; x 0.3; detail x 1.5.

APOCYNACEAE **Periwinkle Family** **(frangipanni; oleander)**

Parsonsia sp. (Fig. 42) is one of Kaindi's prettiest plants, a vine whose slender, curving dark green leaves can be seen almost everywhere as it meanders through the bush, adorning various plants. Visitors from Hawaii are reminded of the maile vine, which is not too distantly related.

BIGNONIACEAE **Bignonia Family** **(jacaranda; gold tree)**

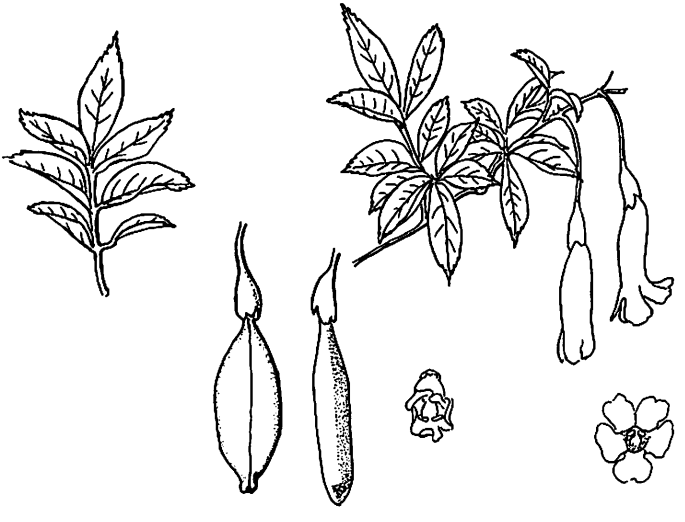
Pandorea montana (Fig. 43). There are at least 3 kinds of vines of this genus on Kaindi, this being most common. Its graceful compound leaves, the leaflets faintly serrate near tips, are nearly as prevalent as *Parsonsia*. With luck and right season, you can see flowers, shading from greenish at base through buff to old rose lobes lined with whitish. Some species have large flowers of bright pink.

GESNERACEAE **Gloxinia Family** **(gloxinia; African violet)**

There are many gesneriads about the summit, mostly with bright red flowers. One can at first glance confuse them with bignonias. However most are quite hairy, some of *Cyrtandra* spp. even having velvety or plush leaf surfaces. The one illustrated, *Aeschynanthus* sp. (Fig. 44) is neither hairy nor red-flowered. Its leaves are glabrous with margins entire; the large pendant flower is deep plum color. Not common, but handsomest.

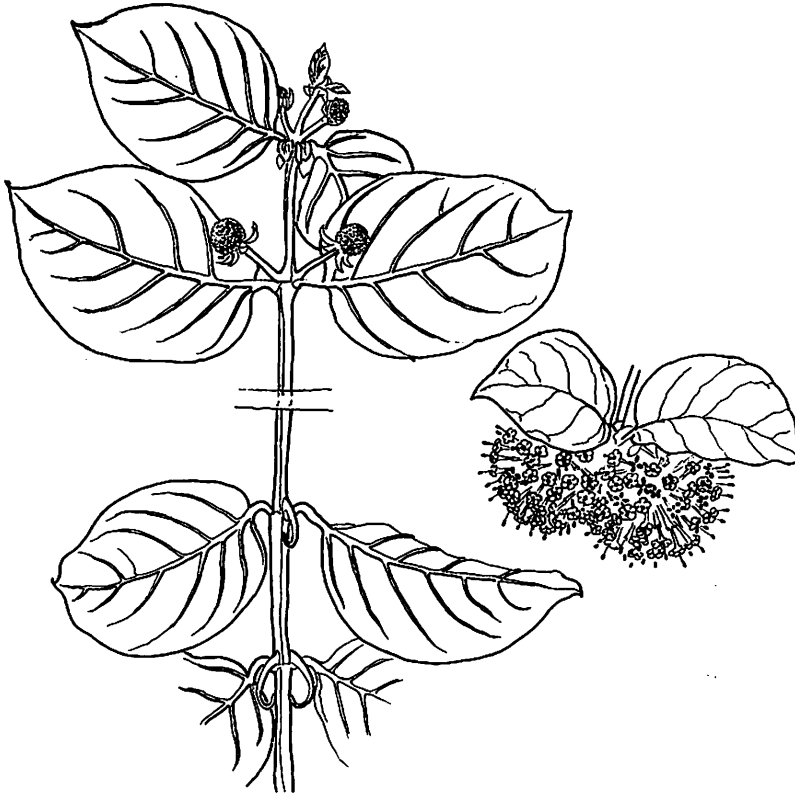
RUBIACEAE **Madder Family** **(coffee; gardenia)**

To demonstrate a member of this family other than coffee, we present the



43. *Pandorea montana* (Bignoniaceae), fruit left, flowers right; x 0.7.

44. *Aeschynanthus* sp. (Gesneriaceae), with flowers; x 0.6.

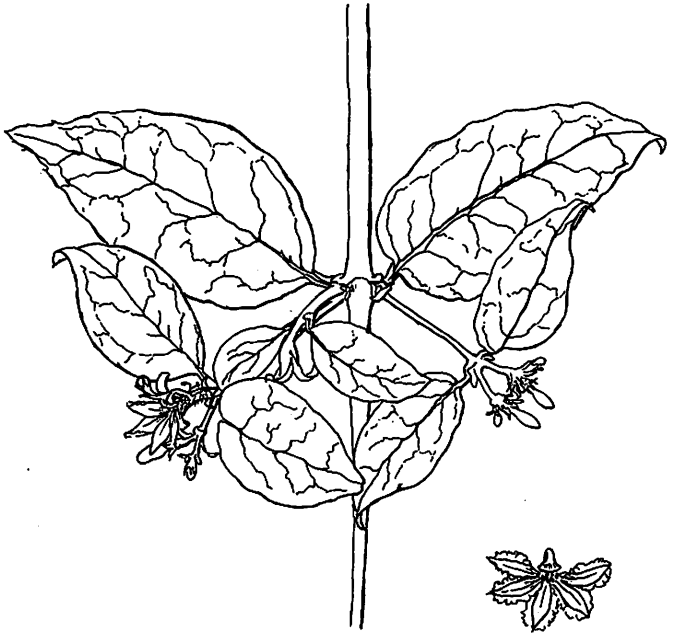


45. *Uncaria* sp. (Rubiaceae), with buds (left) & flowers (right); x 0.5.

distinctive *Uncaria* sp. (Fig. 45). The name means recurved thorn (hook); these are conspicuous at leaf nodes, in pairs. Stem is 4-angled and square in cross-section. Inflorescence recalls Christmas tree ornaments made of spheres of styrofoam stuck with sequins. The Uncaria floral sphere is studded with tiny 5-pointed corollas, like stars. These creamy white corollas drop off at random, leaving the darker calyxes as maroon-colored stars. The flower balls have a strong scent resembling that of hyacinth or bowstring hemp. Younger leaves and new terminal growth are tinged rusty.

GOODENIACEAE **Naupaka Family** **(scaevola)**

The family common name is Hawaiian, and the flowers that look as if cut in half grow on beaches in Hawaii and on many other Pacific islands. Kaindi's only species, *Scaevola oppositifolia* (Fig. 46), a creeper, might be confused at a distance with Uncaria, above. But there is no mistaking *Scaevola's* half flower, which can be seen at any season, unlike the flowers of *Uncaria*. It is also rarely or not at all rusty-tinged; does not have square stems; and no thorns.



46. *Scaevola oppositifolia* R.Br. (Goodeniaceae), with flowers; x 0.6.

PHENOLOGY OF COMMON PLANTS OF SUMMIT AREA

A question of tropical ecology which remains largely unanswered concerns the periodicity of flowering and fruiting of trees. Although easily discernible in temperate regions where climatic extremes cause leaf fall and successful plant reproduction requires a strict flowering schedule, the warm temperatures and lack of a dry season make continuous leaf and flower presence a possibility in the tropics. Only through long-term and continuous observation of individual tree species can the phenology be confirmed.

Flowering and fruiting times of forest trees to a large extent control the regional fauna. Many insect, bird, and mammal species are dependent upon flowers and fruits for nectar and food. Thus, by discovering the times of year when these nutritional sources are available, much can be understood about population changes and life histories of their associated fauna.

The records presented here are admittedly incomplete. They have been collected over a period of several years, some only intermittently. It is hoped that a long-term study of this important aspect will be extended in the future.

Table 13. PHENOLOGY OF COMMON WOODY PLANTS KAINDI SUMMIT AREA

The asterisks refer to flowers and the dots to fruit.

	Ja	Fe	Ma	Ap	My	Je	Jy	Au	Se	Oc	No	De
FAGACEAE												
Nothofagus pullei Steen.											**	..
WINTERACEAE												
Drimys ?dictiophlebia Diels				**	..			**	**	**	..	**
MONIMIACEAE												
Palmeria ?arfakiana Becc.	**			**	..				**			
Trimenia papuana Ridl.						**	**	**	**		**	
CUNONIACEAE												
Spiraeopsis sp.		**						**		**	**	**
ROSACEAE												
Prunus sp.									**			
Rubus moorei F.v.M.	**	..						**	..	**	**	**
rosaefolius L.	**	**		**	**	**		**	**	**		
fraxinifolius Poir.	**	**	**		**	**	**	**	**			
RUTACEAE												
Acronychia papuana Gibbs	**		..	**		**		**	**			
Evodia (thick shiny leaves)	..								**	**	**	
(thin pale leaves)	..	**	..		**	**		**	**	**		
Melicope	..	..	..			**	**	..	..			
Evodiella		**	..		**	..						
EUPHORBIACEAE												
Homalanthus sp.	**	**	**		**	**		**	**			
Macaranga sp.					**			**	..			
AQUIFOLIACEAE												
Ilex sp.									**	..		

	Ja	Fe	Ma	Ap	My	Je	Jy	Au	Se	Oc	No	De
RHAMNACEAE												
Alphitonia incana (Roxb.) T. & B.	..	**	..	..	..	..	..	..	**	**	**	
ELAEOCARPACEAE												
Elaeocarpus sp.										**		
Sericolea sp.	..			..	..			**	**	**		
SAURAUIACEAE												
Saurauia sp (rough)	**	**	**					**	**			..
sp. (smooth)								**	**			
OCHNACEAE												
Schuurmansia henningsii K.Sch.	**									**		
THEACEAE												
Archboldiodendron calosericeum	**	**	**	**	**	**	**	**	**	**	**	**
Eurya tigang Laut. & K.Sch.	**	**	**	**	..	..	..	..	**	..		**
MYRTACEAE												
Decaspermum ?neurophyllum Laut. & K.Sch.			**		..			**	**	**		
Mearnsia cordata Wh. & Fr.							**			**		
Metrosideros parviflora Wh.	**	**			**				**	**	**	**
Rhodomyrtus novoguineensis Diels	**	**	**	**	**	**	**	**	**	**	..	**
MELASTOMATACEAE												
Medinilla ?crassinervis Bl.		**	**			**	**	**	**			
Poikilogyne ledermannii Mansf.	**	**	**	..	**			**	**	..		
ARALIACEAE												
Schefflera elliptica (Bl.) Harms									**			
Polyscias forbesii Baker f.			..		**	**	**	**	**	**		
ERICACEAE												
Dimorphanthera denticulata Sl.				**	..							
kempteriana Sl.	**					**	**			**		
ingens Sl.	**	**	**	**	**	..	**	**	**	**	..	

	Ja	Fe	Ma	Ap	My	Je	Jy	Au	Se	Oc	No	De
amplifolium F.v.M.		..			**		**	**	**	**	**	**
Vaccinium												
mollissimum Sl.	..	**	..				**	**	**		**	**
reticulatovenosum Sl.		**	**						..		**	
Rhododendron gracilentum F.v.M.		**					**		**	**	..	**
leptanthum F.v.M.			**						**	**		
herzogii Warb.												**
macgregoriae F.v.M.		..	**	..		**			**	**		
superbum Sl.	**											
Gaultheria pullei J.J.Sm.		..	**						**	**		
MYRSINACEAE												
Rapanea vaccinioides Kan. & Hats.		..	..					**	**	**		**
SYMPLOCACEAE												
Symplocos sp.										**		
APOCYNACEAE												
Parsonsia lata Mgf.								**	**	..		
BIGNONIACEAE												
Pandorea montana	**	**	**					**	**	**		
GESNERACEAE												
Aeschynanthus pachyanthus Schltr.									**	**		
Cyrtandra sp. (red)				**	**		**	**	**			**
RUBIACEAE												
Psychotria sp.									**			
Timonius sp.									**			
Uncaria sp.		**	**	**	**							
GOODENIACEAE												
Scaevola oppositifolia R.Br.	**	**	**	**	**	**	**	**	**	**	..	

FAUNAL ANALYSIS

The following sections on fauna are quite unbalanced and do not give a synthesis or equivalent information. Some of the lists represent only common or larger species, while others are fairly complete. Knowledge of the insects and most other invertebrate groups is such that few useful lists or comments can be presented at this time. Partial insect lists, such as might be extracted from taxonomic papers including many records from Mt Kaindi, have not been attempted here. Rather, tentative lists are presented for some spiders, beetles, moths and butterflies. These are largely presented through the kindness of P. Mackey, J.C.E. Riotte, M. Robinson and T. Davies. Collections of all groups from Kaindi are in Bishop Museum in Honolulu, made during New Guinea-wide surveys from 1955 to 1971. The surveys were based at Wau during the period of the Bishop Museum Field Station, 1961–1971. The majority of insect groups from those collections have still not been studied, but identified duplicates are being returned to WEI and to the Papua New Guinea National Museum in Port Moresby (or Konedobu D.P.I. collection) as studies are completed.

The lists for vertebrates (none included for fish) are more complete than those for insects, or at least than those other than butterflies. Some of them are based on work by various people, but principally by J. Menzies, A. Allison, T. Pratt, B. Beehler, Abid Beg Mirza and A. Ziegler.

The fauna of Kaindi is highly diverse. The diversity is closely related, for many groups, with the complexity of structure of the vegetation in the ecosystems. For many groups, in this mid-montane environment, it appears that species diversity is greater than in low altitude forests and than in subalpine or upper montane environments. The latter contrast is probably real, but the suggested contrast with lowland forest requires further comparisons. Certainly insects are conspicuous at low altitudes, but this is partly because many of the larger and more aggressive species occur near sea level and rarely above 500 m altitude. However, the greatest concentration of endemic species, and perhaps also the greatest diversity of species, seems to occur in the lower and mid-montane zones.

Although animal species diversity is greater where the forests are more complex, this does not necessarily mean that numerous species will be observed on entering such forests. On the contrary, most new visitors to such an area will be greatly disappointed and puzzled at the quiet and apparent lack of animals and activity within the dense shady forests. Considerable experience is required before the diversity can be really appreciated. This can be partially explained by pointing out that much activity, especially with mammals, is at night; that populations in many groups are actually low and thinly spread over large areas; and that many of the insects are under the humus, or feeding on or in high branches, and that most adult insects plus the birds feeding upon them are primarily in the canopy associated with flowers, fruit and new leaf growth. In general, more insects and various others may be found at the edge of the forest and where there has been disturbance such as felling of trees by natural or artifical means.

SPIDERS

Dr Michael Robinson and colleagues of the Smithsonian Tropical Research Institute have found, while studying at WEI over extended periods, that spiders, and other animals, are not only diverse on Kaindi, but carry on activities more or less throughout the year. However, activities are not uniform month to month, and relate mainly to timing of rainfall extremes, but also to other variables. They concluded that high species diversity is related to biological accommodation resulting from sustained coexistence of species in a tropical area; and that diversity of habitat structure favored species diversity, but that the predictable benign environment at Wau throughout the year was most significant in contributing to the high local species diversity. Following is a condensed list of spiders studied at Wau (1100–1400 m). (after Robinson, Lubin & Robinson).

	Known extra-New Guinea Range
Araneidae	
Cyclosa insulana (Costa)	Europe, N. Africa, Asia
bifida (Doles.)	SE Asia
Gasteracantha theisi Guerin	SE Asia, Polynesia, Australia
taeniata (Walck.)	S. Asia, Polynesia, Australia
brevispina Doles.	SE Asia + ?
sp.	–
Argiope aemula (Walck.)	S. Asia, Australia
picta L. Koch	Indonesia, SW Pacific, Australia
reinwardti (Doles.)	SE Asia, Australia
trifasciata Forskal	Asia + ?
aetheria (Walck.)	S. Asia + ?
Nephila maculata (F.)	Africa, S. + E. Asia
Araneus theisi (Walck.)	Africa, Asia, Australia, N. America
laglaizei (Simon)	S. Asia
spp.	–
Cyrtophora moluccensis	SE Asia + ?
monulfi	SE Asia + ?
Poltys illepidus C.L. Koch	?
Tetragnathidae	
Tetragnatha sp.	–
Leucage papuana Kulcz.	Malaysia
grata (Guerin)	Malaysia, Polynesia
Psechridae	
Psechrus argentatus (Doles.)	S. Asia, Bismarcks
Fecenia nr *angustatus*	–
Pholcidae	
?*Pholcus* sp.	–
Linyphiidae	
Linyphia sp.	–
Theridiidae	

Free-living spp. –
Kleptoparasites –

MOTHS

This list comprises primarily larger species, usually spoken of as macrolepidopterans. These were mostly collected and identified by Dr and Mrs J.J.H. Szent-Ivany and by Peter Mackey, but the Sphingidae and Saturniidae were identified by Father J.C.E. Riotte of Bishop Museum, who also kindly transcribed the Szent-Ivany identifications. To these lists are added a few species, partly microlepidopterans, of vegetable insects reared by Dr W. Gagné and Mr G. Nalu in the WEI grounds. Principal surveys were made at top and bottom of Kaindi, so only 2 altitudes are indicated, by numbers as follows:

1 = 1200–1350 meters
2 = 2362 m
3 = both 1 and 2

Anthelidae	*Cycethra angiana* Joicey 1	*Anthela eheikei* B.-Bkr 3
Arctiidae	*Asuridia decussa* B.-Bkr 1	*Asura basitesselata* Roths. 1
	Asura melitaula Meyr. 1	*wandammensis* J. & T. 1
	Micrilema bipunctata B.-Bkr 2	*Oenistis bistrigata* Roths. 2
	Maenas avola B.-Bkr 3	*Diacrisia alberti* Roths. 2
	Diacrisia niceta Stoll 1	*kebea* B.-Bkr 1
	owgarra B.-Bkr 1	*ochrifrons* Joicey 1
	Rhodogastria caudipennis Walk. 3	*Rhodog nigropunctata* B.-Bkr 3
Bombycidae	*Elachophthalma goliathina* Roths. 2	*Elach. kebeae* B.-Bkr 1
Drepanidae	*Argodrepana marilo* Wilk. 2	*Argo. verticata* (Warr.) 1
	Hyalospecta diaphana Warr. 2	*Teldenia inanis* Wilk. 1
	Teldenia nigrinotata Warr. 1	*pura* Warr. 1
	specta Wilk. 1	*Tridrepana fulvata* Snell. 1
	Tridr. mediata Warr. 1	*Callidrepana argenteola* (Moore) 1
	Callidr. discipunctata Warr. 2	*superba* Warr. 1
	Campylopteryx fleximarga (Warr.) 1	*Urogonodes scintillans* (Warr.) 1
	Oreta jaslidea (Warr.) 1	*Oreta singapura* Swin. 1
	Psiloreta patiens (Warr.) 2	
Epiplemidae	*Epiplema candidaria* (Walk.) 1	*Epipl. coeruleotincta* Warr. 1
	conflictaria Walk. 1	
Eupterotidae	*Tagora styx* B.-Bkr 2	
Geometridae		
Oenochrominae	*Dicyclodes hieroglyphica* Warr. 3	*Thamatographe singularis* Warr. 3
	Eumelea genuina Kirsch 11	*Eumel. unipuncta* Warr. 1
	Derambila aetherialis (Butl.) 1	*Alex continuaria* (Walk.) 1
	Ozola macariata (Walk.) 1	*Celerana connexa* Walk. 1
Hemitheinae	*Pingasa angulifera* Warr. 1	*Ping. blanda* (Pagen.) 1
	chlora Stoll 1	*meeki* Warr. 1
	nobilis Prout 1	*venusta* Warr. 1
	Hypodoxa semiliaria (Guen.) 1	*Hypod. leprosa* (Warr.) 2
	Aeolochroma albifusaria (Walk.) 1	*Aeolo. amethystina* (Warr.) 2
	languida (Warr.) 1	*purpurissa* (Warr.) 2
	saturataria (Walk.) 2	*subrubella* (Warr.) 1
	viridimedia Prout 1	*Dysphania tentans* (Walk.) 1

Agathia asterias Meyr. 1
prasinaspis Meyr. 1
Tanaorhinus unipuncta Warr. 1
melanomma Warr. 1
Ornithospila psittacina (Feld.) 1
Aniso. albifusa (Warr.) 1
albinata (Warr.) 3
commaculata (Warr.) 2
diazeuxis Prout 1
exililinea (Warr.) 2
iridescens (Warr.) 3
orbimaculata (Warr.) 1
stellifera Prout 3
aphrias (Meyr.) 1
Uliocnemis cassidara (Guen.) 1
Agathiopsis basipuncta Warr. 1
Comibaena inductaria (Guen.) 1
Celasma atrapophanes Prout 1
nr commixta (Warr.) 2
orthodesma (Lower) 1
Thalassodes interalbata Prout 1
Prasinocyma annexa Prout 2
caniola (Warr.) 1
fragilis (Warr.) 1
latistriga (Warr.) 2
periculosa (Warr.) 1
punctulata (Warr.) 1
seminivea (Warr.) 2
ultima Prout 2
venata Prout 2
Strep. remissa Prout 1
Gigantothea gigas (Warr.) 1
Oenospila flavifusata (Walk.) 1
Metallo. lineata Warr. 1
neomela (Meyr.) 1
Episothalma obscurata Warr. 1
Diplodesma celataria (Walk.) 1
Berta fenestrata Prout 1
Comos. rufimargo Warr.
Pyrrhorachis pyrrhogona Walk. 1

Sterrhinae

Chrysocraspeda callima B.-Bkr 1
dinawa B.-Bkr 1
flavimacula Prout 1
praegriseata Warr. 1
Gnamptoloma aria Prout 1
Anis. epicocastria Prout 1
illepidaria Guen. 1
nigricosta (Warr.) 1
rufiplaga (Warr.) 3
Problepsis appolinaria Guen. 1
transporita Warr. 1
Antitrygodes parvimacula Warr. 1
Agath. conjunctiva Warr. 1
Alloeopage cinerea (Warr.) 1
Dioscore fulgurata (Warr.) 3
thalassias (Warr.) 1
Anisozyga absona (Warr.) 1
albilauta (Warr.) 1
beetrix Prout 3
decorata (Warr.) 3
diversofimbria Prout 1
gracililinea (Warr.) 2
lithocrossa (Meyr.) 1
rufipunctata (Warr.) 3
veniplaga (Warr.) 2
Chloromachia pulchella (Warr.) 1
Ulio. partita (Walk.) 1
Agath. maculata Warr. 1
Comib. viridifimbria (Warr.) 2
Gelas. balteata (Warr.) 2
eumixis (Prout) 1
submixta Prout 1
Thal. nivestrota Warr. 1
Pras. bicolor (Warr.) 2
discoprivata Prout 2
glauca (Warr.) 2
nivisparsa (Butl.) 1
perpolluta Prout 1
rhodocosma (Meyr.) 1
syntyche Prout 1
vagabonda (Warr.) 3
Strepsichlora nubifera (Warr.) 1
Oxychora batis (Warr.) 1
Gigan. minor (Warr.) 1
Metallochlora decorata (Warr.) 1
meeki Warr. 1
venusta (Warr.) 1
Episo. sequestrata Prout 1
Berta capiosa Prout 1
Comostola flavifimbria Warr. 1
chlorargyra (Walk.) 1

Chryso. concentrica Warr. 1
euryodia Prout 1
inundata Warr. 1
uncimargo Warr. 1
Anisodes aurora (Warr.) 1
festiva (Warr.) 2
jocosa (Warr.) 1
pauper Butl. 1
Bytharia marginata Walk. 1
Probl. magna Warr. 1
Nobilia aphrodite Prout 1
Scopula ?hypochlora Meyr 1 (Chinese cabbage)

Larentiiae

Gonanticlea semiflava Warr. 2
Spectr. nr *maligna* Warr. 1
Ecliptopera sagittatoides (Pag.) 1
Horisme xylinata Warr. 1
Chloro. seminotata Warr. 1
Mariaba semifascia (Warr.) 1
Sauris aroensis (warr.) 2
Asthena papuensis (Warr.) 1
Hydrelia flavidula (Warr.) 3
Nomenia hebe (B. -Bkr) 1

Ennominae

Tolmera albibasalis Warr. 2
marcenses Warr. 2
Petelia medardaria Herr. -Sch. 1
Sabaria semifulva (Pag.) 1
Idiodes unilinea (Warr.) 1
Polyacme straminea (Warr.) 1
Garaeus papuensis Warr. 1
Bulonga griseoserica Prout 1
Fascellina papuensis Warr. 1
Euotea heteroneurata (Guen.) 1
Semi. funebris (Warr.) 1
Ectropis abducta Warr. 1
sabulosa Warr. 1
Buzura recursaria (Walk.) 1
Rutt. ochroocosta (B. -Bkr) 1
Para. purpurea (Warr.) 1
xylinopa Meyr. 1
Racotis maculata (Luc.) 1
Elphos subrubida Warr. 1
Alcis papuensis Warr. 3
Cleora compectinata Warr. 2
hospita Prout 1
perfumosa extendata Fl. 1
repetita Butl. 1
semidiscoida Warr. 2
transinuata Warr. 1
Luxiaria submonstrata (Walk.) 1
Ascotis margarita (Warr.) 1
Plectoneura albida Warr. 1
Lomographa lucifera (Warr.) 1
Eugnesia lyparemprix Prout 1
sordidata Warr. 2
Casbia albinotata Warr. 1
carmeocostata Warr. 1
vulpina (Warr.) 1
Aryc. flexilinea (Warr.) 1
infans Warr. 1
obsolete (Warr.) 1
Cosmethis rosenbergi (Pag.) 1
Euchar. labyrinthodes Prout 2
Craspedosis aurigutta Warr. 1
ernestina (Stoll) 1
Ctimene basistriga (Walk.) 1
Pseudeudesmia bursadoides Warr. 1
Spectrobasis nr *conferens* Pr. 2
Crasilogia dispar Warr. 2
Horisme disrupta (Warr.) 2
Chloroclystis dentifera (Warr.) 2
Calluga gyroducta Fletch. 1
Phthonoloba definita (j. & T.) 1
Asthena argentipuncta Warr. 3
Bihastina viridata (Warr.) 2
Poecilasthena paucilinea Warr. 2

Tolmera exuberans Prout 2
sordida Warr. 2
Eurychoria oenophila Prout 2
Idiodes robusta Warr. 1
Xylinophila maculata (Warr.) 1
Anisographe dissimilis Warr. 1
Kranandra extranotata Prout 1
Oxymacaria ekeikei B. -Bkr 1
Euippe undulateria (Pag.) 1
Semiothisa drepanata (Rot.) 1
goramata (Röber) 1
Ectr. pallidistriga Warr. 1
Iulotrichia semiumbrata Warr. 1
Ruttelerona lithina (Warr.) 3
Paradromulia lacta (Warr.) 1
subdivisa Warr. 3
spp. (11 x 1; 1 x 2)
Apophyga griseiplaga Warr. 3
Xerodes albisparosa (Warr.) 1
Cleora callicrossa Meyr. 1
costiplaga Fletch. 1
onycha Fletch. 1
perlepidaris (Warr.) 1
sabulata Fletch. 1
tenebrata fumata Flet.
Boarmia infaustaria Walk. 1
Paralcidia subnivosa Prout 2
Myrteta cymodegma Prout 1
Bapta homographata Warr. 2
Borbacha carneata Warr. 1
Eugn. parattelaria Warr. 1
Synegia decolorata Warr. 1
Casbia asinina (Warr.) 2
scardamiata Warr. 1
Arycanda alternata Warr. 3
frittillaria Warr. 1
hypanis tenuisignata Pr. 1
umbrilinea Warr. 1
Eucharidema aroensis (Roths.) 2
Bracca ribbei (Pag.) 1
Cras. costimaculata Warr. 2
purpurea Warr. 1
Ctimene hyaloplaga (Warr.) 1
Pseud. longimacula (Warr.) 1

	Bursadopsis apicipuncta Warr. 1	*Eubordeta miranda* Roths. 2
	Eubor. eichhorni Roths. 1	*meeki amynta* Prout 2
	Stenocharta nr flavicollis Warr. 2	*Plutodes polygnampta* Prout 1
	Plut. separata Warr. 2	*signifera Warr.* 1
	Hyposidra ?talaca Walk. 1 (Snakebean, Custard apple)	*Hypo. incomptaria* Walk. 2
	Milionia mediofasciata Roths. 1	*Milio. dohertyi* Roths. 1
	grandis Druce 1	*paradisea* Jord. 1
	aglaia Roth. & Jord. 1	*isodoxa* Prout 1
	callima Roth. & Jord. 1	
Gracillariidae	*?Caloptilia* sp. 1 (Wingbean)	
Hypsidae	*Agape leonina* Butler 1	*Neochera dominia* Cramer 1
	Asota plana Walk. 1	*Asota heliconia* L. 1
	caricae F. 1	*versicolor* F. 1
	Nyctemera baulus Boisd. 1	
Limacodidae	*Doratifera vulnerans* Lewin 1	*Lasiochara pulchra* B. -Bkr 1
	Hydrocladia antigona 1	*Iragoides crispa* Swinhoe 2
Lymantriidae	*Euproctis lutearia* B. -Bkr 1	*Eupr. luteomarginata* B. -Bkr 1
	pratti B. -Bkr 2	*apatetica* Coll. 2
	sp. 1 (on Broccoli)	*Lymantria nova-guinensis* B. -Bkr 1
	Lymantria kebeae B. -Bhr 2	*Dura niveus* B. -Bkr 2
	Dasychira mendosa Hubn. 3 (on Eggplant)	*Dasy. horsfieldii* Saund. 1
	kendricki B. -Bkr 2	*Dasychiroides pratti* B. -Bkr 1
Lyonetiidae	*Leucoptera* sp. 1	
Noctuidae		
Noctuinae	*Agrotis interjectionis* 1 (Tomato)	*Agrotis pediciliata* Prout 2
	debeae B. -Bkr 2	
Heliothinae	*Heliothis armigera* (Hυγn.) 3	*Hel. assulta* Guen. 1 (Onion, Sunflower)
	punctigera Wllgr. 1 (Pea, Maize, Tomato, Lettuce, Sunflow.)	*Spodoptera exempta* (Walk.) 1 (Pea, Sunflower, Kohl-Rabi)
	Spod. litura (F.) 2	
Hadeninae	*Elusa pratti* B. -Bkr 1	*Dasygaster albiviata* Hamps. 1
	Tiracola plagiata Walk. 3 (on Banana)	*Tira. rufimargo* 1 (on Apple)
	Mythimna loreyi Dupon. 1	*Myth. yu* Guen. 1
	decisissima Walk. 2	*?Sideris* sp. 1 (on Carrot)
Acronictinae	*Perigea prodita* Walk. 1	*Peri. illecta* B. -Bkr 1
	incertissima B. -Bkr 2	*Elydna bipuncta* Snell. 1
	Elydna pratti B. -Bkr 1	*Magusa tenebrosa* Moore 2
	Euplexia novaeguineae B. -Bkr 2	*Euplex. complicata* Warr. 2
	Cordylepalpa calochroa Hamps. 2	*Cordyl. monogramma* J. & T. 2
	Craniophora fasciata Moore 2	
Eutelinae	*Eutelia olivaceiplaga* B. -Bkr 1	*Bombotelia jocosatrix* Guen. 2
Stictopterinae	*Stictoptera describens* Walk. 2	*Stict. cuculoides* Guen. 2
	melanistis Hamps. 2	*atrifera* Hamps. 2
	bakeri Prout 2	*swinhoei* B. -Bkr 2
Sarrothripinae	*Macrobarasa xantholopha* Hamps. 2	*Gadirtha exacta* Semp. 1
	Ochthophora sericina Turn. 1	*Risoba avola* B. -Bkr 1
Chloephorinae	*Aiteta subflava* B. -Bkr 2	*Carea pratti* B. -Bkr 2
	Paracarea rubigenea B. -Bkr 2	*Maceda ignefumosa* Warr. 2
	Maurilia iconica Walk. 2	*Xanthodes transversa* 1 (Okra)
Plusiinae	*Plusia albostriata* Brem. 1	*Plusia kebeae* B. -Bkr 1

	orichalcea F. 2	*Chrysodeixis chalcites* Esp. 2 (on Khol-Rabi)
Catocalinae	*Ulotrichopus dinawa* B. -Bkr 2	*Anua sublutea* B. -Bkr 2
	Achaea janata L. 2	*Mocis frugalis* F. 1
	Mocis trifasciata Steph. 1	
Ophiderinae	*Sypna avola* B. -Bkr 2	*Catephia sericea* Butl. 1
	Cateph. leucomelas L. 2	*Isoura pratti* B. -Bkr 1
	Leistera splendens B. -Bkr 2	*Leist. hampsonia* B. -Bkr 2
	pulchristigata B. -Bkr 2	*Anomis sabulifera* Guen. 1
	Anomis ?flava 1 (on Okra)	*rufa* B. -Bkr 2
	strigocrenulata B. -Bkr 2	*Ericeia rhanteria* B.-Bkr 2
	Eric. setosipedes B. -Bkr 2	*Axiocteta turneri* B. -Bkr 2
	Axioc. obliqua B. -Bkr 1	*Hulodes hilaris* Prout 2
	Athyrma pulcherrima Butl. 2	*Hamodes propitia* Guen. 1
	Oxyodes ochreata Roths. 1	*Pseudozalissa bella* B. -Bkr 2
	Hypocala violacea Butl. 2	*Paragonitis rufa* B. -Bkr 2
	Lacera alope Stoll 2	*Episparis angulatilinea* B. -Bkr 2
	Phytometra orichalcaea (F.) 1 (Parsley, Coriander, Dill, Sunflower, Lettuce, Turnip, Bruss. Sprouts)	
	Anticarsia irrorata 1 (Mungbean)	
Hypeninae	*Simplicia kebeae* B. -Bkr 1	*Hypena inconspicua* Snell. 1
	Chasmina tibiopunctata B. -Bkr 1	
Notodontidae	*Cascera bella* B. -Bkr 1	*Casc. olivacea* Roths. 1
	Stauropus chloridolus J. & T. 2	*Staur. viridigriseus* Roths. 2
	leucophaeus Roths. 2	*Damata varians* Walk. 1
	Drymonia mediogrisea Lemp. 2	*Desmeocraera purpurascens* Roths. 2
	Chadisra striata Roths. 1	*Pygaera rubida* Druce 2
	Ortholomia moluccana Feld. 1	*Omionlis strigata* B. -Bkr 2
Saturniidae	*Syntherata janetta* (White) 1	*Opodiphtera albicera* Roths. 2
	Opod. strigata B. -Bkr 2	
Plutellidae	*Plutella sera* Meyr. 1 (Chinese Cabbage, Turnip)	*Plut. xylostella* (L.) 1 (Cabbage, Turnip, Broccoli)
Pyralidae	*Crocidolomia binotalis* (Zell.) 1 (Cabbage, Kohlrabi, Broccoli, Turnip, Radish)	*Hymenia recurvalis* F. 1 (Spinach, Silverbeet, Chinese Cabbage)
	Lamprosema ?indica F. 1 (Pea, Peanut, Soybean, other beans)	*Maruca testulalis* Gey. 1 (Soybean)
	Ostrinia furnacalis (Guen.) 1 (Maize)	*Sylepta derogata* (F.) 1 (Okra)
	Tirathaba ?rufivena (Warr.) 1 (Guava)	
Sphingidae	*Agrius luctifera* (Walk.) 1	*Agrius convolvuli* (L.) 1 (Sweetpotato)
	Megacorma obliqua (Walk.) 1	*Psilogramma menephron* (Cram.) 1
	Psilo. incerta (Walk.) 1	*Oxyambulyx liturata* (Butl.) 1
	Oxy. wildei (Miskin) 1	*dohertyi* (Roths.) 1
	jordani B. -Bkr 1	*phalaris* Jord. 1
	Cypa decolor (Walk.) 1	*Cephonodes rothschildi* Rebel 1
	Gnathothlibus erotus (Cram.) 1	*heliodes* (Meyr.) 1
	meeki (Roths.) 3	*Deilephila dohertyi* (Roths.) 3
	Deilephila hypothous (Cram.) 3	*placida* (Walk.) 1
	protrudens (Feld.) 3	*Acosmeryx anceus* (Stoll) 1
	Acosmeryx miskini (Murr.) 1	*Panacra micholitzi* Roths. & J. 1
	Panacra splendens (Roths.) 1	*Angonyx papuana* Roths. & J. 1
	Macroglossum calescens (Butl.) 1	*Macro. spilonotum* Roths. & J. 2
	stevensi B.P. Clark 3	*Hippotion velox* (F.) 3

	Hippotion celerio (L.) 1 (Taro)	*boerhaviae* (F.) 1
	depictum Dup. 1	*brennus* (Stoll) 3
	johanna (Kirby) 2	*Theretra nessus* (Drury) 3
	Theretra rhesus (Boisd.) 1	*polistratus* (Roths.) 1
	indistincta (Butl.) 1	*celata* (Butl.) 1
	tryoni (Misk.) 1	*oldenlandiae* (F.) 1
	silhetensis (Walk.) 1	*brunnea* (Semp.) 1
	Cechenena helops (Walk.) 1	
Thyatiridae	*Horithyatira delattini* Werny 2	*Habrona brunnea* B. -Bkr 2
	Habrona trimacula Gaede 2	*papuata* Warr. 2
Thyrididae	*Betousa dilecta* Walk. 1	*Oxycephina theorina* Meyr. 1
Tortricidae	*Adoxophyes* sp. 1 (Okra, Sugar Pea) Unidentified sp. 1 (Cucumber)	
	Homona coffearia Niet. 1 (Soyben, Pea, Peanut, Okra, Cucumber, Sunflower)	
Uraniidae	*Nyctalemon patroclus* (L.) 1	*Pseuomicronia justaria* (Walk.) 1
	Micronia pardata (Warr.) 2	*Micron. caudiferaria* Boisd. 1
	multistrigaria Warr. 1	*semiobsoleta* (Warr.) 3
	swinhoei (Joic.) 1	*albisecta* Warr. 2
	strigifera Roths. 2	
Zygaenidae	*Herpolasia augarra* Roths. 2	

BUTTERFLIES

This list was kindly supplied by Thomas Davies of the California Academy of Sciences, and is based on considerable collecting at various altitudes on the slopes of Mt Kaindi. The main areas of collecting do not coincide with the transect used in the Earthwatch projects. However, the altitudinal stratification is rather clearly documented in the records, here united in a single table from separate lists. The lower altitudes recorded relate to Big Wau Creek and Little Wau Creek, at the same altitude range as the lower parts of the WEI grounds and just to the east of the foot of Mt Kaindi, on the same (S) side of the Wau Valley. Little Wau Creek forms the bottom of the E to SE slope of Kaindi. Kunai Creek drains much of the NE slope of Kaindi. Namie (Nami) Creek drains part of the north slope, just west of the Kunai Creek drainage. Maori Creek and Blue Point are in the area of the N slope, near and above the Edie Creek Gorge. Merri Creek and the portion of the Edie Creek Goldfields sampled are on the W side of the summit of Kaindi.

Sampling Zones, with altitudes in meters :	Big Wau, Little Wau to WEI 1100–1200	Kunai Creek 1300–1500	Nami Cr. 1600–1700	Maori, Blue Pt 1800–1850	Merri, Edie, Summit 2000–2362
PAPILIONIDAE					
Ornithoptera priamus poseidon Doubl.	*		*		
Troides oblongomaculatus papuensis Wall.	*				
Pachliptera polydorus lascarus Fruhs.	*				
Papilio ulysses autolycus Feld.	*				
euchenor euchenor Guer.	*				
a. ambrax Boisd.	*				
aegeus ormenus Guer.	*				
fuscus indicatus Butl.	*				
laglaizei Dep.	*	*			
Graphium aristeus parmatus Gray	*				
w. wallacei Hew.	*				
agamemnon ligatus Roths. (Anona, Avocado)	*				
euryplus lycaonides Roths.	*				
macfarlanei Butl.	*				
codrus medon Feld.	*				
sarpedon choredon Feld.	*				
weiskei Ribbe		*	*	*	*
thule Wall			*		
PIERIDAE					
Leuciacria acuta Rthsch & Jord.	*	*	*		
Elodina hypatia mulliercula Fruhs.	*				
Delias e. enniana Rthsch.	*				
l. ladas Grose-Sm.	*	*	*		*
g. geraldina Grose-Sm.	*				
i. isocharis Roths & Jord.	*	*	*	*	*
i. subsp?			*		

	1100–1200	1300–1500	1600–1700	1800–1850	2000–2362
mysis onca Frhst.	*				
ennia xelianthe Sm.	*				
gabia zarate Grose-Sm.	*				
m. mavroneria Fruhs.	*				
sagessa Fruhs.		*	*	*	*
microsticha terranea Talb.		*	*	*	*
hypomelas rawlinsoni Talb.		*	*	*	*
pheres endela Jord.		*	*	*	*
a. aroae Ribbe		*	*	*	*
nais entima Jord.		*	*	*	*
w. weiskei Ribbe		*	*	*	*
iltis luctuosa Jord.		*	*	*	*
k. kummeri Ribbe		*	*	*	*
l. ligata Roths. & Jord.		*	*	*	*
m. meeki Roths.		*	*	*	*
niepelti Ribbe		*	*	*	*
cuningputi aemula Jord.			*	*	*
e. eichhorni Roths. & Jord.			*	*	*
callima satura Jord.			*	*	*
mira excelsa Jord.			*	*	*
clathrata limata Jord.				*	*
Cepora permale dohertyana Grose-Sm.	*				
Appias paulina saina Grose-Sm.	*				
celestina galerus Frhs.	*				
sp. 1	*				
Saletara c. cycinna Hewit.	*				
Catopsilia p. pomona Fabr.	*				
p. crocale Cram.	*				
Eurema candida papuana Butl.	*		*		
hecabe oeta Fruhs.	*	*	*		
sp. 1			*		
DANAIDAE					
Tellervo zoilus hiemsal Fruhs.	*				

Danaus plexippus Linn.	*	*			
philene bonguensis Fruhs.	*		*		
hamata subnubila Talb.	*		*		
melusine Grose-Sm.	*				
w. weiskei Roths.				*	*
Euploea spp. 1–3	*				
batesi resarta Feld.	*				
wallacei melia Fruhs.	*		*		
tulliolus mardonia Fruhs.	*				
usipetes rezia Kirby	*				
callithoe hansemanni Honr.	*				
NYMPHALIDAE					
Miyana meyeri Kirsch	*	*	*	*	
Cupha prosope oderca Fruhs.	*				
Vagrans egista offaka Fruhs.	*				
Symbrenthia hippocle hippocrates Stau.	*	*	*		
Vindula arsinoe rebeli Fruhs.	*				
Cethosia chrysippe praestabilis Fruhs.	*	*	*	*	*
Yoma algina netonia Fruhs.	*		*		
Precis hedonia zelima Fabr.	*		*		
erigone tristis Misk.	*				
villida Fabr.	*				
orithya novaguineae Hagen	*				
Cirrochroa regina sophene Fruhs.	*				
Cyrestis a. achates Butler	*		*		
acilia gades Fruhs.	*				
Argyreus hyperbius niugini Sams.				*	*
Mynes geoffroyi atinia Fruhs.	*		*		
g. eugenius Fruhs.	*		*		
halli Joicey & Talb.				*	*
websteri Grose-Sm.			*		
Hypolimnas alimena eremita Butl.	*				
bolina nerina Fabr.	*				

	1100–1200	1300–1500	1600–1700	1800–1850	2000–2362
decis panopion Grose-Sm.	*		*		
Doleschallia dascylus eudascylus Fruhs.	*				
hexophthalmus ardys Fruhs.	*				
d. dascon Godm. & Salv.			*		
Apaturina erminea papuana Ribbe	*				
Pantoporia venilia cyanifera Butl.	*		*		
consimilis stenopa Fruhs.	*		*		
Neptis praslini meridionalis Talb.	*				
Neptis brebissonii simbanga Hagen	*				
Phaedyma shepherdi damia Fruhs.	*		*		
Helcyra chionippe thyiada Fruhs.	*				
Prothoe australia hewitsoni Wall	*				
Polyura j. jupiter Butler	*		*		
Charaxes latona stephenus Roths. & Jord.	*				
SATYRIDAE					
Mycalesis sirius antecanis Fruhs.	*				
terminus flagrans Butl.	*		*		
phidon phidonides Fruhs.	*		*		
p. perseus Fabr.	*				
discobolus Fruhs.		*	*	*	*
b. barbara Grose-Sm.			*		
Orsotriaena medus licium Fruhs.	*				
Melanitis leda destitans Fruhs.	*		*		
amabilis valentina Fruhs.	*		*		
c. constantia Cram.	*				
Erycinidia gracilis Roths. & Jord.			*		*
hemileuca Jord.			*	*	*
ternera Jord.					*
Ypthima arctous papuana Fruhs.	*				
Hypocysta osyris isis Fruhs.	*				
Harsiesis hygea noctula Fruhs.	*				
Lamprolenis nitida Godm. & Salv.	*				
Elymnias agondas melagondas Fruhs.	*				

Pieridopsis virgo Roths. & Jord.		*	*	*	*
ducis Jord.			*	*	*
Platypthima decolor Roths. & Jord.			*	*	*
simplex Roths. & Jord.			*	*	
placiva Jord.			*		
ornata Roths. & Jord.			*	*	
sp. 1			*		
homochroa Roths. & Jord.				*	*
AMATHUSIIDAE					
Taenaris catops Westw, subsp.	*				
Morphopsis ula Roths. & Jord.			*		
meeki Roths. & Jord.				*	
RIODINIDAE					
Dicallaneura amabilis Roths.	*			*	*
Praetaxila satraps mambarensis R & J.	*	*			
leucomelas Roths. & Jord.	*				
weiskei Roths. & Jord.			*	*	*
LYCAENIDAE					
Libythea geoffroyi maenia Fruhs.	*		*		
Bindahara phocides Fabr. subsp.	*				
Deudorix e. epirus Feld.	*				
Hypolycaena phorbos silo Fruhs.	*				
Arhopala arta Tite	*				
c. chamaeleona Bet. –Bak.	*				
antharita hyacinthus Rob.	*				
Amblypodia annetta eberalba Fruhs.	*				
Hypochlorosis lorquinii metilia Fr.	*		*		*
danis deripha Hew.	*				
Danis cyanea manto Grose-Sm. & Kirby	*				
albula Grose-Sm.		*	*	*	
Hypochrysops polycletus rex Boisd.	*				
p. pythias Feld.	*	*	*		
theon alix Grose-Sm.	*				

	1100–1200	1300–1500	1600–1700	1800–1850	2000–2362
rufinus Grose-Sm.		*			
Pepliphorus inops pilumna Druce	*		*		
Nacaduba ruficirca Tite	*				*
Parachrysops bicolor Beth.–Bak.	*				
Parelodina a. aroa Beth.–Bak	*				
Erysichton palmyra coelia Grose-Sm.	*			*	
lineata Murray	*				
Catopyrops ancyra mysia Watk. & Lyall	*				
Jamides reverdini Fruhs.	*				
p. purpurata Grose-Sm.	*		*		
cytia claudia Watk. & Lyall	*				
alevas nitidus Tite	*				
n. nemophila Butl.	*				
Lampides boeticus linn. (Wingbean)	*		*		
Catochrysops panormus papuanus Tite	*				
Euchrysops cnejus cnidus Watk. & Lyall	*				
Everes lacturnus australis Couch	*				
Zizinia otis aruensis Swin. (Snakebean)	*		*		
Holochila grandissimia morobea Wind & Clench	*		*	*	*
ardosiacea Tite	*				
helenita dimorpha Rober	*				
neurapacuna Beth.–Bak	*		*	*	
Philiris fulgens septentrionalis J & T.	*		*		
i. intensa Butl.	*				
philitoides Tite	*	*	*		
sp. 1	*				
sublutea Beth.–Bak.			*		*
sp. 2			*		
sp. 3			*		
Paraduba owgarra Beth.–Bak.	*	*	*	*	
Eupsychellus dionisius Boisd.	*	*	*		
Callictita cyara albiplaga Joic. & Tal.	*		*	*	

c. cyara Beth.–Bak.		*	*		
Spalgis epeus pharnus Feld.			*		
Pistoria nigropunctata Beth.–Bak.	*		*	*	
Luthrodes cleotas kaiphas Fruhs.	*				
Celastrina d. drucei Beth.–Bak.		*	*	*	*
meeki Beth.–Bak.			*	*	
owgarra Beth.–Bak.			*	*	
argrioloides Roths.				*	
Udara rona Grose-Sm.		*	*		
HESPERIDAE					
Notocrypta renardi partita Fruhs.	*		*	*	*
waigensis mangala Fruhs.			*	*	
Tagiades menaka sivoa Swin.	*				
Hasora d. discolor Feld.	*				
Ismene doleschalli albertisi Ober.	*				
Banta banta Evans	*				
Borbo cinnara Wallace (Maize)	*				

	Altitude Range in Metres 1200	1800	2360	Hosts
COCCINELLIDAE				
Henosepilachna haemorrhoea (Biel.)	X			Egg Plant, Potato
signatipennis (Biel.)	X			Pumpkin, Beans
Subepilachna latemarginata (Biel.)	X			Potato
CHRYSOMELIDAE				
Cricocerinae				
Lilioceris brandti Gres.		X		
sedlaceki Gres.	X			Kunai, grass
Oulema diminuta Gres.	X			Grasses
Lema (Petauristes) ardleyi Gres.	X			
painei Gres.	X			*Alpinia*
variator Gres.	X		X	Ginger
sirunki Gres.			X	*Alpinia*
wauensis Gres.		X	X	Ginger
nr. *goilala* Gres.			X	Ginger
sp. 1		X		*Eugenia*
(Enoplolema) alpiniae Gres.	X			*Alpinia*
sapientae Gres.	X			*Ficus*
Stethopachys nr. *papuana* Gres.	X			*Dendrobium musciferum*
Clytrinae				
Aetheomorpha papuana Gres.	X			
Cryptocephalinae				
Cryptocephalus papuamontis Gres.	X			*Homalanthus*
wauensis Gres.	X			*Ficus*
Cadmus (s. str.) *intermontanus* Gres.			X	*Macaranga*
alternatus Gres.	X		X	*Dimorphanthera*
kaindi Gres.			X	
strigatus Gres.	X			

latus Gres.	X			*Homalanthus*
Eumolpinae				
Stethotes punctissima Gres.		X		
similis Gres.		X		
integra Jacoby	X	X		*Ficus, Alstonia, Pipturus, Atalantia*
rubrofasciata Bry.	X			*Pandanus, Pipturus, Ficus*
coerulescens Gres.	X			
semicastanea Gres.			X	*Nothofagus*
Pseudolpus sp.	X			*Alpinia, Lantana*
Cleoperus sp.	X			*Alpinia*
Deretrichia nr *plebeja* (Jac.)	X			*Embelia*
Thyrasia sp.	X			*Coffea, Litsea*
sp.			X	*Nothofagus*
Rhyparida kuskus Gres.		X	X	
rugicollis Gres.	X			
margaretae Gres.	X			
intermontana Gres.		X		*Pipturus*
sobria Gres.	X			
rudipunctata Gres.		X		
calami Gres.		X		*Calamus*
coriacea Jac.	X			*Coffea, Eucalyptus*, grasses, beans, *Clausena*, Sunflower, Ficus, *Mischocarpus, Castanopsis, Evodia, Elaeocarpus, Litsea, Macaranga*
brassi Gres.	X	X	X	*Pipturus*
rugosa Bry.	X			
gemmula Gres.	X			*Coffea*
sculpturata Gres.			X	*Evodia, Astronia, Nothofagus*
Rhyparidella wauensis Gres.	X			*Pipturus, Trema, Beans, Pumpkin*
cobaltina Gres.	X			*Pipturus*
rufometallica Gres.	X			*Pipturus*
bicolor Gres.	X			*Ficus casearoides*
Micromolpus sp.			X	*Vaccinium*

	1200	1800	2360	
CHRYSOMELINAE				
Promechus schefflerae Gres. & Hart.		X	X	*Schefflera*
bimaculatus (Ws.)		X		*Boerlagiodendron*
parvus Gres. & Hart		X		
pittospori Gres. & Hart		X	X	*Pittosporum*
whitei Baly.	X			*Schefflera*
Galerucinae				
Oides submetallica	X			*Pipturus*
vitae Gres.	X			*Vitis*
Aulacophora nr. *atripennis* (F)	X			Pumpkin
femoralis (Mots.)	X			Veg. Marrow, pumpkin, Cucumber
pallidifasciata Jac.	X			Pumpkin, Cucumber
nr. *pygidialis*	X			Cucumber
similis (Oliv.)	X			Cucurbits
Cassena papuana Jac.	X			Beans, cucurbits
Atysa terminalis Baly		X		*Ficus*
Alticinae				
Arsipoda tenimberensis (Jac.)	X			Bean, Soybean
Amphimeloides flavicornis Sam.	X			
wauensis Sam.	X			
cheesmanae Bry.	X			
confusus Sam.		X	X	
Hispinae				
Brontispa palmivora Gres.	X			Pinnate palm
lateralis Uhmann		X	X	Sedges
Ischnispa nigra Gres.			X	*Nastus*
Ceratispa (C). palmicola Gres.	X			Pinnate palm
Callistola fordi Gres.	X			*Freycinetia*
boisduvali buloloensis Gres.	X			*Pandanus*
Dactylispa cincta (Gestro)	X			
Dicladispa linnei (Weise)	X			Grasses
Cassidinae				
Aspidomorpha australasiae (Boisd.)	X			*Ipomoea*

CURCULIONIDAE				
Brachyderinae				
Oribius cinereus Mshl	X			Sunflower, Beans
Apirocalus cornutus Pasc.	X			Apple, Hibiscus, etc.
Pantorhytes lichenifer Gres.			X	*Evodia*, etc.
Attelabinae				
Aphorina australis (Hllr)			X	*Cryptocarya*
sp.			X	*Evodia*
Cryptorhynchinae				
Ectatocyba permutata Hllr			X	*Evodia* (Epizoic symbiosis)
sp.			X	*Eurya*, etc.
Molytinae				
Carbonomassula glaberrima Hllr			X	*Embella*
Alcidinae				
Alcidodes elegans Guer.	X			*Ficus, Pipturus*
Hylobiinae				
Vanapa oberthueri Pouil.	X			*Araucaria*
Leptopiinae				
Gymnopholus marquardti Hllr			X	*Rubus, Caldcluvia, Alphitonia, Evodia,*
urticivorax Gres.	X			*Laportea*
interpres Hllr			X	*Rubus, Caldcluvia, Elaeocarpus, Evodia*
weiskei Hllr	X	X	X	*Trema, Dioscorea, Melia, Alphitonia, Saurauia*
lichenifer Gres.			X	*Eurya, Evodia, Nothofagus, Elaeocarpus*
Eupholus nickerli Hllr	X			*Lithocarpus, Ipomoea, Dioscorea*

Vegetable Insects at foot of Kaindi

This list includes insects other than Coleoptera and Lepidoptera, associated with vegetables or other crops in WEI grounds at 1150 m. See the separate lists of those orders. We are indebted to Dr Wayne Gagné for this data, which is here condensed.

	Hosts	Role
DERMAPTERA		
Chelisoches morio (F.)	Maize, Tomato	Predator of larvae
DIPTERA		
Agromyzidae		
Lyriomyza brassicae (Rilley)	Chinese Cabbage, Turnip	Leaf miner
Ophiomyia phaseoli (Tryon)	Beans	Stem miner
Unidentified sp.	Okra, Bean	Leaf miner
Drosophilidae		
Parascaptomyza ?pallida Zett.	Turnip	Leaf miner
Syrphidae		
?Asarcina sp. etc.	Beans	Aphid predators
Tachinidae		
Carcelia sp.	Tomato	Parasite of *Heliothis* pupa
Palexorista sp.	Chinese Cabbage, Radish	Parasite of Crocidolomia larva
Other species (c. 5)	Sunflower, Beet, Beans, Onion	Parasites of Lepidoptera larvae & pupae
Tephritidae		
Dacus atrisetosus	Cucurbits	Larvae destroy fruit
cucurbitae Coq.	Cucurbits	Larvae destroy fruit
trivialis	Capsicum	Larvae destroy fruit
strigifinis atritus	Squash	Larvae destroy flowers
HETEROPTERA		
Alydidae		
Riptortus annulicornis	Snakebean, Wingbean	Pod sucker
Coreidae		
Amblypelta sp.	Roselle	Fruit sucker
Lygaeidae		
Germalus sp.	Sunflower, Mungbean	General predator
Geocoris sp.	Mungbean	General predator
Nysius sp.	Sunflower, Lettuce	Seed feeder
Miridae		
Halticus tibialis	Parsnip, Chinese Cabbage, Okra, Soybean etc.	Sap feeder
Lygus sp.	Coriander, Dill Soybean	Nectar feeder
Nabidae		
Gorpis sp.	Sunflower	General predator
Nabis sp.	Okra	Predator of Lepidoptera larvae
Pyrrhocoridae		
Dysdercus cingulatus	Okra	Pod sucker
Pentatomidae		
Agonoscelis nr. *rutilia*	Basil	?Predator (Lep. larvae)
?Allocotus sp.	Snakebean, Okra	Sapsucker
Nezara viridula (L.)	Beans, Tomato	Sapsucker

Plautia brunneipennis	Snakebean, Sunflower	Sapsucker
HOMOPTERA		
Aphididae		
Aphis craccivora Koch	Beans	Sapsucker
Brevicoryne ?brassicae (L.)	Turnip	Sapsucker
Myzus persicae (Sulz.)	Maize	Sapsucker
Cicadellidae		
Cicadella sp.	Taro	Sapsucker
?Empoasca sp.	Chinese Cabbage,Wingbean, Okra	Sapsucker
?Tartessus sp.	Avocado	Sapsucker
Unidentified spp.	Sunflower, Spinach, Soybean, etc.	Sapsucker
Coccidae		
Unidentified spp.	Wingbean, Sunflower	Sapsucker
Flatidae		
Colgar sp.	Sunflower, Okra, Avocado	Sapsucker
Membracidae		
Terentius nubifasciatus	Soursop, Avocado, Eggplant	Sapsucker
Ricaniidae		
Euricania villica Steal	Sunflower, Avocado	Sapsucker
Ricania spp.	Sunflower, Snakebean	Sapsucker
Ricanula puncticosta Walk.	Sunflower	Sapsucker
HYMENOPTERA		
Braconidae		
Aparteles spp.	Chinese Cabbage, Spinach, Snapbean	Parasites of larval moths
circumscriptus group	Wingbean	Parasite of *Leucoptera* pupa
Chelonus sp.	Beans	Parasite of leaftier, *?Lamprosema indica*
Biosteres sp.	Squash	Parasite of *Dacus* pupae
Chalcidoidea		
Brachymeria euploeae	Okra	Parasite of *Xanthodes* pupa
Closterocerus splendens	Wingbean	?Hyperparasite of *Apanteles* in *Leucoptera* pupa
Unidentified spp.	Beans	Parasites of geometrid larva, *Ophiomyza* pupa
	Soybean	?Hyperparasites of ichneumonids ex *Lamprosema i.*
Sphegigaster sp.	Turnip Beans	Parasite of syrphid pupa Parasite of agromyzid pupa
Ichneumonidae		
Diplazon laetatorius (F).	Turnip	Parasite of syrphid pupa
Enicospilus nr. *obliquus* (Morley)	Maize	Parasite of moth larva
Unidentified spp.	Turnip	Parasite of *Crocidolomia*
	Silver Beet, Spinach	Parasite of *Hymenia r.*
	Beans	Parasite of *Lamprosema i.*
Mesochorus sp.	Soybean	Hyperparasite of *Apanteles* sp.
Vespidae		
Ropalidia bambusae Richards	Turnip	Predator of moth larvae
NEUROPTERA		
Hemerobiidae		
Micromis timidus Hagen	Sunflower, Soybean	Aphid predator
ORTHOPTERA		
Acridiidae		

Gesonula mundata	Taro	Defoliator
Unidentified sp.	Broadbean	Defoliator
Gryllidae		
Homeoxipha ?fuscipennis (Chop.)	Sunflower, Turnip Avocado	Leafchewer
Pyrgomorphidae		
Atractomorpha crenaticeps Bl.	Okra, Brussels Sprouts	Defoliator
Desmopterella sp.	Sunflower	Defoliator
Tettigoniidae		
Euconocephalus sp.	Maize	Defoliator
Hexacentrus mundus Walk.	Sunflower, Maize	General predator
Phaneroptera brevis Serv.	Sunflower, Okra, Brussel Sprouts	Leafchewer
THYSANOPTERA		
Thrips tabaci Lind.	Onion	Plant feeding.

AMPHIBIANS

The amphibian fauna of Kaindi was only incidentally examined by the Earthwatch teams. The frogs of Kaindi have been studied over a considerable period of time by James Menzies, and many of them are treated in his "Handbook of common New Guinea frogs" (WEI Handbook no 1). Prof. Menzies has kindly supplied the following list, including a few not recorded but probably occurring there (asterisked). All of the native amphibians are frogs. Only one introduced species of amphibian occurs (at foot of Kaindi), the cane toad *Bufo marinus*.

Hylidae

*Litoria angiana, arfakiana, contrastens, *genimaculata, infrafrenata, pratti* group (1 or 2 spp), *thesaurensis, wollastoni.*

**Nyctimystes cheesmanae, foricula, *kubori, *papua, daymani* group.

Microhylidae

Barygenys flavigularis.

Cophixalus cryptotympanum, riparius, shellyi, variegatus group, sp. 'J', sp. 'K', sp. 'N'.

**Hylophorbus rufescens.*

**Oreophryne* sp.

**Phrynomantis lateralis, stictogaster.*

Sphenophryne brevicrus group, *palmipes, rhododactyla.*

Ranidae

Rana sp. 'B' (forest streams), sp. 'F' (ponds).

REPTILES

Observations on Mt Kaindi have been extensive for lizards but rather limited for snakes, and not many were seen by the Earthwatch groups. One hard-shelled turtle occurs in Wau Valley. The following annotated list of lizards was provided by Allen Allison, who studied skinks, especially, during 1974–75. The list of snakes was provided by S. B. McDowell.

Lizards

Agamidae — Agamid lizards

Gonocephalus ?papuensis Macleay, 1877 ca 1200 m.

Gekkonidae Geckos

Hemidactylus frenatus Dum. & Bibr., 1836 0–1350 m.

Gymnodactylus sp. Uncommon at 1200 m.

Scincidae Skinks

Emoia callistricta Peters & Doria, 1878 ?0–1200 m; disturbed areas.

loveridgei Brown, 1953 ?0–1300 m; shaded area; not abundant.

mivarti Boul 1887. 0–1350 m; widespread; disturbed area.

physicae Dum. & Bibr., 1839 Up to 1750 m; common in disturbed areas; scarce in primary forest.

submetallica Macl., 1877 Up to 1500 m; common, widespread; habitat same as *physicae.*

Eugongylus rufescens Shaw, 1802 Up to 1250 m; uncommon at WEI; widespread; preys upon smaller lizards.

Lobulia elegans Boul., 1897 2000–3200 m; summits of Missim & Amungwiwa; on logs and trunks.

morokana Park., 1936 Up to 1750 m; terrestrial; moderately common around WEI.

stanleyana Boul., 1897 1750–2850 m; abundant in open disturbed habitats; terrestrial.

Prasinohaema prehensicauda Lover., 1945 1900–2600 m; arboreal; rarely seen.

Sphenomorphus cf darlingtoni Lover. 1100–2000 m; shy; under rocks, logs.

jobiensis Mayer, 1874 Widespread at lower elevations; rare at WEI; in fairly dense underbrush.

pratti Boul., 1903 Up to 1350 m; rare at WEI; in dense underbrush.

sp. A Single individual from WEI lower arboretum.

sp. B 1900–2362 m; apparently arboreal; said to be common in Pandanus crowns in highlands.

Varanidae Monitor lizards

Varanus indicus Daud;. 1802 0–1400 m; widespread; not abundant at Wau.

prasinus Doria, 1874 Up to 1100 m; widespread but rare locally.

Snakes

Snakes are rather seldom seen on Kaindi above 1400 m or so. In disturbed portions of Wau valley, and WEI grounds, they are moderately abundant, but primarily nocturnal. Poisonous species are rare at Wau and Kaindi.

Typhlopidae

Typhlops inornatus: Small blind snake or burrowing snake.

Typhlina bramina: Widespread relative of preceding; likewise subterranean.

Boidae

Liasis albertisi: Albertis' python. Shiny black except beneath. *L. papuanus* is known from as high as Garaina.

Python amethistinus: Amethistine python. Multicolored, intricate pattern.

Python boeleni: Boelen's python. Shiny black with oblique yellow partial

bands. This is a protected species.

Chondropython viridis: Green tree python. Much shorter than preceding; bright green but usually yellow or red when young.

Candoia carinata: One record for Wau; usually at lower altitudes.

Colubridae

Dendrelaphis calligastra: Same comment as preceding. *D. gastrostictus* should occur here. Slender tree snakes.

Stegonotus cucullatus: A somewhat spotted brownish snake.

Stegonotus parvus: Pigment of lateral scales concentrated at bases.

Amphiesma cf. multiscutellata: Foot of Mt Kaindi.

Amphiesma cf. montana: Higher portions of Kaindi. A brownish snake. *A. picturata* may occur in bottom of Wau Valley.

Boiga irregularis: Rear-fanged tree snake; brown with slender neck; slightly venomous.

Elapidae

Aspidomorphus lineaticollis: Poisonous; middle to lower altitudes.

Apidomorphus muelleri: Poisonous; lower altitudes.

Micropechis ikaheka: Small-eyed snake. Highly venomous; rare; foot of Kaindi.

Acanthophis ?antarctica: "Death adder." Poisonous, but not a true adder; wide altitude range and perhaps more than one species.

Toxicocalamus (Apistocalamus) loriae: Known from east and west of Wau.

BIRDS

The following list includes the great majority of the bird species occurring from the bottom of the Wau Valley to the summit of Mt Kaindi. It was compiled by Bruce Beehler and was augmented by Thane Pratt.

		Altitude Range (m)		
		1200	1800	2360
Accipitridae – Kites, Hawks, Eagles				
Aviceda subcristata	Crested lizard Hawk	*		
Henicopernis longicauda	Long-tailed Buzzard	*	*	*
Milvus migrans	Black Kite	*		
Haliastur indus	Red-backed Kite	*	*	
Accipiter poliocephalus	Grey-headed Goshawk	*		
novahollandiae	Grey Goshawk	*		
melanochlamys	Black-mantled Goshawk		*	*
fasciatus	Australian Goshawk	*		
cirrhocephalus	Collared Sparrow Hawk	*	*	
Megatriorchis doriae	Doria's Goshawk	*		
Harpyopsis novaguineae	New Guinea Eagle	*	*	*
Hieraaetus morphnoides	Little Eagle	*		
Circus spilonotus	Spotted Marsh Harrier	*		
Falconidae – Falcons				
Falco peregrinus	Peregrine Falcon	*	*	*
berigora	Brown Falcon	*	*	
Megapodidae – Mound Builders				
Megapodius freycinet	Common Scrub Hen	*		

		Altitude Range (m)		
		1200	1800	2360
Aepypodius arfakianus	Wattled Bush Turkey	*	*	*
Talegalla jobiensis	Brown-collared Bush Turkey	*	*	
Phasianidae – Pheasant and Quail				
Synoicus ypsilophorus	Brown Quail	*	*	
Excalfactoria chinensis	Chinese Quail	*	*	
Rallidae – Rails .				
Rallus philippensis	Banded Land Rail	*		
pectoralis	Slate-breasted Rail	*		
Rallina tricolor	Red-necked Rail	*		
Rallicula forbesi	Forbes Chestnut Rail	*	*	*
Amaurornis olivaceus	Rufous-tailed Moorhen	*		
Porphyrio porphyrio	Purple Swamp Hen	*		
Scolopacidae – Sandpipers and Snipe				
Actitus hypoleucos	Common Sandpiper	*		
Scolopax saturata	East Indian Woodcock		*	*
Columbidae – Doves and Pigeons				
Ptilinopus superbus	Superb Fruit Dove	*		
coronulatus	Little Coroneted Fruit Dove	*		
rivoli	High Mountain Fruit Dove	*	*	*
ornatus	Ornate Fruit Dove	*	*	*
perlatus	Pink-spotted Fruit Dove	*		
Megaloprepia magnifica	Magnificent Fruit Dove	*		
Ducula chalconota	Rufous-breasted Imperial Pigeon		*	*
zoeae	Zoe Imperial Pigeon	*		
Macropygia amboinensis	Ambon Cuckoo Dove	*	*	
nigrirostris	Black-billed Cuckoo Dove	*	*	*
Reinwardtoena reinwardtsi	Great Cuckoo Dove	*	*	*
Gymnophaps albertisii	Mountain Pigeon	*	*	*
Columba vitiensis	Wood Pigeon	*	*	
Chalcophaps indica	Green-winged Pigeon	*		
Gallicolumba jobiensis	White throated Ground Dove	*	*	
beccarii	Beccari's Ground Dove	*	*	*
Otidiphaps nobilis	Magnificent Ground Pigeon	*	*	
Psittacidae – Parrots				
Pseudeos fuscata	Dusky orange Lory	*	*	
Trichoglossus haematodus	Rainbow Lory	*	*	
Psitteuteles goldei	Red-capped Streaked Lory	*	*	*
Charmosyna pulchella	Little Red Lory	*	*	
papou	Fairy Lory		*	*
wilhelminae	Pygmy Streaked Lory		*	*
Oreopsittacus arfaki	Plum-face Mountain Lory			*
Neopsittacus musschenbroekii	Yellow-billed Mountain Lory	*	*	*
pullicauda	Orange-billed Mountain Lory			*
Opopsitta diophthalma	Two-eyed Fig Parrot	*		
Micropsitta bruijnii	Red-breasted Pygmy Parrot		*	*
Geoffroyus simplex	Blue-collared Parrot	*	*	
Alisterus chloropterus	Papuan King Parrot	*	*	*
Psittacella brehmii	Brehms Parrot		*	*
madaraszi	Plain-breasted Little Parrot	*	*	
Cuculidae – Cuckoos				
Cuculus saturatus	Oriental Cuckoo	*		
Cacomantis variolosus	Grey-breasted Brush Cuckoo	*		
castaneoventris	Chestnut-breasted Brush Cuckoo	*	*	*
pyrrhophanus	Fan-tailed Brush Cuckoo	*	*	*
Chrysococcyx ruficollis	Mountain Bronze Cuckoo		*	*
meyeri	Meyer's Bronze Cuckoo	*	*	
malayanus	Malay Bronze Cuckoo	*		

		Altitude Range (m)		
		1200	1800	2360
Caliechthrus leucolophus	White-crowned Koel	*		
Eudynamys scolopacea	Common Koel	*		
Centropus phasianus	Common Coucal	*	*	
Tytonidae – Barn Owls				
Tyto alba	Barn Owl	*	*	
tenebricosa	Sooty Owl	*	*	*
Strigidae – Typical Owls				
Ninox theomacha	Brown Owl	*	*	*
Podargidae – Frogmouths				
Podargus papuensis	Great Papuan Frogmouth	*		
ocellatus	Little Papuan Frogmouth	*		
Aegothelidae – Owletnightjars				
Aegotheles insignis	Large Owlet Nightjar		*	*
albertsii	Mountain Owlet Nightjar	*	*	*
Caprimulgidae – Nightjars				
Caprimulgus macrurus	Large-tailed Nightjar	*		
Apodidae – Swifts				
Collocalia esculenta	Glossy Swiftlet	*	*	*
hirundinacea	Mountain Swiftlet	*	*	*
Hemiprocnidae – Treeswifts				
Hemiprocne mystacea	Moustached Treeswift	*	*	
Alcedinidae – Kingfishers				
Alcedo lepida	Dwarf Kingfisher	*		
Clytoceyx rex	Shovel-billed Kingfisher	*	*	
Halcyon megarhyncha	Mountain Yellow-billed Kingfisher	*	*	
sancta	Sacred Kingfisher	*		
Meropidae – Bee-eaters				
Merops ornatus	Rainbow Bee-eater	*		
Coraciidae – Rollers				
Eurystomus orientalis	Dollarbird	*		
Alaudidae – Larks				
Mirafra javanica	Bush Lark	*		
Hirundinidae				
Hirundo tahitica	Pacific Swallow	*		
Campephagidae – Greybirds				
Lalage leucomela	White-browed Triller	*		
Coracina morio	Muller's Greybird	*		
montana	Black-bellied Greybird	*	*	*
lineata	Barred Greybird	*		
caeruleogrisea	Stout-billed Greybird	*	*	
longicauda	Black-headed Greybird			*
papuensis	Papuan Greybird	*		
Motacillidae – Pipits and Wagtails				
Motacilla cinerea	Grey Wagtail		*	*
Anthus novaeseelandiae	Richard's Pipit	*	*	
Turdidae – Thrushes				
Saxicola caprata	Pied Chat	*	*	
Amalocichla incerta	Lesser New Guinea Thrush		*	*
Cinclosomatidae – Babbler-thrushes				
Eupetes castanonotus	Mid-mountain Eupetes	*		
leucostictus	High Mountain Eupetes		*	
Melampitta lugubris	Lesser Melampitta			*
Ifrita kowaldi	Blue-capped Ifrit			*
Maluridae – Fairywrens				
Malurus alboscapulatus	Black and White Wren Warbler	*	*	
Clytomyias insignis	Rufous Wren Warbler			*
Sylviidae – Warblers				

		Altitude Range (m)		
		1200	1800	2360
Phylloscopus trivirgatus	Leaf Warbler	*	*	*
Gerygone cinerea	Grey Gerygone Warbler		*	*
chloronota	Grey-headed Gerygone Warbler	*		
palpebrosa	Black-headed Warbler	*		
ruficollis	Red-necked Gerygone Warbler	*	*	*
Sericornis spilodera	Pale-billed Sericornis	*		
perspicillatus	Buffy-faced Sericornis		*	*
papuensis	Papuan Sericornis			*
nouhuysi	Large Mountain Sericornis		*	*
arfakianus	Grey-green Sericornis	*	*	
Crateroscelis murina	Lowland Mouse Warbler	*	*	
robusta	Mountain Mouse Warbler		*	*
Megalurus timoriensis	Rufous-capped Grass Warbler	*		
Cisticola exilis	Golden-headed Fantail Warbler	*		
Muscicapidae – Flycatchers				
Peltops montanus	Mountain Peltops Flycatcher	*	*	
Rhipidura leucothorax	White-breast Thicket Fantail	*		
brachyrhyncha	Dimorphic Rufous Fantail			*
atra	Black Fantail	*	*	*
hyperythra	Chestnut-bellied Fantail	*	*	
albolimbata	Friendly Fantail		*	*
leucophrys	Willie Wagtail	*		
rufiventris	White-throated Wagtail	*		
Monarcha axillaris	Black Monarch Flycatcher	*	*	*
frater	Black-winged Monarch	*		
telescophthalmus	Frilled Monarch	*		
Myiagra rubecula	Leaden Monarch	*		
Machaerirhynchus nigripectus	Mountain Flatbill Flycatcher		*	*
Eugerygone rubra	Red-backed Flycatcher		*	*
Microeca griseoceps	Yellow-footed Microeca Flycatcher	*		
papuana	Yellow Microeca Flycatcher		*	*
Tregellasia leucops	White-faced Robin	*	*	
Poecilodryas albonotata	Black-throated Thicket Flycatcher		*	*
Peneothello cyanus	Slaty Thicket Flycatcher		*	*
Heteromyias albispecularis	Ground Thicket Flycatcher		*	*
Pachycephalopsis poliosoma	White-throated Thicket Fly Flycatcher	*	*	
Pachycephalidae – Whistlers				
Pachycare flavogrisea	Golden-faced Whistler	*	*	
Pachycephala leucostigma	Mottled Whistler	*	*	*
soror	Sclater's Whistler	*	*	
schlegelii	Schlegel's Whistler		*	*
griseiceps	Grey-headed Whistler	*		
modesta	Brown-backed Whistler		*	*
monacha	White-bellied Whistler	*		
rufinucha	Rufous-naped Whistler		*	*
Colluricincla megarhyncha	Rufous Shrike-thrush	*	*	
Pitohui dichrous	Black-headed Pitohui	*	*	
nigrescens	Black Pitohui		*	*
Eulacestoma nigropectus	Wattled Shrike-tit			*
Laniidae – Shrikes				
Lanius schach	Red-backed Shrike	*	*	
Artamidae – Woodswallows				
Artamus maximus	Greater Woodswallow	*	*	*
Sturnidae				
Aplonis metallica	Metallic Starling	*		
Oriolidae – Orioles				
Oriolus szalayi	Brown Oriole	*		

		Altitude Range (m)		
		1200	1800	2360
Grallinidae – Mudnest Builders				
Grallina bruijni	Torrent Lark	*	*	*
Cracticidae – Butcherbirds				
Cracticus cassicus	Black-headed Butcherbird	*		
Dicruridae – Drongos				
Dicrurus hottentottus	Spangled Drongo	*		
Chaetorhynchus papuensis	Mountain Drongo	*	*	*
Paradisaeidae – Birds of Pardise				
Cnemophilus loriae	Loria's Bird of Paradise			*
Manucodia chalybatus	Green-breasted Manucode	*		
keraudrenii	Trumpetbird	*	*	
Epimachus meyeri	Brown Sickle-billed Bird of Paradise			*
albertisii	Black-billed Sicklebill	*	*	
Astrapia stephaniae	Princess Stephanie's Astrapia		*	*
Lophorina superba	Superb Bird of Paradise	*	*	*
Parotia lawesii	Lawes' Six-wired Bird of Paradise	*	*	*
Ptiloris magnificus	Magnificent Riflebird	*		
Diphyllodes magnificus	Magnificent Bird of Paradise	*		
Paradisaea raggiana	Count Raggi's Bird of Paradise	*		
rudolphii	Blue Bird of Paradise	*	*	
Ptilonorhynchidae – Bowerbirds				
Amblyornis macgregoriae	MacGregor's Bowerbird		*	*
Ailuroedus melanotis	Black-eared Catbird	*	*	
Chlamydera cerviniventris	Fawn-breasted Bowerbird	*	*	
Neosittidae – Sittellas				
Neositta papuensis	Papuan Sittella	*	*	*
Climacterus placens	Papuan Creeper	*	*	*
Nectariniidae – Sunbirds				
Nectarinia jugularis	Yellow-breasted Sunbird	*		
Meliphagidae				
Toxorhamphus poliopterus	Slaty-chinned Longbill	*	*	*
Melilestes megarhynchus	Long-billed Honeyeater	*	*	
Oedistoma iliolophum	Grey-billed Longbill	*	*	
Myzomela adolphinae	Mountain Red-headed Myzomela	*	*	
nigrita	Black Honeyeater	*		
rosenbergii	Black and red Honeyeater	*	*	*
Timeliopsis fulvigula	Mountain Straight-billed Honeyeater	*	*	*
Meliphaga subfrenata	Black-throated Honeyeater		*	*
albonotata	White-eared Honeyeater	*		
aruensis	Puff-backed Honeyeater	*		
orientalis	Small Spot-breasted Meliphaga	*	*	
montana	White-eared forest Meliphaga	*		
gracilis	Slender-billed Meliphaga	*		
flavirictus	Yellow-gaped Meliphaga	*		
flaviventer	Tawny-breasted Honeyeater	*		
polygramma	Spotted Honeyeater	*		
Melipotes fumigatus	Common Melipotes	*	*	*
Ptiloprora guisei	Brown-backed Streaked Honeyeater		*	*
Pycnopygius cinereus	Marbled Honeyeater	*	*	
Philemon novaeguineae	New Guinea Friarbird	*		
Melidectes belfordi	Belford's Melidectes		*	*
torquatus	Cinnamon-breasted Wattle bird	*	*	
Dicaeidae – Flowerpeckers				
Dicaeum geelvinkianum	Red-capped Flowerpecker	*	*	*
Melanocharis versteri	Fan-tailed Berrypecker	*	*	*
nigra	Black Berrypecker	*		
striativentris	Streaked Berrypecker	*		*

		Altitude Range (m) 1200	1800	2360
longicauda	Mid-mountain Berrypecker	*	*	
Oreocharis arfaki	Tit Berrypecker			*
Zosteropidae – Silvereyes				
Zosterops atrifrons	Black-fronted White-eye	*		
novaeguineae	Mountain White-eye	*	*	*
Estrildidae – Mannikins				
Erythruca trichroa	Blue-faced Parrot-finch	*	*	*
papuana	Papuan Parrot-finch	*	*	*
Lonchura spectabilis	Hooded Mannikin	*		
tristissima	Streak-headed Mannikin	*		

MAMMALS

Although the flora and insect fauna of New Guinea are closely related to those of SE Asia, the native mammals belong to the same groups as occur in Australia. The most striking feature of the Australian and especially New Guinean fauna is the paucity of major groups. Only 4 orders of mammals are truly native to New Guinea, and each is represented on Mt Kaindi. These include the order Monotremata (egg-laying mammals), Marsupialia (pouched mammals), Chiroptera (bats) and Rodentia (rats and mice). The more spectacular elements of the mammal fauna are marsupials. On this island of few placentals, none of them carnivorous, the marsupials have become diverse and exploit the ecological niches usually occupied by placentals such as weasels, rabbits, flying squirrels and additional types in other parts of the world. The New Guinea marsupials are less diverse than those of Australia, but some Australian types have been found in New Guinea as fossils (see Geology section, above).

Mammals are rarely seen on the nature trails and the transect for a number of reasons. Many are nocturnal, active and feeding only at night. There has been heavy hunting pressure in recent years. Some species live among tree canopy epiphytes, high above ground level. The best method of mammal observation is "night-spotting," i.e., walking quietly on trails and occasionally flashing a torch into the lower tree branches.

The list of mammals which follows has been compiled by Abid Beg Mirza and Alan Ziegler in the course of the ectoparasite/host collecting. Specimens were gathered primarily by trapping and shooting; sample skins are preserved and curated in the WEI collection. Several species, such as sugar gliders, wallabies and tree kangaroos, live in the WEI zoo, and some have bred successfully in captivity.

		Probable Occurrence on Kaindi (m) 1100–1500	1600–1900	2000–2362
MONOTREMATA				
Tachyglossus aculeatus	Short-beaked Echidna	X	X	
Zaglossus bruijni	Long-beaked Echidna		X	X
MARSUPIALIA				
Dasyuridae				
Murexia longicauda	Short-haired Marsupial Mouse	X	X	

		Probable Occurrence on Kaindi (m)		
		1100–1500	1600–1900	2000–2362
Antechinus melanurus	Black-tailed Marsupial Mouse	X	X	
naso	Long-nosed Marsupial Mouse		X	X
wilhelmina	Lesser Marsupial Mouse		X	X
Myoictis melas	Three-striped Marsupial Mouse	X		
Phascolosorex dorsalis	Narrow-striped Marsupial Mouse		X	X
Dasyurus albopunctatus	New Guinea Marsupial Cat	X	X	X
Peramelidae				
Peroryctes longicauda	Striped Bandicoot		X	X
raffrayanus	Raffray's Bandicoot	X	X	X
Echymipera kalubu	Spiny Bandicoot	X		
Phalangeridae				
Phalanger gymnotis	Gray Phalanger	X	X	X
orientalis	Common Phalanger	X		
vestitus	Silky Phalanger		X	X
Distoechurus pennatus	Feather-tailed Possum	X		
Cercartetus caudatus	New Guinea Pygmy Possum		X	X
Petaurus breviceps	Sugar Glider	X	X	X
Dactylopsila trivirgata	Common Striped Possum	X	X	X
palpator	Long-fingered Possum		X	X
Pseudocheirus corinnae	Eastern Ring-tail		X	X
cupreus	Coppery Ring-tail			X
forbesi	Moss-forest Ring-tail		X	X
Macropodidae				
Thylogale bruijni	Dusky Wallaby	X	X	
Dendrolagus dorianus	Unicolored Tree Kangaroo		X	X
goodfellowi	Ornate Tree Kangaroo		X	X
Dorcopsulus vanheurni	Lesser Forest Wallaby		X	X
CHIROPTERA				
Pteropodidae				
Rousettus amplexicaudatus	Common Rousette Bat	X	X	
Dobsonia moluccensis	Greater Naked-backed Bat	X	X	X
Macroglossus lagochilus	Long-tongued Fruit Bat	X	X	X
Syconycteris crassa	Common Blossom Bat	X	X	X
Nyctimene sp.	Tube-nosed Bat	X	X	X
Paranyctimene raptor	Unstriped Tube-nosed Bat	X		
Emballonuridae				
Emballonura sp.	Sheath-tailed Bat	X	X	
Rhinolophidae				
Hipposideros sp.	Horseshoe Bat	X	X	
Vespertilionidae				
Pipistrellus angulatus	Greater NG Pipistrelle		X	X
papuanus	Lesser NG Pipistrelle	X	X	
Miniopterus australis	Lesser Bent-winged Bat	X	X	X
schreibersi	Common Bent-winged Bat	X	X	X
RODENTIA				
Muridae				
Hyomys goliath	Rough-tailed Giant Rat			X
Rattus exulans	Pacific Rat	X	X	X
niobe	Moss-forest Rat		X	X
rattus	House Rat	X		
ruber	Variable Spiny Rat	X	X	X
verecundus	Slender Rat	X	X	X
Melomys levipes	Long-nosed Melomys	X	X	X
lorentzi	Long-footed Melomys	X		
moncktoni	Southern Melomys		X	X
platyops	Lowland Melomys	X		

		Probable Occurrence on Kaindi (m)		
		1100–1500	1600–1900	2000–2362
rubex	Highland Melomys		X	X
rufescens	Rufescent Melomys	X		
Pogonomelomys mayeri	Shaw Mayer's Brush Mouse		X	X
ruemmleri	Rümmler's Brush Mouse		X	X
sevia	Highland Brush Mouse			X
Uromys anak	Black-tailed Tree Rat		X	X
caudimaculatus	Mottle-tailed Tree Rat	X	X	
Macruromys major	Eastern Small-toothed Rat	X		
Lorentzimys nouhuysi	New Guinea Jumping Mouse	X	X	X
Anisomys imitator	Squirrel-toothed Rat		X	X
Pogonomys macrourus	Long-tailed Tree Mouse	X		
mollipilosus	Soft-haired Tree Mouse		X	X
sylvestris	Gray-bellied Tree Mouse		X	X
Mallomys rothschildi	Smooth-tailed Giant Rat			X
Crossomys moncktoni	Earless Water Rat	X		
Hydromys chrysogaster	Common Water Rat	X	X	
Pseudohydromys murinus	Eastern Shrew Mouse			X
Mayermys ellermani	One-toothed Shrew Mouse		X	X
Neohydromys fuscus	Short-tailed Shrew Mouse			X

DISCUSSION AND SUMMARY

BIOGEOGRAPHY

Biogeography attempts to answer the questions as to how certain types of plants and animals occur in one area and not in another. It therefore bears heavily on geological history, fossils and past land connections, as well as on natural dispersal for different forms of life and on their ecological roles and requirements.

New Guinea, the highest and second largest of islands, is continental and thus boasts far greater diversity of life than isolated oceanic islands never connected to a continent or continental island. Its proximity to both Australia and Asia has important bearing on its biota. But the fact that it was directly connected with Australia in recent geological periods whereas not so to Asia, has produced a situation whereby different authorities have expressed quite opposite veiws on the biogeographical relationships of New Guinea, depending on the group in question. Thus, the mammals of New Guinea belong to the same 4 orders (monotremes, marsupials, rodents, bats) as do those of Australia, whereas in SE Asia there are about 9 additional orders not occurring on the 2 former. On the other hand, relationships of birds and other land vertebrates of New Guinea are not so predominantly Australian. Moreover, the majority of the plants and insects of New Guinea have their closest relationships with those of SE Asia including various parts of Indonesia. Thus on the one hand though actual past land connections prove very significant (most mammals shun salt water), on the other hand latitude and climate prove of greater overall importance, as most plants and insects have little trouble in crossing

limited water barriers, through wind transport; floating, attached to birds, or by other means.

The island of New Guinea, plus the Moluccas, Bismarcks and Solomons are usually referred to collectively as the Papuan Subregion, biogeographically speaking. To most workers this is a subregion of the Oriental Region, but to mammalogists and some others it is considered part of the Australian Region.

The great altitude range, geographical diversity, favorable climate and other assets of New Guinea render the island extremely rich and diverse in many senses for most groups of plants and animals. While tropical biota and environments in general are poorly known compared to temperate areas, those of New Guinea are among the least known. The altitudinal zonation is impressive and there are in many cases differences in species representation on different mountain ranges. On the other hand, many species in the lowland biota have much wider ranges, and may extend from one end of the island to the other, or from the Moluccas to the Solomons. In general, species on the N side are different from those in the S, but not necessarily so. The neighboring islands lack many of the characteristic montane New Guinea forms, and have some of their own endemics. Some conspicuous New Guinea elements like birds-of-paradise are lacking in the Bismarcks and Solomons.

A great proportion of the endemic New Guinea forms are found in the lower and mid-montane zones, tapering off in the upper montane. Thus, Kaindi's position is precisely in this rich, characterstic, zone. For example, among the 40 or so species of birds-of-paradise, 12 occur on Kaindi, and 2 more in the same zone on Mt Missim.

MacArthur & Wilson (1967) have discussed in detail the theories of populating of small islands from larger islands and continents, and Diamond (1974) has developed further theories on the dynamics of bird movements in and near New Guinea. Gressitt (1961, 1974) discussed faunal relationships of S Pacific islands.

DIVERSITY

Diversity in tropical rainforests: In characterizing tropical rainforests, Richards (1966) stated that they are the richest in species of all plant communities, and that they are conspicuous for the frequent high numbers of related sympatric species. This refers to the undisturbed climax forest, whereas the second growth, after clearing or abandonment of gardens, consists of fewer species which are those that are more light-tolerant and also called the seral species of cleared ground. Among the major tropical areas of the world, SE Asia has the greatest diversity, and Africa the least (latter having pronounced dry season). Few comparisons have been made to show whether diversity is greater in New Guinea or in S America, but it may be so with the latter.

In attempting to explain the great diversity of tropical rainforest, MacArthur (1969) cited 4 theories, which he considered all partly correct,

and not mutually exclusive:

1. There are more opportunities for speciation in the tropical rainforest and these species are slow in adapting to areas with a winter. Moreover, that the number of species is still increasing, and that there is a balance between production of new species and extinction.

2. In the tropical areas there is more predation, parasitism and disease, restricting the abundance of single species.

3. In the more uniform tropical climates competitors can crowd closer (MacArthur & Levins 1967), and competition restricts increase of a particular species. Colonizing species have a decreased chance of establishing (MacArthur & Wilson 1967).

4. In more productive tropical environments more niches are favorable and can be occupied by more species. Also more species may cause more stability, which in turn allows yet more species.

Robinson, Lubin & Robinson (1974) have discussed this in greater detail in the Wau area context.

One of the characteristics of the benign climate and the relative uniformity of the annual cycle at Kaindi is the lack of migration of species. Most of the bird species are local residents and do not leave in their non-breeding periods. Moreover, different species breed at different times of year, so there is not a single breeding season. The same applies even more completely for other groups of animals. The flowering of trees and other plants likewise occurs at all times of year. Many species are flowering in any given month, and some flower throughout the year (Table 13).

In comparing the Kaindi environment with Hawaii, which has a similar climate, analogies and contrasts are noted. From the standpoint of the biota, a large proportion of the genera of native trees in Hawaii occur on Kaindi. In fact this includes nearly all of the non-endemic woody Hawaiian genera. In the case of the fauna, most genera are different, but practically all of the major groups of Hawaii occur on Kaindi. Among the contrasts are the very much greater number of genera, in all major groups of plants and animals, in New Guinea. Thus the environment is much more complex on Kaindi than in Hawaii. Another contrast is that there are relatively far fewer introduced species in New Guinea, and their impact on the environment is proportionately much less. The same species of exotic weeds, especially woody ones, introduced into Hawaii and New Guinea have much greater environmental effect in Hawaii than here. To a great extent this probably relates to the greater number of genera and species with which the exotics have to compete in New Guinea, and to the fragile nature of the Hawaii environment resulting from the evolution of the biota there in the absence of many groups of plants and animals. This impoverishment, or disharmony, of the Hawaii biota resulting from extreme geographical isolation has fostered many dramatic evolutionary results. As examples may be mentioned the evolution of trees from ancestors that were herbs (violets, for instance), and spineless plants from ancestors that were spiny.

SYMBIOSIS and other aspects of ecology

One of the most complex and fascinating aspects of ecology is *symbiosis*, the close association or "together-living" of 2 or more groups of plants and animals with positive, negative, or neutral effects. There are many examples of symbiosis in this environment, but only a few have been studied in detail.

One striking example found on Mt Kaindi involves a very large leaf-eating weevil, *Gymopholus lichenifer* Gressitt. In cavities on the backs of these weevils grow various cryptogamic plants: algae, fungi, liverworts, lichens, and moss. Sometimes mature lichens cover the entire upper surface. The weevils have structures such as pits, tubercles, modified scales and hairs which encourage the growth of the plants and protect them from being scraped off. Living on or under the plants on the weevils are several groups of lower animals: protozoans, nematode worms, rotifers, plant-feeding and predaceous mites, and less commonly, spring-tails and bark-lice. (See Gressitt 1977a)

Another example of symbiosis here are insects which visit extra-floral nectaries of certain plants. The brilliant-flowered *Impatiens* plants on the top of Mt Kaindi are visited by ants, apparently feeding at extra-floral nectaries. Near the peak, large cryptorhynchine weevils and other insects feed at extra-floral nectaries on the terminal stems of *Evodia* (Rutaceae). At the foot of Mt Kaindi, extra-floral nectaries near the bases of the leaves of *Macaranga quadriglandulosa* Warb are visited by ants and members of several families of flies. *Homalanthus* (also Euphorbiaceae) also has similar nectaries.

The relationships of ants with scale insects and aphids are well-known in many places, and have been studied to some extent on coffee plants at Wau (see Szent-Ivany & Stevens). Communal spider webs, some spanning over 6 meters and containing over fifty individual spiders of a number of different species, can be observed stretching between trees near clearing edges. Many interesting aspects of spider ecology and symbiotic relationships have been studied at Wau by Dr M. Robinson and colleagues. (See Robinson; Robinson, Lubin & Robinson, etc)

Other aspects of the ecology of the area mainly await further study, although some important investigations are in progress and various reports are being written. Extensive new data are being assembled on bird feeding habits and seed dispersal by Thane Pratt; on movements of birds and other aspects by Bruce Beehler; on animal behavior by Michael Robinson and associates; on plant-feeding insects by Wayne Gagné, J. L. Gressitt and Goaru Nalu; and additional work by others.

DISCUSSION

The ecosystems of the montane New Guinea environment in large part fall into the montane humid tropical rainforest biome in the broad sense. Since much of New Guinea is montane and has considerable rainfall, the

local Kaindi forests are fairly typical of much of the island. The rainforest biota are therefore widespread. Moreover much of the New Guinea biota evolved in humid forest situations. This is why there are such differences between the biota of New Guinea and Australia in spite of their having been connected at more than one time during the Pliocene and Pleistocene periods.

The great diversity of the biota of montane New Guinea results partly from periods of evolution in isolation from other continents under favorable environmental circumstances. Likewise the geologic history of fluctuating size of island and possible break-up into small islands with later reunion, has fostered speciation and production of special essentially endemic groups such as the birds-of-paradise.

The Mt Kaindi environment appears to be unusually favorable, with its protection by higher mountains from strong winds and storms. The numbers of species of birds and other animals which these forests support is impressive. With the birds, for instance, it must be stressed that very few of these species are migrants and thus most are present at all times of year. Longer locality-lists for birds in temperate areas include many species that pass briefly through or spend short breeding seasons in the area.

In spite of the diversity and complexity of the montane biota, one can easily recognize quite contrasted zones with ecosystems quite different from others. Among the contrasted types for Kaindi are *Araucaria* mixed rainforest, of the Lower montane zone, and mixed Lower montane and lower Mid-montane rainforest without *Araucaria*; oak forest, and other lower Mid-montane rainforest with some oaks or lacking oaks; mid and upper Mid-montane forests of great diversity but often with elaeocarp trees of varying dominance; *Nothofagus* mixed Upper montane rainforest with varying degrees of dominance of *Nothofagus*, or without beech.

The zonation on Kaindi is conspicuous also in that species of trees at the foot of the mountain are different from those at the top, and even most of the genera are different. Only a few species of birds range from bottom to top of Kaindi. The same can be said of the majority of the insects. Among 95 species of phytophagous beetles (see Faunal lists), only 3 occur at both foot and summit of Kaindi, with 14 at top, 19 at middle and 63 at foot. Of 199 kinds of butterflies on Kaindi, only 8 were found both at the foot and the summit, with 38 at top, 101 at middle and 141 at foot. Of 566 kinds of moths listed, only 36 are recorded as common to both top and bottom, out of 182 from summit and 348 from the WEI grounds at foot of the mountain. Further analyzing some of the major groups of moths, the following figures emerge (numbers of species):

	1200–1350 m	2362 m	In common
Arctiidae	11	6	3
Drepanidae	13	4	0
Geometridae			
Oenochrominae	8	2	2
Hemitheinae	77	28	10

Sterrhinae	22	2	1
Larentiinae	11	10	2
Ennominae	88	24	5
Lymantriidae	6	6	1
Noctuidae	36	51	0
Notodontidae	5	7	0
Sphingidae	41	10	7
Uraniidae	6	4	1
Misc. families	25	11	1

It may be noted from these figures that with the butterflies and beetles, there are about 4 times as many species at the foot of Kaindi as at the summit, and that only 3 to 4% of the totals are common to top and bottom. However, with the moths, more than half as many species occur at the top as at the bottom, and over 6% of them are common to both.

In observations over 15 years, and more casually for longer periods, it has become evident that the montane New Guinea forest has great powers of self-regeneration. This contrasts greatly with the situation in Hawaii. Although most of the non-endemic genera of Hawaiian woody plants occur on Mt Kaindi, Hawaii's natural environments are far more fragile than those of New Guinea and tend to retreat rapidly in the face of human activities and/or invasion by introduced plants, birds or insects. On Kaindi introduced plants make little or no headway, with exceptions like weeds in completely changed environments, such as in plantings, along roads and such. Presumably the rich harmonic biota of New Guinea confront the introduced species with competition at so many levels that only under non-native conditions can the introductions make headway.

Small clearings within forest tend to be naturally revegetated in a relatively short time with a complement of tree species not greatly different from the local climax forest. This no doubt relates to availability of some shade and some humic soil, as appropriate, and presence of seeds in the soil. On the other hand, the kunai soil is depleted and oxydized, and the microorganisms are largely killed by sun, so that the forest is slow to regenerate, even when the kunai is not burned. The forest regeneration in a not too greatly changed environment clearly functions in a much shorter space of time than would be expected from statements in many textbooks. It is often stated that it would take 700 or so years to regenerate climax rainforest.

Diamond (1972) has demonstrated that a volcanic peak on an island N of New Guinea which exploded about 200 years earlier, is now covered with climax moss forest rich in epiphytes. On the Kaindi summit, *Usnea* lichens have developed on the weevil observation cage in 2 years. Roadcuts become covered with moss in several months where there is fog and shade.

The native slash-burn or Swidden agriculture has been carried on for centuries, with cyclical cutting of patches of forest, and abandonment of

gardens when soil became depleted – usually in about 2 years time. If the weeds and grass are not regularly burned, the forest will regenerate and may be cut again for new gardens in 20 years or less if required. However, if cultural methods are modified in the manner of the contour-mound composted agro-silviculture, to prevent erosion, enrich the soil and avoid burning, a better long-term system can be developed to reduce forest destruction.

CONCLUSIONS

The Mid-montane and the adjacent portions of the Lower and Upper montane zones of New Guinea form a highly favorable environment for evolution, and likewise for rapid regeneration of the highly diverse and luxurient forest. The primary dangers from the conservation standpoint are fire and wasteful cutting of forest. These foster transformation to grassland of little utility as well as excessive loss of soil and additional forest through severe erosion and recurrent landslides. The erosion and landslides have a wide range of severe effects on environment all the way to the ocean, as well as on development undertakings, such as roads, agriculture and others.

The environment is specially favorable by reasons of : 1) Lack of pronounced dry season; frequent fog as well as rain; 2) Infrequency of strong wind; 3) Moderate temperatures of very slight variation for both diurnal and annual cycles; 4) Great topographic range and diversity of rocks for soil sources; 5) Numerous niches and habitats as a result of favorable physical factors fostering lush forest and multiplicity of species in the biota.

Since regrowth in small areas cut in these rainforests consists of a considerable fraction of the elements of the climax forest, it would appear that reasonably similar forest can regenerate in this environment in less than 50 years, and a close approximation in 25 or 30 years.

Much of New Guinea is very young geologically and changes occur constantly. With the continuing elevation of mountains, slopes are steep. With the stress on the rocks from upthrust, earthquakes are frequent and there is much fragmentation of some of the weak metamorphic rocks, such as with the extensive schists of Mt Kaindi. With high rainfall there is thus rapid erosion and landslides are frequent.

The soils in these usually steep montane zones are thin in the main and are not extremely rich as the nutrients are being constantly recycled through rapid plant growth. Excessive exposure to sunshine destroys soil-forming organisms, which is one reason the kunai soils are so poor. Thus, these slopes need to have plants, including trees, growing on them from several different standpoints, for : 1) Constant production of new soil to sustain any useful growth (i.e., other than kunai); 2) Retention of soil by protection from excessive erosion including landslides; 3) Water conservation and flood prevention; 4) Providing habitat for at least a portion of the elements of the local native biota.

The prevention of fires in general will foster natural regeneration of forests on abandoned land. The practice of extensive burning of kunai has many harmful effects, both short-term and long-term.

The biota of the montane zones are rich and highly diverse. This diversity relates to the favorable environment, the complex topography and many other factors enhancing rapid evolution and local speciation. Many of the endemic species are limited to rainforest areas and many are found only in the montane zones. Evolution has proceeded in various directions on different mountain ranges as a result of isolation of populations when mountains were pushed higher or new ranges pushed up while rivers cut or maintained low altitude barriers. In relatively limited areas, large numbers of species have evolved. To protect these valuable portions of the natural heritage of Papua New Guinea it is necessary to take steps to preserve for posterity adequate sections of these environments. Not enough is known as yet of the ecology of individual species and of ecosystems to judge what are the minimum size areas to preserve all the species involved. This suggests the need for caution in all plans for forest exploitation.

An agricultural system that can help solve some of the major problems that will develop in the montane zones with population growth is being demonstrated at Wau Ecology Institute. It is called "Composted contour-mound agro-silviculture." This system incorporates some of the useful aspects of native agricultural customs but adds several tried by various workers. Some of the techniques have been further improved by Dr Gagné and colleagues at WEI. The principal features of this system include: 1) Constant re-use of the same land to avoid repeated cutting of more forest and consequent deforestation and excessive landslides and soil loss; 2) Contouring to reduce soil erosion and to permit gravity irrigation when required; 3) Heavy composting to provide nutrients, using all types of agricultural and animal wastes, grass cuttings, weeds, etc; 4) Diversified planting to provide varied diet and repeated small harvests of different kinds for reduction of build-up of large numbers of a single kind of pest or disease; 5) Planting 3 kinds of crops in each row (partly for preceding reasons), one a legume for soil nitrification; 6) Inter-planting some fruit trees and some for firewood – to draw nutrients from lower soil levels, to add to diet and to provide appropriate shade as well as materials for compost and fuel; 7) Non-use of chemical fertilizers or insecticides to foster self reliance and to avoid cash outlay and environmental abuses.

CONSERVATION

Because of Mt Kaindi's unique position and special interest, it is important that it be protected for posterity. The mountain's accessibility by road to the summit, with overnight accommodation available at the edge of the moss forest, the various nature trails, exceptional scenery, rich biota, and nearby institute with collections, make the area of special teaching and research value. The many scientific papers bearing on Mt Kaindi, and the extensive ongoing research on its biota, make the area one of great scien-

tific and educational importance.

Considerable damage from gold-mining and tree-cutting has been done to the environment on the Edie Creek and Wau sides, but about 2,000 hectares of relatively undisturbed forests remain. One notable aspect which is very encouraging from the conservation standpoint is that abandoned clearings within the forest area start regenerating native forest almost immediately if there is no further burning. Several such clearings have been observed over recent years, and some of these have young forest with many of the constituent tree species of the climax moss forest, reaching heights of 5 to 10 meters within 10 years.

In 1970, Wau Ecology Institute initiated a project for reforestation of bare kunai (grassland) slopes on the Wau side of the foot of Mt Kaindi, adjacent to the Institute grounds. This project has been proceeding consistently since that time, and the results are already observable. The very steep slope immediately above the Institute, being very rocky and almost without soil, has been very difficult to reforest. The local tradition is that this was the site of a great landslide a century or so ago. Wartime photographs taken on the Wau airstrip (Anon. 1974; Australian War Memorial; WEI files) shows the slope to have been very much the same in 1943–1944 as it was in 1970. Before September 1970 the grass was burned frequently, no doubt enlarging the treeless area at times, but it has not suffered burning since that time. In addition to *Pinus*, as well as *Araucaria, Casuarina* and many other kinds of native trees planted since 1970, other volunteers are appearing and in a few more years the slope should have a very different appearance.

Planting of other kunai slopes to the E and W commenced in 1976 and positive results are already evident. The less steep slopes and more extensive soil on some of these other grassy slopes permit the reforestation to proceed more rapidly than on the steeper rocky mountainside. The regrowth of the forest will make the whole area less subject to harm from soil erosion and fire.

Attemps are under way to encourage the traditional owners and neighbours of the Wau Valley and Kaindi areas to appreciate the value of keeping Kaindi under forest as a regional asset for education and appreciation of the local environment. Some of the leaders of the Biangai and Watut peoples are showing considerable interest.

In spite of continuing goldmining, vegetable cultivation, firewood harvesting and other exploitation of the Kaindi slopes, the prospects of perpetuating the remaining forests on Kaindi are not hopeless. With the continued planting of trees and greater success in fire prevention, kunai areas and clearings are gradually regaining forest status. The timidity of birds and the scarcity of certain larger birds and birds-of-paradise is a matter of considerable concern. This relates to heavy pressure of hunting with bows and arrows by squatters and miners. However, as trees of the second growth grow taller, the populations of various species of birds become more secure. Fortunately, there are few shotguns in the area and additional licences are unlikely to be issued.

The Institute is situated at the foot of Mt Kaindi and is dedicated to education, research and conservation. WEI has been involved in teaching and guiding classes from primary and high schools, colleges and universities of the country. In this instruction the understanding of the local environment and the protection of the natural resources of the country have been stressed. The Institute possesses representative collections of the many groups of plants, mammals, birds and insects, as well as a large arboretum and a growing zoo. As the arboretum is extended and the trees grow in height, the grounds are becoming more of a nature sanctuary. The planting of trees on nearby slopes is widening the connecting strip between the arboretum and the mountainside forests. Thus more elements of the native biota are entering the Institute grounds. Each year more species of birds and other animals are seen in the 80 hectares of the WEI grounds. Now at least 100 species of birds inhabit the grounds.

The Institute also guides nature tours and other groups, and provides facilities for researchers. WEI has a hostel, a staff house, staff residences and guest houses, which provide accommodation for students, researchers, fellows, nature tours and casual visitors as space allows. An Audubon Society nature movie has been made at the Institute. WEI publishes handbooks, pamphlets, guides, leaflets, biennial reports and newsletters. These deal with fauna, flora, ecology and conservation. WEI welcomes collaboration with other institutions toward the goals of better understanding and protection of the New Guinea environment. The Institute is a non-profit corporation and is to a considerable extent self-supporting; it depends also on the founding sponsor (Bishop Museum of Honolulu), associate sponsors, and donations from foundations, corporations and individuals.

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APPENDIX

GUIDE TO KAINDI NATURE TRAILS

Mt Kaindi has 2 summits on its N-S ridge, 2365 m (N) and 2362 (S), or nearly 7,800'. The road leads to S summit and WEI branch station (3 small buildings) just before open area with telephone repeater station. The nature walks consist of 6 sections (Many of the plants mentioned are illustrated in the flora section) :

I. Clock-wise around flat area of S summit.
II. Counter-clock-wise around S summit, starting W down power line, left on 1st or 2nd water-race, past several ponds, crossing track S from repeater station and around on 2200 m contour, across power-line track to Wau and eventually up to road between N and S summits. (Allow 3 hours).
III. To N summit along road to parking space at end of pond by Omas' house on ridge, up track into moss forest, straight or veering right, eventually to helicopter pad beyond summit. Or early path to left and along summit ridge. (Allow 2 hours return, or a few minutes for just a glimpse of moss forest).
IV. Down power line track (transect) to Wau, past WEI branch station (E). Come out on WEI main grounds. (Allow at least 3 hours).
V. Down road to Wau (16 km).
VI. WEI zoo circuit, with extension to bird-of-paradise display area.

I. REPEATER STATION AREA

1. *Poecilogyne* shrub (Melastomataceae) along side of main WEI building.
2. *Rubus moorei* (Rosaceae) vine at entrance from road. Berries edible. Mixed with *Dicranopteris* (*Gleichenia*) fern.
3. Rhododendrons (Ericaceae) planted on left, at start of flat area. Also some young *Phyllocladus* (gymnosperm with thick flat needles of unusual shape).
4. *Evodia* (Rutaceae). Small tree left side of gate. Smell a crushed young leaf for citrus odor. Two other species grow on this walk, one with single leaf instead of trifoliate.
5. *Elaeocarpus* (Elaeocarpaceae). Some young trees near wind gauge. Most species have glands at bases of leaf veins.
6. *Eurya tigang* (Theaceae). Very common small tree. Favorite host of *Gymnopholus* weevils which often bear plant growth (see Symbiosis ....). Please do not collect or remove weevils, as they are under study.
7. *Albizia falcataria* (Leguminosae). This tree grows very tall; usually occurs on steep slopes of ravines, 900–1800 m. Some large ones near road below 1800 m weather station.
8. *Alphitonia incana* (Rhamnaceae). Common second-growth tree in highlands.

9. *Archboldiodendron calosericeum* (Theaceae). This rare tree is only known from a few localities. Named after the Archbold brothers (Archbold Expeditions).
10. *Macaranga* (Euphorbiaceae). Common 2nd-growth tree with hanging ovate leaves. Other species occur on slope of Kaindi and in WEI grounds. From here observe slope below you. Less than 10 years ago it was a wide bare landslide and is now almost completely self-revegetated. The flat area behind (3) was also nearly bare, as was the opposite W slope, in 1968.
11. *Polyscias* (Araliaceae). Tall slender trees on slope, with long pinnate leaves. Look across to next ridge to E. It was completely forested until 1965, and the ridge beyond still more recently.
12. *Spiraeopsis* (Cunoniaceae). There are several genera of this family nearby. Large leaf-bracts are conspicuous.
13. Birds frequently seen here: Wood swallow (*Artamus maximus*) flying out from telephone towers to catch insects in air. Swiftlets (*Collocalia*) with slender wings also catch insects on the wing, usually lower down. Doves and lories fly above tree-tops below you. *Rhipidura, Pachycare*, etc in trees nearby. Princess Stephanie bird-of-paradise with long tail, in tall trees, and sometimes Brown sickle-billed bird-of-paradise, with long pointed tail.
14. Distant mountains; if clear, see Mt Missim to N; Bowutu Mts parallel to coast of Huon Gulf, to N of Garaina (ESE). To SE are the Owen Stanley Mts – Mt Strong a large shield-like dome, Mt Chapman to right. The Bulldog Road starts in Edie Creek basin below you on W and extends along ridge connecting Kaindi/Edie with main divide (Ekuti Range), passing behind E end of range. Highest peak of this range is Mt Amungwiwa, 3400 m, well to W of middle of range. See alpine grassland (pale) around and beyond Amungwiwa. Then Kratke Range (E Highlands), WNW, and N of it a mass including Mt Otto, Mt Wilhelm, etc. On start of steep down-slope on way down road, look for Saruwaged Mts on Huon Peninsula (NNE).
15. *Nothofagus* (Fagaceae). Southern beech dominate much of main ridge and include the single tall remaining tree NW of repeater station, and groves of various size-classes to left, right and behind. These are *N. carrii* and *pullei*, whereas the even taller and straighter *N. grandis* are near road on hump above Blue Point.
16. *Sericolea* (Elaeocarpaceae). Tree with slender pointed leaves with golden pubescence beneath.
17. Ericaceae. There are several species of *Vaccinium, Rhododendron, Dimorphanthera* and *Gaultheria* near the edge, and along track down S ridge to contour track.
18. *Scaevola* (Goodeniaceae). Vine on fringe of flat area with yellow "half-flowers."
19. *Planchonella* (Sapotaceae). Tree with long narrow leaves with buff pubescence beneath, near large insect cage containing *Gymnopholus*

weevils and young *Eurya, Evodia, Rapania, Homalanthus* and *Rubus.*

20. Young Southern beech trees (R. Hynes donation) brought from other parts of New Guinea. Planted along top of road bank, W wide (S to N) on each side of power line. Left to right: *Nothofagus starkenborghi*, (2 rhododendrons), *N. resinosa* (2), (*Phyllocladus*), *N. starkenborghi*, (*Phyllocladus*), (power line), *N. pullei, N. rubra,* (*Rhododendron*), *N. perryi.* Some of these species are again duplicated along lower fringe of WEI cabins and outhouse.

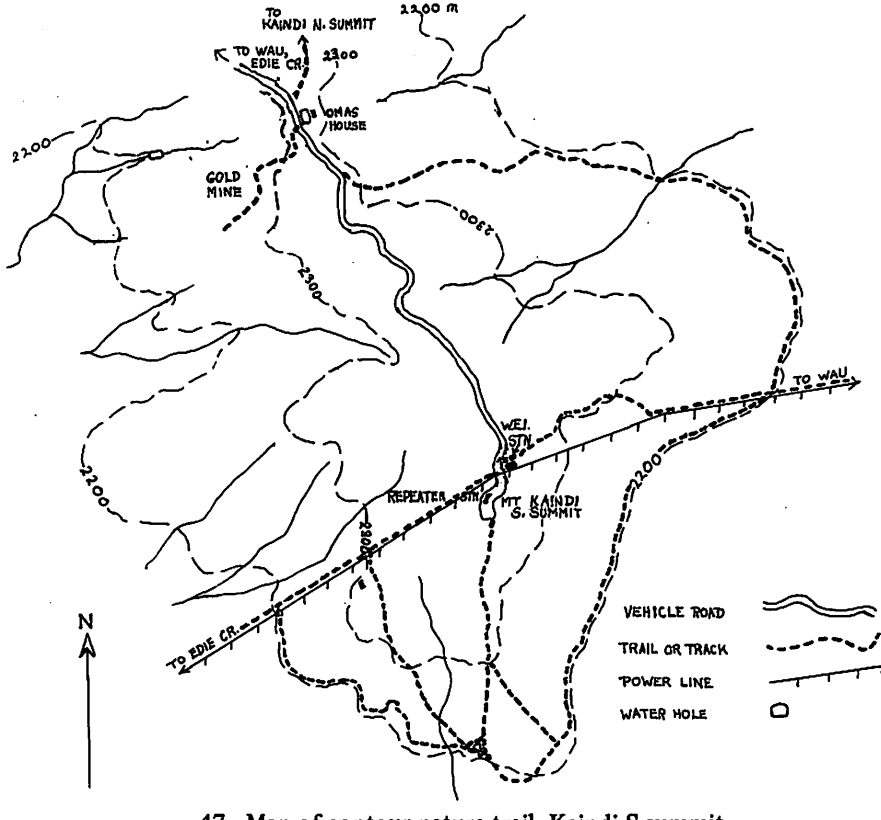
II. CONTOUR CIRCLE WALK

Follow powerline to W, toward Edie Creek, to right facing flat area. This powerline stretches from town of Wau, over S summit of Kaindi, to Edie Creek. It is maintained by New Guinea Goldfields through regular cutting, so vegetation remains in a constant state of new regrowth. The small buildings across the road form the Kaindi branch station of Wau Ecology Institute. The dormitory, bunk house and laboratory provide living and working space for researchers, students and other visitors on Kaindi.

1. Tangled ground cover includes false-staghorn fern (*Dicranopteris*), raspberries (*Rubus*) and *Uncaria* shrub/vine with hooks. Also small-leaved *Elaeocarpus, Evodia* and *Macaranga* trees.
2. Tree fern, *Cyathea atrix*, with umbrella-like form.
3. Vine bamboo. Hanging tangled strands to right is *Nastus productus.* Its dense, at times almost impenetrable, growth form occurs in recently disturbed areas such as along paths and in small openings in forest.
4. Trees at bottom of dip are mostly *Elaeocarpus, Saurauia* and *Evodia.*
5. Stump at top of rise. Several Ericaceae at bank of stump, including *Dimorphanthera* and *Vaccinium.* Turn left at small water race and follow it to clearing. (If you miss that and find yourself on larger water-race bank, turn left likewise, 1 km to high dam of logs and climb up bank to higher water race.)
6. *Dawsonia* moss. This spiky ground cover is one of the world's largest mosses, and is common in mid-montane rainforest. The male and female fruiting bodies may be visible, a central cup-like structure on stalk, or a diamond-shaped flattened-concave lobe to one side.
7. Clearing near house. Here you observe plant succession response to clearing of original forest by man. Primary forest has been cut for housing and firewood, and cleared ground used for gardening. Soon, tree species such as Macaranga and Homalanthus invade, and following them other species from surrounding forest establish themselves, increasing species diversity and ecosystem stability as time passes. Walk to left, on level following ponds and water race.
8. Gold works. These ponds and water races are used by people mining gold a bit farther down in Edie Creek basin, a continuing activity from the 1920's. This has great impact on many aspects of environment.
9. Large ginger plant across water race (Zingiberaceae). This group is well

represented in New Guinea rainforests, and includes edible ginger. There are numerous species on Kaindi. The brightly colored flowers and fruits are *caducous*, falling off early as compared with such structure on other plants. Beginning of forest; cross stream and follow middle path, on contour.

10. Red groundcover. Red leaves are juvenile forms of ferns and herbs. As they mature, normal green color will mask red pigments now seen. Some consider the pigment a protective device against strong radiation on the young and more vulnerable vegetation. Being red, it reflects hot rays.
11. *Pandanus* plants. These large monocots with long spined leaves in spirals have serial prop roots to support them above ground. The pandan heads provide a rich habitat for many types of arthropods and other invertebrates, and even some birds (swiftlets) and mammals (possums). Fruit of some pandans, as "karuka" a large many-sectioned nut and the pulpy red "marita" are prized foods in many parts of the country.



47. Map of contour nature trail, Kaindi S summit.

12. Epiphytes. A fascinating aspect of rainforest is the wealth of epiphytes, growing on other plants, deriving support but not nourishment from their hosts. Many upper tree branches are loaded with layers of epiphytic mosses, ferns, rhododendrons, orchids and others. They obtain moisture from rain and fog and organic material accumulating around their roots provides nutrients. These plants in turn provide suitable habitat for insects and other animals.
13. Wau overlook. If weather is clear, part of Wau Valley will be visible below. The frequent fog keeps the moss forest lush at this elevation.
14. Nettle family. Much of the low shrubby ground cover includes members of the Urticaceae, which includes nettles. Many of the local species do not sting, and some do only mildly. The genus *Laportea*, however, which includes sizeable trees and has large leaves, is a painfull stinger. It usually occurs at lower altitudes.
15. Epiphytic flowers. You may see blossoms scattered on the ground with no parent plant evident. These often fall from epiphytes high in trees. Some common epiphytic rhododendrons on Kaindi are *leptanthum* and *konori*.
16. Landslide. This landslide is result of combination of natural and man-induced forces. Natural processes such as heavy rainfall and earth tremors shift rock or surface layer. When trees are felled and soil-binding roots die, further weakening in loss of soil stability results and landslides occur. A similar process of vegetational succession which occurs on man-made clearings such as the vegetable garden at Station 7 will eventually take place here. It is a long-term process to re-establish forest on bare and unstable rock. On approach to powerline, observe Begonia plants, some of which are usually flowering near path. At powerline, several paths are available. Up the powerline is direct but very steep; down the line takes you to WEI and Wau (2.5 hours). Continuing on contour trail takes you gradually up to the road on summit ridge, between N and S summits. Often interesting birds to see in the somewhat disturbed mossforest.

III. NORTH SUMMIT MOSS FOREST AND HELICOPTER PAD

1. Start at pond by road, at pass on main ridge (Omas' house and mine). Go N, up bank to left from parking lot, N end of pond. Facing the forest, Wau is on your right and Edie Creek on your left. Enter moss forest on small path up through grass and left of small cleared area above parking lot.
2. At edge of forest notice regeneration by *Macaranga, Eurya,* bamboo (*Nastus*), etc outside forest, and by more species, including *Nothofagus*, in cut areas along path. There are branch paths to left, but keep going straight, through 2nd growth, and the path will improve in the less cut portions, except where trees have fallen over it.
3. Look upward and notice great masses of epiphytes on high branches

of the *Nothofagus, Elaeocarpus, Sloania,* various Rutaceae and other trees. Large fruit bats (flying foxes) sleep among hanging epiphytes.

4. Notice that gaps where large trees fell or were cut earlier may be partly filled with young *Macaranga, Homalanthus, Eurya* and those mentioned under (3). When a very large tree laden with epiphytes dies, the epiphytes continue to live (demonstrating that they are not parasitic) and long after, as the trunk rots, the whole mass will fall, pushing down other trees in its way, to make a natural clearing. This can completely obliterate a path for some distance, or on steep slopes a large landslide may result.
5. Look for the tall *Dawsonia* mosses (see 6 under II).
6. Note the various kinds of gingers, as well as lilies, orchids, ferns, mosses, hepatics (liverworts) and others, on ground as well as on trunks and branches. Also *Freycinetia* (Pandanaceae), *Nastus* bamboo, and other vines.
7. Keep going in a fairly straight line, to N, passing summit on your left. Summit is forested like rest of ridge, until you approach helicopter pad.
8. From helicopter pad, if clear, you will see Bulolo Valley beyond the Edie Creek and Bulolo Gorges, and beyond is Mumeng and the Zenag pass leading to Markham Valley and Lae, with 2-peaked Mt Shungol to right of pass, where Lae road crosses. If very clear, you may see the Saruwaged Range beyond (Huon Peninsula). Wau is to right, out of view.
9. Several small *Metrosideros* trees to right (toward Wau), bright red flowers when blooming. Return by same route.

IV. WALK DOWN POWER LINE TO WEI

1. Allow at least 3 hours. Track is slippery when wet, and partly quite steep. Go left (facing repeater station) from road, under power line, past WEI cabins, and to left of power pole.
2. Enter moss forest; observe submature, or young, *Nothofagus, Evodia, Elaeocarpus, Sloania, Drimys* (white flowers or green fruit on long petioles; Winteraceae). Notice moss/liverwort groundcover; take care stepping between roots as there may be bryophytes and no soil. Algae on logs, roots or rocks make them slippery.
3. Returning to power line clearing you see regrowth of *Macaranga, Homalanthus, Eurya, Evodia,* etc. On banks or stumps are shrubs: *Rhodomyrtus, Cyrtandra, Dimorphanthera, Poecilogyne, Medinilla,* and vines of *Rubus, Scaevola, Palmeria*, etc.
4. At 2200 m you pass the contour trail; slope becomes steeper. There is no more *Nothofagus*, but more *Macaranga, Homalanthus, Sericolea, Elaeocarpus, Saurauia*, Rutaceae, etc. The climbing bamboo (*Nastus*) and *Uncaria* go a bit lower, but not as far as the preceding.
5. Below 2000 m more species of *Macaranga* and *Ficus* occur, and partly

different species of Elaeocarpaceae. A bit lower, exotic composits and other weeds begin to appear in the open power line strip. There are some *Phyllocladus* and other Podocarpaceae below 2000 m, some to 1700 m.

6. At about 1900 m *Albizia* begin to appear. This very tall pale-barked leguminous tree grows mostly in the ravines between 800 and 1700 m.
7. At 1850 m there is considerable large bamboo (*Bambusa vulgaris*) and another kind, along a somewhat level stretch, suggesting that there may have once been a village in the area, though it would have been long ago, before the goldminers came. Also at this altitude and a bit higher the oak zone begins, with *Castanopsis* and *Lithocarpus*.
8. Inside the forest *Dawsonia* moss may be seen to as low as 1745 m.
9. At 1760 m the track enters remnant forest. Many of the trees are Elaeocarpaceae, as well as oaks. This is opposite top of the steep grassy slope, to left, being reforested by WEI. At path going left you can walk out and have a view. This path re-enters forest and goes into Kunai Creek basin (requires extra time).
10. At 1650 m the path passes through a Goilala squatter village, then along ridge into WEI grounds. Below here prominent 2nd growth trees are *Trema, Pipturus, Ficus* and *Macaranga quadriglandulosa*. Just below water race is path through coffee to WEI coffee factory and house No 1. Or continuing down ridge a level path takes you left to bend in road, still above WEI office, or continuing down ridge you can reach WEI zoo.

V. BY ROAD BACK TO WAU FROM SUMMIT

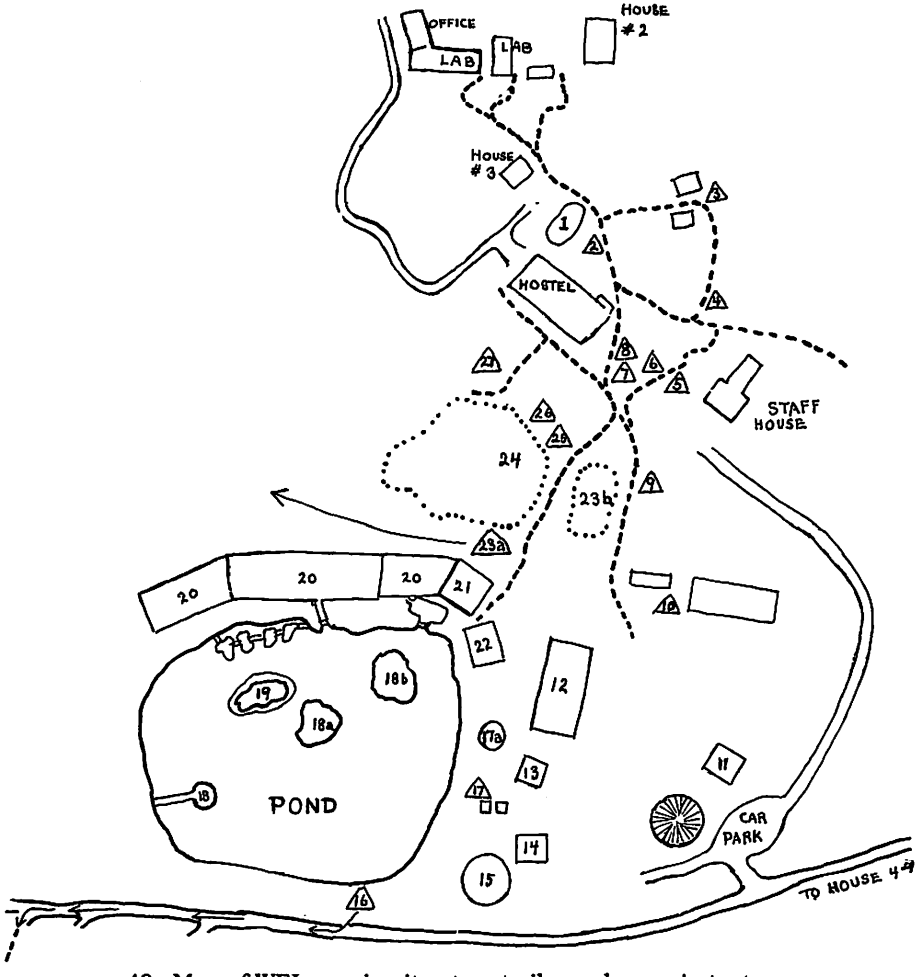
1. Along main ridge vegetation is as described above for S summit, with little difference between primary and secondary forest. Dropping through part of the steep portion, between the rise after the switch-back for Edie Creek and the low peak at left, 2100 m, the Southern Beech has changed from *Nothofagus pullei* to *N. grandis*. Latter is taller and straighter, with rougher bark and larger leaves. Below this there is no more beech. There is a gap between the beech and oak zones, characterized by many elaeocarps.
2. At 2000 m or higher both the Princess Stephanie and Brown sickle-bill birds of paradise are sometimes seen. Below this the 6-wired Parotia, the Blue bird of paradise and still lower, 1400–1500 m, the magnificent bird of paradise occur.
3. At about 1900 m a water race passes under road. One may walk along it in either direction, but particularly to right (E) there is good bird viewing. Parrots, hawks, owls, gray birds, flycatchers and others in the tall trees.
4. After the 1800 m return to the old road, the environment is more disturbed. Tall *Albizia* trees below road and forest above; then the highest coffee plantation, golden ridges mines below and reforestation on kunai above.

5. From about 1700 m or a bit higher you are in the oak zone, with numerous *Castanopsis* and *Lithocarpus*. There are still elaeocarps with them, as well as many other kinds of trees, but the *Castanopsis* sometimes occur in almost pure stands.
6. At about 1550 m you reach the upper edge of the *Araucaria* zone, which overlaps with the oak zone. As you enter Kunai Creek gorge watch for the black and white torrent larks.
7. As you round the sharp bend at 1360 m, leaving Kunai Creek gorge you are just below the steep kunai tree-planting slope and below you is coffee again. The King parrot and some doves are often seen here. Many more kinds of birds occur inside the institute grounds, in portions where trees are taller.

VI. WEI ZOO CIRCUIT NATURE TRAIL

1. Hostel pond. This is a complete and balanced ecosystem with the components of the larger world of nature in miniature. Trophic, or energy transfer, relationships keep an equilibrium among the elements. Energy comes from the sun; green plants, the primary producers, convert sun energy to usable sugar and oxygen; fish and some insects feed on plants and are primary consumers. Secondary consumers, or predators, including frogs, birds and some insects. Dead animals and plants decompose and provide nutrients that are re-used, continuing cycle.
2. Orchid on *Lithocarpus* tree. This epiphyte, *Coelogyne fragrans*, is 1 of over 3000 orchid species in PNG. Note its roots and "pseudobulbs" which store water.
3. Rhododendron garden. A WEI project, carried out by Paul Kores from 1974 to 1978, concerned rhododendrons of New Guinea, which number well over 100 kinds. Rhododendrons are propagated from cuttings, in the mister, the fine spray of which maintains high humidity. Nutrients are provided by liquid fertilizer. After root formation in 3–4 weeks, the cuttings are moved to the hardening-off beds, with more shade and less water. After another month they are put in open beds, with still less water. In 6 months they are ready for planting out or shipping.
4. Mature rhododendron: *R. aurigeranum*, found mostly in the Wau Valley.
5. Kunai. This patch of grassland was formerly kunai, which has been replaced by molasses grass, *Melinis minutiflora*. Kunai, a combination of grasses (*Themeda, Saccharum, Imperata*) did not occur naturally, but was induced by repeated burning, which was harmful to the land. Its replacement is an example of ecological succession by an immigrant species.
6. Ecological succession. In the shade of these trees you can observe succession also. In absence of fire the grasslands can be replaced by forest.

7. Heliconia and ginger plants. Heliconia belongs to the banana family. The large red and yellow "flowers" are bracts, modified leaves, and store water. Mosquitoes may breed in the stored water. Gingers belong to Zingiberaceae, which includes edible ginger and turmeric. Cardamom is closely related.
8. Bamboo. *Ngele* in Biangai or *mambu* in pidgin, it is used for building, bows, arrows, combs, flutes, pipes and spearpoints, while tender shoots are eaten.
9. General view of WEI grounds. Here you can see several of our projects. WEI, established as a field station of Bishop Museum of Honolulu in 1961, became a partially self-supporting independent institution in



48. Map of WEI zoo circuit nature trail; numbers as in text.

1971. Above you are the slopes of Mt Kaindi where WEI has a branch station. The kunai slope to your right is being reforested with conifers and local trees and shrubs. The amphitheatre before you has demonstration and experimental gardens, fruit-tree orchards, and coffee. The zoo, with ponds, is below you. The staff house is on the hill 100 metres W, and lecture hall will be built on hill to SW.

10. Snake house to left and 4-section mammal cage to right. Usually housing at least green tree pythons and black d'Albertis pythons, and various kuskus (possums) respectively.
11. Tall bird cage. By round kunai house: main entrance to zoo. Parrots and lories.
12. Large kokomo cage. The hornbill is one of the largest forest birds, feeding on fallen fruit. This male was born in 1973.
13. Tree kangaroo cage. *Dendrolagus goodfellowi* is one of 4 kinds of tree kangaroos.
14. Cage for flying foxes (large fruit bats). These bats rest in large trees and fly around in search of fruit at night. Note the staghorn fern on nearby tree trunk.
15. Crocodile pen. Large one is saltwater crocodile and 2 smaller ones are freshwater species. The numerous carp are feeding on algae and on meat thrown to the crocodiles.
16. Raggiana bird of paradise. This bird, the national emblem, is abundant in the arboretum. Its loud repeated call is common. You might see males displaying about 06:30 in remnant forest from trail turning off to left from road below big pond, where taller trres are close to road.
17. Sugar glider. This "flying" marsupial is strictly nocturnal, but may be seen coming out to feed late in afternoon.
18. Pond islands. Water for this large pond comes from upper branches of Hospital Creek over 2 km away. From this island you see water lilies, water insects, and probably the ubiquitous cane toad, *Bufo marinus*, introduced, poisonous and a nuisance, though it does feed on insects. Two large islands have a different species of tree kangaroo each (Matchie's and Ornate).
19. Wallaby island (surrounded by fence). Lesser forest wallaby. Nocturnal and living in forest shade (*Dorcopsulus vanheurni*).
20. Dwarf Cassowary (Muruk). Three pens each have 1 muruk.
21. White cockatoo (*Cacatua galerita*), or Sulphur-crested cockatoo. Feeds on nuts, some fruits, maize and sugar cane.
22. Larger forest wallaby (*Thylogale bruijni*). This wallaby also lives in shady rainforest.
23. Fruit and nut tree culture. One of WEI projects is cultivation of fruit and nut tree crops appropriate to this altitude zone. Alistair Hay is developing this project, together with Wayne Gagné's agrosilviculture. There are avocado, citrus, banana, various Annona (soursop, custard apple, etc), pineapples and many other kinds to left, behind muruk pens (23A); and apples planted by Ken Willson of University PNG

upslope (right) at 23B.

24. Research garden. This is the Contour-mound composted agro-silviculture project under W. Gagné and G. Nalu. This system is demonstrated to advocate continued use of same ground to reduce forest destruction, erosion, burning and other harmful practices. It incorporates various benefical aspects of PNG traditional agriculture. Main emphasis is on heavy use of all kinds of material for compost, such as coffee pulp/hulls and other agricultural wastes, kunai, lawn cuttings, weeds, garbage, manure, leaves, etc. Some forest humus should also be added. Vegetables are grown with some fruit trees or other trees, to recycle nutrients from greater depths in soil and to reduce erosion on steeper slopes. Vegetables are planted in as great variety as practicable, to reduce insect problems. No chemical fertilizers or insecticides are used. Three crops, including a legume, are planted parallel in each mound. After harvest, rows are switched, with new compost put in ditch between rows, and soil shifted over.
25. *Castanopsis* tree. Predominant tree in oak zone, from here to half way up Mt Kaindi. The nuts, like small acorns, are edible.
26. *Araucaria* trees. This is a young klinkii pine. Hoop pine is also *Araucaria*. These are the basis of the Bulolo plywood industry. See the tall specimens on ridge to E. Tallest trees in this area. Hoop has small needles, klinkii large needles.
27. Coffee. *Coffea arabica* is grown here and at higher altitudes. This area has study plots for fertilizer evaluation. WEI has a coffee factory up the road. Return to hostel. Another path leads up to laboratory and office.

ADDENDUM

The "pink vaccinium" (page 73) is apparently *Vaccinium acrobracteatum* K.Sch.

WAU ECOLOGY INSTITUTE

This book is published by the WAU ECOLOGY INSTITUTE, which is an organization dedicated to education for ecology and conservation in Papua New Guinea. The Institute is located at Wau (alt. 1200 metres) in the mountains of eastern Papua New Guinea. It encompasses a large arboretum of native plants, a zoo, a small museum, and some facilities for research.

Visitors are welcome at the Institute. There are guest houses and a hostel, with bedding and cooking facilities supplied. There is a branch station at 2360 meters altitude. Inquire for rates.

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Publications of Wau Ecology Institute

Handbook of common New Guinea Frogs, by J. I. Menzies. 1976, 75p. 12 col. pl. Price K3.00; US$4.50.

Handbook of common New Guinea Beetles, by J. L. Gressitt and R. W. Hornabrook. 1977. 87p. many illustr., 4 col. pl. Price as preceding.

Guide to biological terms in Melanesian pidgin. By Martin Simon. 115p., illustr. Price K2.50; US$4.00.

Upland birds of Northeastern New Guinea: A guide to the hill and mountain birds of Morobe Province. 1978. 156p. many illustr., 5 col. pl. Price K5.00; US$8.50.

Guide to Mt Kaindi: Background to montane New Guinea ecology. 1978. illustr. Price K3.00; US$5.00.

Guide to native land mammals of northeast New Guinea, by A. Ziegler. 28p. K1.25.

Ecology and Conservation in Papua New Guinea, edited by K. P. Lamb and J. L. Gressitt. 1976, 153p. K1.35; US$2.00.

Yumi olgeta laikim diwai (We all need trees), by J. L. and M. K. Gressitt. 1975, 8p. K0.20; US$0.40.

First Biennial Report, 1971-1973, 14p. illustr. and Second Biennial Report, 1974-1975, 14p. illustr. each K0.50; US$0.80.