

Oak forest and cloud forest expanded. *Podocarpus* sp. grew at relatively high altitudes on the Saruwaged Mts.

Man was present throughout this time in the Papua New Guinea Highlands. The presence of the pig and possibly the beginnings of agriculture have been recorded after 6,500 BP.

During this period forests, at least on Mt Wilhelm and the Saruwaged Mts, seem to have reached their highest altitudes. From a climatic point of view, this change is consistent with a warm climate with high humidity and low frost frequency, as suggested by Costin *et al* (in press) for the Saruwaged Range. Only a minor change of about $+1^{\circ}\text{C}$ would be involved. The lapse rate may have been slightly lower than present because the shrub-rich zone was apparently constricted, as it did not extend into the summit area of Mt Wilhelm. Accordingly the theoretical snowline may have been as high as 4,900 m. If this applied to the whole island, then the West Irian peaks would have been deglaciated also.

Alternative explanations due to man are examined after the last period is discussed.

Period 4. 5,000 BP to the present.

Glacial advances occurred in the Carstensz Mts, one (or more) before 3,000 BP and at least three post-dating 2,400 BP, the last of which ended possibly only 100 years ago. There may have been snow dome formation or erosion by solifluction on the summit of Mt Wilhelm at least three times since 6,900 BP, the earliest episode being the most severe, while the last episode probably ended recently.

On Mt Wilhelm the closed treeline was depressed below 3,900 m, and shrub-rich grasslands have been present since 5,000 BP at Brass Tarn. Extension of shrub-rich grasslands at lower altitudes has taken place within the last 600 years. Oak forest declined prior to 5,000 BP, and gardens with *Casuarina* occupied previously forested areas after 800 BP. On the Saruwaged Mts subalpine grasslands spread within the last 5,000 years and soils were locally unstable before 2,600 BP. The oak forests near Mt Hagen and Sirunki were disturbed and cut into before 5,100 BP. At Lake Inim disturbance might not have taken place until 1,500 BP.

Man was present in the highlands of New Guinea throughout the period. A complex agriculture, recorded at 2,600 BP, may have begun as early as 5,000-6,500 BP (White 1972). Fires were lit by man at 4,000 m on the Carstensz Mts about 5,000 BP, and charcoal from fires with unknown causes has been found dated at less than 5,000 BP on the Saruwaged Mts and Mt Giluwe.

This period contains vegetation changes that are probably directly caused by man rather than by climate and other changes which could be attributable to either. It seems clear that minor changes in climate at high altitude have occurred with drastic, but probably very local, results for the vegetation. In the Carstensz Mts the glacial advances could have been due to slightly lower mean temperatures or higher snow accumulation rates. Shrub-rich vegetation outside and above the ice advance margins has apparently been unaffected by the most recent advance and so greatly increased frost intensity seems unlikely. The evidence from Mt Wilhelm is for soil instability that might have been the result of solifluction, because there are fossil solifluction terraces on some areas of the summit. Solifluction, implying colder and drier periods, may not have been synchronous with the ice advances of the Carstensz Mts. If the soil instability was due to permanent or seasonal snow cover then the most recent phase might well correlate with the most recent advance of the Carstensz Mts glaciers. Solifluction down to 3,800 m in the Saruwaged Mts shortly before 2,600 BP, as suggested by Costin *et al* (in press), seems most unlikely as an explanation for soil instability at such a low altitude.

The treeline depression on Mt Wilhelm may be consistent with more severe temperatures after 5,000 BP. If so, the reduction in oak forest at lower altitudes at about 6,500 BP may reflect a reversal towards Period 2 conditions, although *Nothofagus* forest evidently did not increase then as might be expected. The forest destruction phase, starting about 800 years ago on Mt Wilhelm and at unknown times on the other mountains, does not seem consistent with a climatic explanation, because the forest now occupies the same range of site types (drainage, aspect, altitude etc.) as those supporting grassland. A climatic deterioration would result in grassland occupying areas less favourable to forest.

The effect of man in this period has obviously been more important than in the previous periods. The climatic changes indicated by the glacier advances may well have had only very local effects, even above 4,200 m. If the depression of the treeline on Mt Wilhelm and of the *Podocarpus* sp. on the Saruwaged Mts, was caused by man-made fires, the climatic inference of a slightly warmer Period 3 must be abandoned. The evidence is not conclusive at this stage, but substantial soil instability seems to have followed fires on Mt Giluwe and the Saruwaged

Mts in the last 3,500-4,500 years. This may explain the deposit which Costin *et al* (in press) attributed to solifluction. The early change in oak forest may reflect clearance for gardens without planting *Casuarina*. This would explain the absence of increases in other forest elements following the *Castanopsis* declines. However, the absence of *Casuarina* from such cleared areas is puzzling, since Powell (1970a) found *Casuarina* to be present at her sites from before 5,000 BP. Temporary slash and burn agriculture may explain this anomaly, but *Castanopsis acuminatissima* is a regrowth tree and could be expected to be prominent in such a system. Thus the causes of change in the lower forests of Mt Wilhelm remain in doubt until 800 BP when it is more certain that active clearance took place in them and at higher levels with an apparently continuous expansion to the present day. White (1972) has reviewed earlier theories that a marked change in the economy of the highlands took place when sweet potato was introduced about 400 BP. He considers that a large increase in population may not necessarily have taken place, although he does not rule out a possible shift in cultivation to higher slopes, more suitable for this crop. The evidence from Mt Wilhelm does, however, support a recent large increase in garden area (and presumably population) in the upper Chimbu that started more or less contemporaneously with the supposed date of introduction of sweet potato. This population has put increasing pressure on the high altitude vegetation of Mt Wilhelm quite recently, whereas a longer history of substantial disturbance may be shown from the Saruwaged and Carstensz Mts in future studies.

The climatic and anthropogenic explanations could be complementary. A forest boundary may be stable in a given area under a given climatic regime, but be unable to recolonise if once removed. Up to a point human disturbance tends to hasten the adjustment of vegetation boundaries to climatic limits. In this respect, to talk of the subalpine shrub-rich or tree fern grasslands as being either 'anthropogenic' or 'natural' at present is to miss the point. It is possible that these grassland communities are in balance with the present climatic conditions over a wide area of the New Guinea mountains and that man has made at least part of this area available by removing forest which first became established there in a milder climate.

Conclusions

From the foregoing discussion it will be clear that I favour a predominantly climatic explanation for the distribution of mountain vegetation prior to 10,000 BP followed by a transfer of emphasis to control by man. For this reason it is not proposed to correlate the results in detail with 'climatic' sequences from other areas in the world, especially since new doubts (eg Mercer 1969, Moar 1971) are now being cast on the extent or synchronism of these sequences, particularly over the past 10,000 years. New Guinea may have had a powerful regional climatic control, imposed by the changes in the extent of the sea on the Arafura shelf, making correlations still more difficult. The nearest area for which comparative results have been obtained is in north Queensland (17°S) (Kershaw 1970, 1971, personal communication) which lies within the southeasterly wind zone. Here the inferred climate changed from effectively wetter before 25,000 BP to relatively cool and dry until 11,800 BP. After this temperature and moisture increased until tropical lowland rainforest communities became widespread after 7,500 BP. The climatic reconstruction of Nix and Kalma (1972) appears to be consistent with these changes as it is for those in New Guinea.

As noted previously, the general retreat of the glaciers from a maximum before 15,000 BP is apparently in agreement with results from other tropical mountains. Although the Otomona advance has no known correlate, it can be explained in terms of precipitation changes related to the Flandrian transgression without recourse to a return of lower temperatures. The glacial history from the Carstensz mountains for the last 6,000 years is generally in agreement with periods of cold deduced for southeast Australasia (Costin in press, Soons 1971) and glacial advances elsewhere (eg Denton and Porter 1970). The latest retreat seems to be consistent with the 'Lac Gris' stage in the Ruwenzori and the abandonment of the 'Group 4' moraines of the equatorial Andes (Clapperton 1972). This does support the concept of a global temperature/precipitation control (eg sunspot cycles, Fairbridge 1961) for these recent minor advances and retreats. There is no reason why other, additional, processes may not have been involved in earlier more extensive environmental changes.

The vegetation history over the past 22,000 years neither confirms nor contradicts the correlations of vegetation history with climate claimed for example, by Heusser (1966) or Coetzee (1967), and it certainly supports the notion of a widespread and rather marked change about 10,000 BP. The ecological data are so tentative at this stage that all the possible climatic inferences after this time have equally strong alternative explanations. The synchronism of vegetation change within New Guinea has not yet been demonstrated, nor is it really to be expected in view of diachronous change found elsewhere (eg South Island of New Zealand, Moar 1971).

Despite the evidence of recent minor glacial advances in New Guinea there is no proof that vegetation responded widely to the implied slight climatic change. The high altitude vegetation may well be sensitive to climatic influences (such as frost frequency and intensity or occasional drought) that differ from those controlling glaciers (average precipitation and mean temperature). For the same reason the apparent stability of the alpine and subalpine vegetation before 10,000 BP, with no evidence for a marked interstadial, cannot be taken as ruling out any changes in ice extent, precipitation or temperature. It is also clear that 'drier cooler' conditions, inferred at Komanimambuno, would not apply to all altitudes and places in New Guinea.

The results presented in this thesis clearly pose more questions than they answer, and suggest areas for further work. The preliminary hypothesis of climatic control imposed by sea level changes could be tested by looking for more evidence of differential climates on the northern and southern faces of the cordillera. If more deglaciation dates were obtained, it might be expected that Mt Giluwe and the Star Mts would show some agreement with the Carstensz Mts results, while the Saruwaged and northern facing peaks would agree with the Mt Wilhelm results. It is most likely that a still more complex picture would emerge if this were done. The subsequent phase of a possible maximum altitude for the treeline, that was found on Mt Wilhelm, can be sought on other mountains and on other aspects of Mt Wilhelm by further pollen analyses. Such work would help determine whether a climatic amelioration or 'hypsithermal' was responsible but, again, a simple answer could hardly be expected. However such investigations would

reveal the times of forest clearance in montane New Guinea and so contribute substantially to the reconstruction of human history there. Specific programmes should aim at dating the reafforestation of the earlier grasslands, the pre-34,000 BP vegetation boundary depression, and deglaciation.

The high mountains of New Guinea will continue to be wet, gloomy but excitingly productive areas for investigation by the itinerant palaeoecologist.

APPENDIX 1

MODERN POLLEN DEPOSITION STUDY - VEGETATION AND
LOCAL POLLEN DATA

A species list is given for each site with the cover (number of 'hits') for each species. Other species present within the quadrat (usually 8 m radius) are marked "P". The lists may be extended for sites above 3,000 m by consulting the relevant Association Table of Wade and McVean (1969). In the lower forest sites the number of individuals and total basal area is given for species with trunk circumference >20 cm. The quadrat size was 15.2 m in the lower forests. Family abbreviations follow Division of Botany (1969).

A table of pollen data is given for each site where the vegetation cover was measured. The pollen sources are given in terms of relative cover percentages based on the sum of the covers of all source species. Plant species that contributed no pollen to either trap or surface sample have been excluded, even if their cover was large.

The pollen percentages given are based on a local sum, restricted to pollen types with local sources. In a few cases these percentages have been adjusted where there is a significant regional deposition of the pollen type in question. The adjustment is based on trap totals.

Local representation values (R_L) are based on both trap and surface sample pollen percentages divided by the relevant vegetation percentage. x implies percentages less than 1%. Local R values based on vegetation cover percentages of less than 5% are liable to be misleading. They are generally not calculated for cover % <2%.

SITE 1 Summit crag 4,510 m

Local community Bare rock

Extra-local Dwarf shrub heath, dry alpine tundra

No vegetation measured.

SITE 2 Southwestern summit ridge slope. Fossil site 'Summit Bog'
4,420 m

Local community Wet alpine tundra

Extra-local Wet alpine tundra, dry alpine tundra

No vegetation measured. Species list for bog catchment:

<i>Tetramolopium macrum</i>	(Aster.)	<i>Astelia papuana</i>	(Lil.)
<i>Styphelia suaveolens</i>	(Epacrid.)		
<i>Parahebe ciliata</i>	(Scroph.)	<i>Anthoxanthum angustum</i>	(Poac.)
<i>Drapetes ericoides</i>	(Thym.)	<i>Deschampsia klossii</i>	"
		<i>Festuca</i> sp.	"
<i>Oreomyrrhis pumila</i>	(Apiac.)	<i>Poa callosa</i>	"
<i>Lactuca</i> sp.	(Aster.)		
<i>Gentiana ettingshausenii</i>	(Gentian.)	<i>Uncinia</i> sp.	(Cyp.)
<i>Ranunculus saruwagedicus</i>	(Ranunc.)		
<i>Potentilla foersteriana</i>	(Ros.)		

SITE 3 Northern slope, summit ridge 4,450 m

Local vegetation Dwarf shrub heath, *Deschampsia klossii* alpine tussock grassland

Extra-local As for local

Species list. 8 m radius quadrat. 100 points.

<i>Pilea johniana</i>	(Urtic.)	P	<i>Trigonotis</i> sp.	(Borag.)	P
<i>Tetramolopium</i> sp.	(Aster.)	3	<i>Astelia papuana</i>	(Lil.)	6
<i>Styphelia suaveolens</i>	(Epacrid.)	14	<i>Deschampsia klossii</i>	(Poac.)	26
<i>Parahebe ciliata</i>	(Scroph.)	2	<i>Festuca papuana</i>	"	9
<i>Drapetes ericoides</i>	(Thym.)	2	<i>Hierochloe redolens</i>	"	3
<i>Oreomyrrhis pumila</i>	(Apiac.)	9	<i>Monostachya oreoboloides</i>	"	P
<i>Sagina</i> sp.	(Caryophyll.)	2	<i>Poa callosa</i>	"	3
<i>Lactuca</i> sp.	(Aster.)	5	<i>P. crassicaulis</i>	"	10
<i>Gentiana ettingshausenii</i>	(Gentian.)	P	<i>P. sp.</i>	"	3
<i>Ranunculus saruwagedicus</i>	(Ranunc.)	4	<i>Uncinia</i> sp.	(Cyp.)	8
<i>Potentilla foersteriana</i>	(Ros.)	3			

Pollen source	%Cover	Local trap	Pollen% surface	Local trap	R _L values surface
Asteraceae I	3	5	1	1.7	0.3
<i>Styphelia</i> sim.	13	8	12	0.6	0.9
<i>Drapetes</i>	2	-	x		<0.5
Apiaceae	8	3	3	0.4	0.4
Liguliflorae	5	2	3	0.4	0.6
Caryophyllaceae	2	2		1.0	
<i>Parahebe</i> sim.	2	2		1.0	
<i>Ranunculus</i>	4	4	12	1.0	3.0
<i>Potentilla</i>	3	1	x	0.3	<0.3
<i>Astelia</i>	5	6	2	1.2	0.4
Poaceae	49	67	64	1.4	1.3
Cyperaceae	7	2	1	0.3	0.2

SITE 4 Northern slope, summit ridge 4,400 m

Local vegetation *Deschampsia klossii* alpine tussock grassland

Extra-local As for local plus dry alpine tundra

Species list. 8 m radius quadrat. 100 points.

<i>Pilea</i> sp.	(Urtic.)	P	<i>Potentilla foersteriana</i>	(Ros.)	16
<i>Ischnea keysseri</i>	(Aster.)	2	<i>Astelia papuana</i>	(Lil.)	1
<i>Styphelia suaveolens</i>	(Epacrid.)	14	<i>Deschampsia klossii</i>	(Poac.)	68
<i>Parahebe ciliata</i>	(Scroph.)	1	<i>Festuca papuana</i>	"	20
<i>Drapetes ericoides</i>	(Thym.)	2	<i>Hierochloe redolens</i>	"	14
<i>Oreomyrrhis pumila</i>	(Apiac.)	15	<i>Monostachya oreoboloides</i>	"	1
<i>Cerastium</i> sp.	(Caryophyll.)	2	<i>Poa callosa</i>	"	3
<i>Lactuca</i> sp.	(Aster.)	1	<i>P. crassicaulis</i>	"	13
<i>Ranunculus</i> sp.	(Ranunc.)	1	<i>Uncinia</i> sp.	(Cyp.)	P

Pollen source	%Cover	Local trap	Pollen% surface	Local trap	R _L values surface
Asteraceae	1	1	1	1.0	1.0
<i>Styphelia</i> sim.	8	6	5	0.7	0.6
<i>Drapetes</i>	1	1	1	0.8	0.8
Apiaceae	9	1	6	0.1	0.7
Liguliflorae	1		2	-	2.0
Caryophyllaceae	1		2	-	2.0
<i>Ranunculus</i>	1		3	-	3.0
<i>Potentilla</i>	9	1	2	0.1	0.2
<i>Astelia</i>	1	2	2	1.0	2.0
Poaceae	68	88	78	1.3	1.1
Cyperaceae	x		2		>1.0

SITE 5 Crest of Bogunolto ridge 4,020 m

Local vegetation Lichen rich short alpine grassland

Extra-local *Danthonia vestita* subalpine grassland, alpine fern meadow

Species list. 8 m radius quadrat. 100 points.

<i>Pilea johniana</i>	(Urtic.)	2	<i>Deschampsia klossii</i>	(Poac.)	5
Asteraceae		7	<i>Deyeuxia brassii</i>	"	1
<i>Styphelia suaveolens</i>	(Epacrid.)	16	<i>Festuca papuana</i>	"	14
<i>Vaccinium amblyandrum</i>	(Eric.)	1	<i>Monostachya oreoboloides</i>	"	15
<i>Drapetes ericoides</i>	(Thym.)	P	<i>Poa callosa</i>	"	21
<i>Oreomyrrhis linearis</i>	(Apiac.)	2	<i>Poa crassicaulis</i>	"	2
<i>Ranunculus</i> sp.	(Ranunc.)	4	<i>Poa</i> cf. <i>epileuca</i>	"	2
<i>Potentilla foersteriana</i>	(Ros.)	19	Poaceae (unident.)	"	19
<i>Plantago aundensis</i>	(Plantag.)	5	<i>Carphe alpina</i>	(Cyp.)	3
<i>Danthonia vestita</i>	(Poac.)	8	<i>Carex</i> sp.	"	3
			<i>Lycopodium</i> sp.	(Lycopod.)	P

Coprosma divergens (Rub.), *Drimys piperita* (Wint.), *Detzneria tubata* (Scroph.) are all common shrubs within 25 m of the quadrat centre.

<u>Pollen source</u>	<u>%Cover</u>	<u>Local trap</u>	<u>Pollen% surface</u>	<u>Local trap</u>	<u>R values surface</u>
Urticaceae	1	—*	—*		
Asteraceae	5	15	1	3.0	0.2
<i>Styphelia</i> sim.	11	1	1	0.1	0.1
Ericaceae I	1	1	—	0.6	
<i>Coprosma</i>	x	19	4	>1.0	>1.0
<i>Drimys</i>	x	—	—		
<i>Oreomyrrhis</i>	1	1	1	1.0	1.0
<i>Ranunculus</i>	3	—	6	<0.3	2.0
<i>Potentilla</i>	14	—	—	<0.1	<0.1
<i>Plantago</i>	4	—	—	<0.1	<0.1
<i>Astelia</i>	29	1	37	<0.1	1.3
Poaceae	46	54	43	1.2	1.0
Cyperaceae	4	6	8	1.5	2.0
<i>Lycopodium</i>	x	2	—	>2.0	—

* Urticaceae make up 50% of total pollen but this may all be regional.

SITE 6A Northeastern crest of Bogunolto ridge 4,000 m

Local vegetation *Danthonia vestita* subalpine grassland

Species list. 8 m radius quadrat. 100 points.

<i>Pilea johniana</i>	(Urt.)	2	<i>Potentilla foersteriana</i>	(Ros.)	2
<i>Keysseria radicans</i>	(Aster.)	6	<i>Astelia papuana</i>	(Lil.)	21
<i>Tetramolopium macrum</i>	"	11	<i>Anthoxanthum angustum</i>	(Poac.)	2
<i>Styphelia suaveolens</i>	(Epacrid.)	13	<i>Danthonia vestita</i>	"	36
<i>Trochocarpa decockii</i>	"	4	<i>Deschampsia klossii</i>	"	16
<i>Vaccinium amblyandrum</i>	(Eric.)	13	<i>Deyeuxia brassii</i>	"	13
<i>Coprosma divergens</i>	(Rub.)	7	<i>Festuca papuana</i>	"	7
<i>Detzneria tubata</i>	(Scroph.)	1	<i>Monostachya oreoboloides</i>	"	1
<i>Drapetes ericoides</i>	(Thym.)	1	<i>Poa callosa</i>	"	13
<i>Oreomyrrhis pumila</i>	(Apica.)	3	<i>Poa crassicaulis</i>	"	3
<i>Lactuca laevigata</i>	(Aster)	1	<i>Poa epileuca</i>	"	2
<i>Gentiana</i> sp.	(Gentian.)	1	<i>Uncinia</i> sp.	(Cyp.)	3
<i>Ranunculus</i> sp.	(Ranunc.)	1	<i>Lycopodium australianum</i>	(Lyc.)	P

Drimys piperita (Wint.) is a common tall shrub near the site.

<u>Pollen source</u>	<u>%Cover</u>	<u>Local trap</u>	<u>Pollen% surface</u>	<u>Local trap</u>	<u>R values surface</u>
Urticaceae	1	*	*		
Asteraceae	9	3	5	0.3	0.6
<i>Styphelia</i> sim.	9	2	20	0.2	2.2
Ericaceae I	7	1	2	0.1	0.3
<i>Coprosma</i>	4	21	20	5.2	5.0
<i>Drapetes</i>	1	1	4	1.0	4.0
<i>Drimys</i>	x	3	—	>1.0	
Apiaceae	2		1	<0.5	0.5
Liguliflorae	1	1	2	1.0	1.5
<i>Ranunculus</i>	1		1		1.0
<i>Astelia</i>	13	5	15	0.4	1.2
Poaceae	55	53	28	1.0	0.5
Cyperaceae	2	3	1	1.5	0.5
<i>Lycopodium</i>	x	2	1	>1.0	>1.0

* Urticaceae make up 50% of total pollen but this may all be regional.

SITE 6B Southwestern crest of Bogunolto Ridge 4,000 m

Local vegetation *Danthonia vestita* subalpine grassland

Species list. 8 m radius quadrat. 100 points

<i>Pilea johniana</i>	(Urt.)	P	<i>Trigonotis pleiomera</i>	(Borag.)	P
<i>Keysseria radicans</i>	(Aster.)	1	<i>Astelia papuana</i>	(Lil.)	12
<i>Styphelia suaveolens</i>	(Epacrid.)	24	<i>Anthoxanthum angustum</i>	(Poac.)	3
<i>Vaccinium amblyandrum</i>	(Eric.)	P	<i>Danthonia vestita</i>	"	10
<i>Coprosma divergens</i>	(Rub.)	8	<i>Deschampsia klossii</i>	"	29
<i>Detzeria tubata</i>	(Scroph.)	1	<i>Deyeuxia brassii</i>	"	6
<i>Drapetes ericoides</i>	(Thum.)	6	<i>Festuca papuana</i>	"	18
<i>Oreomyrrhis pumila</i>	(Apiac.)	19	<i>Hierochloe redolens</i>	"	P
<i>Trachymene tripartita</i>	"	1	<i>Poa callosa</i>	"	1
<i>Gentiana</i> sp.	(Gentian.)	2	<i>Poa crassicaulis</i>	"	4
<i>Ranunculus</i> sp.	(Ranunc.)	2	<i>Poa epileuca</i>	"	4
<i>Potentilla foersteriana</i>	(Ros.)	3	<i>Uncinia</i> sp.	(Cyp.)	8
<i>P. papuana</i>	"	4	<i>Papuapteris linearis</i>	(Aspid.)	7
			<i>Lycopodium australianum</i>	(Lycop.)	P

Drimys piperita (Wint.) is a common tall shrub near the site.

Pollen source	%Cover	Local trap	Pollen% surface	Local trap	R _L values surface
Asteraceae	x	-	3		>3.0
<i>Styphelia</i> sim.	15	1	7	0.1	0.5
Ericaceae I	x	1	2	>1.0	>1.0
<i>Coprosma</i>	5	28	21	5.6	4.2
<i>Drapetes</i>	4	1	1	0.3	0.3
<i>Drimys</i>	x	1	2	>1.0	>1.0
Apiaceae	13	-	4	<0.1	0.3
Liguliflorae	x	1	-	1.0	
<i>Ranunculus</i>	1	2	-	1.0	
<i>Potentilla</i>	5	-	-	<0.2	<0.2
<i>Astelia</i>	8	1	2	0.1	0.3
Poaceae	48	67	58	1.4	1.2
Cyperaceae	5	-	7	<0.2	1.4
<i>Lycopodium</i>	x	2	3	>1.0	>1.0

SITE 7A Brass Tarn. Fossil site. 3,910 m

Local vegetation *Carex gaudichaudiana* fen

Carpha alpina fen, *Danthonia vestita* subalpine grassland, *Coprosma* - *Poa saruwagetica* tussock grassland.

Species list. 8 m radius quadrat, but 37% of circle is open water. 100 points dispersed on land sector only.

<i>Ranunculus pseudolowii</i>	(Ranunc.)	P	<i>Hierochloe redolens</i>	(Poac.)	1
<i>Potentilla foersteriana</i>	(Ros.)	P	<i>Monostachya oreoboloides</i>	"	3
<i>Deschampsia klossii</i>	(Poac.)	2	<i>Carex gaudichaudiana</i>	(Cyp.)	61

Pollen source	%Cover	Local trap	Pollen% surface	Local trap	R _L values surface
<i>Ranunculus</i>	x	14	1	>1.0	>1.0
<i>Potentilla</i>	*	-	5		>1.0
Poaceae	9	89*	17*	9.9	1.9
Cyperaceae	91	11	83	0.1	0.9

* 80% of Poaceae pollen presumed extra-local, not included in calculation.

SITE 7B Brass Tarn Fossil site 3,910 m

Local vegetation *Carpha alpina* fen

Extra-local As for site 7A

Species list. 8 m radius quadrat, but 11% open water. 89 points dispersed on land area only.

<i>Drapetes ericoides</i>	(Thym.)	P	<i>Astelia papuana</i>	(Lil.)	6
<i>Ranunculus pseudolowii</i>	(Ranunc.)	P	<i>Carex gaudichaudiana</i>	(Cyp.)	4
<i>Deschampsia klossii</i>	(Poac.)	16	<i>Carpha alpina</i>	"	50
<i>Monostachya oreoboloides</i>	"	9	<i>Scirpus crassiusculus</i>	"	29

<u>Pollen source</u>	<u>%Cover</u>	<u>Local trap</u>	<u>Pollen% surface</u>	<u>Local trap</u>	<u>R_L values surface</u>
<i>Drapetes</i>	x	4	-	>1.0	
<i>Ranunculus</i>	x	-	1		>1.0
<i>Astelia</i>	5	-	1	<0.2	0.2
Poaceae	19	32*	5*	1.7	0.3
Cyperaceae	75	63	94	0.8	1.3

* 90% of Poaceae pollen presumed extra-local and not included in the calculation.

SITE 8 Pengagl Mire

Local vegetation *Carex gaudichaudiana* fen, *Carpha alpina* fen

Extra-local *Coprosma-Poa saruwagetica* tussock grassland

Species list. 8 m radius quadrat. 100 points.

<i>Pilea johniana</i>	(Urt.)	1	<i>Deschampsia klossii</i>	(Poac.)	18
<i>Styphelia suaveolens</i>	(Epacrid.)	1	<i>Monostachya oreoboloides</i>	"	17
<i>Gentiana</i> sp.	(Gentian.)	1	<i>Poa callosa</i>	"	3
<i>Ranunculus</i> sp.	(Ranunc.)	2	<i>Carex capillacea</i>	(Cyp.)	2
<i>Astelia papuana</i>	(Lil.)	11	<i>Carex gaudichaudiana</i>	"	29
<i>Agrostis reinwardtii</i>	(Poac.)	2	<i>Carpha alpina</i>	"	27
			<i>Scirpus crassiusculus</i>	"	32

<u>Pollen source</u>	<u>%Cover</u>	<u>Local trap</u>	<u>Pollen% surface</u>	<u>Local trap</u>	<u>R_L values surface</u>
<i>Styphelia</i>	x	5	4	>1.0	>1.0
<i>Gentiana</i>	x		1		1.0
<i>Ranunculus</i>	x		14		>1.0
<i>Astelia</i>	6		2	<0.2	0.3
Poaceae	28	42*	44*	1.5	1.6
Cyperaceae	63	53	36	0.9	0.6

* 77% of Poaceae pollen presumed extra-local and not included in the calculation.

SITE 9 100 m south of Upper Pindaunde lake 3,620 m
 Local vegetation *Coprosoma-Poa saruwagetica* tussock grassland
 Extra-local Scattered fragments of upper subalpine forest

Species list. 8 m radius quadrat. 100 points.

<i>Styphelia suaveolens</i>	(Epacrid.)	23	<i>Agrostis reinwardtii</i>	(Poac.)	1
<i>Trochocarpa decockii</i>	"	1	<i>Anthoxanthum angustum</i>	"	4
<i>Gaultheria mundula</i>	(Eric.)	10	<i>Danthonia vestita</i>	"	40
<i>Coprosma divergens</i>	(Rub.)	14	<i>Deschampsia klossii</i>	"	23
<i>Oreomyrrhis pumila</i>	(Apiac.)	1	<i>Deyeuxia brassii</i>	"	10
<i>Trachymene</i> sp.	"	1	<i>Dichelachne rara</i>	"	16
<i>Lactuca</i> sp.	(Aster)	7	<i>Hierochloe redolens</i>	"	6
<i>Ranunculus pseudolowii</i>	(Ranunc.)	11	<i>Poa saruwagetica</i>	"	13
<i>Potentilla foersteriana</i>	(Ros.)	17	<i>Carex celebica</i>	(Cyp.)	P
<i>Astelia papuana</i>	(Lil.)	9	<i>C. sp.</i>	"	2
			<i>Schoenus curvulus</i>	"	P

Shrubs of *Rhododendron* sp (Eric.), *Olearia floccosa* (Aster.) and tree ferns, *Cyathea* sp. are common within 25 m of the quadrat.

Pollen source	%Cover	Local trap	Pollen% surface	Local trap	R _L values surface
<i>Styphelia</i> sim.	13	7	4	0.5	0.3
Ericaceae I, II & III	6	24	3	4.4	0.5
<i>Coprosma</i>	8	29	10	3.5	1.2
Apiaceae	1	-	-	-	-
Liguliflorae	4	-	1	-	0.3
<i>Ranunculus</i>	6	2	2	0.3	0.3
<i>Potentilla</i>	9	-	-	<0.1	<0.1
<i>Astelia</i>	5	-	-	<0.2	<0.2
Poaceae	62	40*	74*	0.6	1.2
Cyperaceae	2	x	4	0.5	2.0

* 20% of Poaceae pollen presumed extra-local and not included in the calculation.

SITE 10A South edge, lower Pindaunde lake 3,520 m
 Local vegetation *Coprosoma-Poa saruwagetica* tussock grassland
 Extra-local Lower subalpine forest 25 m to south

Species list. 8 m radius quadrat. 100 points.

<i>Olearia spectabilis</i>	(Aster.)	3	<i>Potentilla foersteriana</i>	(Ros.)	3
<i>Styphelia suaveolens</i>	(Epacrid.)	6	<i>P. papuana</i>	"	5
<i>Gaultheria mundula</i>	(Eric.)	P	<i>Geranium potentilloides</i>	(Geran.)	2
<i>Coprosma divergens</i>	(Rub.)	3	<i>Epilobium keysseri</i>	(Onag.)	3
<i>C. papuensis</i>	"	11	<i>Acaena anserinifolia</i>	(Ros.)	3
<i>Lactuca</i> sp.	(Aster.)	14	<i>Deschampsia klossii</i>	(Poac.)	18
<i>Sagina papuana</i>	(Caryophyll.)	2	<i>Dichelachne rara</i>	"	4
<i>Gentiana</i> sp.	(Gentian.)	1	<i>Hierochloe redolens</i>	"	21
<i>Parahebe ciliata</i>	(Scroph.)	1	<i>Poa saruwagetica</i>	"	90
<i>Ranunculus pseudolowii</i>	(Ranunc.)	10	<i>Belvisia</i> sp.	(Polypod.)	2

<u>Pollen source</u>	<u>%Cover</u>	<u>Local trap</u>	<u>Pollen% surface</u>	<u>Local trap</u>	<u>R_L values surface</u>
Asteraceae	2	x	1	0.4	0.8
<i>Styphelia</i> sim.	3	17	-	5.4	0.4
Ericaceae	x	1	x		
<i>Coprosma</i>	7	1	1	0.2	0.2
Liguliflorae	7	x	-	<0.2	<0.2
Caryophyllaceae	1	-	-		
<i>Gentiana</i>	x	x	-		
<i>Ranunculus</i>	5	x	1	<0.2	0.2
<i>Potentilla</i>	4	-	x	<0.3	0.3
Poaceae	70	81	96	1.2	1.4
<i>Belvisia</i> comp.	1	-	1		1.0

SITE 10B See Site 10A 3,515 m

Species list.

<i>Styphelia suaveolens</i>	(Epacrid.)	2	<i>P. papuana</i>	(Ros.)	6
<i>Gaultheria mundula</i>	(Eric.)	1	<i>Trigonotis</i> sp.	(Borag.)	1
<i>Coprosma divergens</i>	(Rub.)	1	<i>Agrostis reinwardtii</i>	(Poac.)	1
<i>Oreomyrrhis parvula</i>	(Apiac.)	18	<i>Deschampsia klossii</i>	"	51
<i>Lactuca</i> sp.	(Aster.)	14	<i>Dichelachne rara</i>	"	5
<i>Sagina papuana</i>	(Caryophyll.)	2	<i>Hierochloe redolens</i>	"	12
<i>Ranunculus pseudolowii</i>	(Ranunc.)	4	<i>Poa saruwagetica</i>	"	66
<i>Potentilla foersteriana</i>	(Ros.)	4			

<u>Pollen source</u>	<u>%Cover</u>	<u>Local trap</u>	<u>Pollen% surface</u>	<u>Local trap</u>	<u>R_L values surface</u>
<i>Styphelia</i> sim.	1	3	3	>1.0	>1.0
Ericaceae	x	3	2	>1.0	>1.0
<i>Coprosma</i>	x	3	-	>1.0	
Apiaceae	11	-	1	<0.1	<0.1
Liguliflorae	10	3	1	0.3	0.1
Caryophyllaceae	1	-	-		
<i>Ranunculus</i>	2	-	-		
<i>Potentilla</i>	6	-	-	<0.2	<0.2
<i>Trigonotis</i>	x	-	-		
Poaceae	82	89	93	1.1	1.1

SITE 10C See Site 10A 3,505 m

Species list

Asteraceae		1	<i>Trigontis</i> sp.	(Borag.)	1
<i>Styphelia suaveolens</i>	(Epacrid.)	6	<i>Geranium potentilloides</i>	(Geran.)	1
<i>Gaultheria mundula</i>	(Eric.)	5	<i>Anthoxanthum angustum</i>	(Poac.)	5
<i>Coprosma divergens</i>	(Rub.)	1	<i>Danthonia vestita</i>	"	9
<i>Oreomyrrhis pumila</i>	(Apiac.)	10	<i>Deschampsia klossii</i>	"	45
<i>Lactuca</i> sp.	(Aster.)	7	<i>Deyeuxia brassii</i>	"	1
<i>Ranunculus pseudolowii</i>	(Ranunc.)	9	<i>Hierochloe redolens</i>	"	19
<i>Potentilla papuana</i>	(Ros.)	9	<i>Poa saruwagetica</i>	"	53

<u>Pollen source</u>	<u>%Cover</u>	<u>Local trap</u>	<u>Pollen% surface</u>	<u>Local trap</u>	<u>R_L values surface</u>
Asteraceae	x	-	1		
<i>Styphelia</i> sim.	4	7	1	1.7	0.3
Ericaceae	3	2	-	0.6	
<i>Coprosma</i>	x	2	1	>1.0	>1.0
Apiaceae	6	-	-	<0.2	<0.2
Liguliflorae	4	3	-	0.7	
<i>Ranunculus</i>	6	2	x	0.3	0.2
<i>Potentilla</i>	6	-	-	<0.2	<0.2
Poaceae	82	84	96	1.0	1.2

SITE 11 Lower Pindaunde lake. Fossil site 'Lake Aunde' 3,500 m

Local vegetation None - open water

Extra-local Subalpine grassland and lower subalpine forest
Surface sample MS11B obtained from water tank
near lake. Mainly *Coprosma-Poa saruwagetica*
tussock grassland around the tank catchment with
occasional tree ferns, *Cyathea* sp.

SITE 12 Southern slope, Imbuka ridge. Fossil site 'Imbuka Bog'
3,550 m

Local vegetation Subalpine short grass bog

Extra-local *Coprosma-Poa saruwagetica* tussock grasslands,
Deschampsia klossii subalpine tussock grassland

Species list. Area within 3 m of coring site.

<i>Styphelia suaveolens</i>	(Epacrid.)	<i>Monostachya oreoboloides</i>	(Poac.)
<i>Drapetes ericoides</i>	(Thym.)	<i>Carex echinata</i>	(Cyp.)
<i>Lactuca</i> sp.	(Aster.)	<i>Cyperus alpina</i>	"
<i>Ranunculus pseudolowii</i>	(Ranunc.)	<i>Scirpus subcapitatus</i>	"
<i>Deschampsia klossii</i>	(Poac.)		

SITE 13A South bank, Pindaunde creek Kombuglomambuno 3,200 m

Local vegetation *Cyathea atrox* tree fern tussock grassland

Extra-local *Deschampsia klossii* tussock grassland, *Brachypodium*-
Carex fen. 150 m to upper cloud forest edge.

Species list. 8 m radius quadrat. 100 points.

<i>Styphelia suaveolens</i>	(Epacrid.)	12	<i>Agrostis reinwardtii</i>	(Poac.)	1
<i>Gaultheria mundula</i>	(Eric.)	5	<i>Anthoxanthum angustum</i>	"	4
<i>Lactuca laevigata</i>	(Aster.)	9	<i>Danthonia penicillata</i>	"	7
<i>Sagina papuana</i>	(Caryophyll.)	4	<i>Deschampsia klossii</i>	"	62
<i>Gentiana</i> sp.	(Gentian.)	1	<i>Dichelachne rara</i>	"	1
<i>Ranunculus pseudolowii</i>	(Ranunc.)	9	<i>Hierochloa redolens</i>	"	6
<i>Potentilla papuana</i>	(Ros.)	21	<i>Poa saruwagetica</i>	"	50
<i>Epilobium keysseri</i>	(Onag.)	1	<i>Carex</i> sp.	(Cyp.)	3
<i>Viola kjellbergi</i>	(Viol.)	1	<i>Schoenus curvulus</i>	"	1
			<i>Cyathea atrox</i>	(Cyath.)	20

<u>Pollen source</u>	<u>%Cover</u>	<u>Local trap</u>	<u>Pollen% surface</u>	<u>Local trap</u>	<u>R₁ values surface</u>
<i>Styphelia</i> sim.	6	x	1	<0.2	0.2
Ericaceae	2	1	1	0.5	0.5
Liguliflorae	4	-	x	<0.2	<0.3
Caryophyllaceae	2	-	-	<0.5	<0.5
Ranunculaceae	4	2	3	0.5	0.6
<i>Potentilla</i>	10	-	1	<0.1	0.1
Poaceae	62	11	47	0.2	0.8
Cyperaceae	2	-	2		0.8
<i>Cyathea</i> comp.	9	86	46	9.6	5.1

SITE 13B Northbank, Pindaunde creek, Kombuglomambuno 3,200 m

Local vegetation *Cyathea atrox* treefern tussock grassland,
Deschampsia klossii tussock grassland. No tree
 ferns inside quadrat.

Extra-local As above plus *Brachypodium-Carex* fen. 80 m to
 edge of upper cloud forest.

Species list. 8 m radius quadrat. 100 points.

<i>Keysseria radicans</i>	(Aster.)	3	<i>Agrostis reinwardtii</i>	(Poac.)	14
<i>Styphelia suaveolens</i>	(Epacrid.)	4	<i>Danthonia penicillata</i>	"	3
<i>Gaultheria mundula</i>	(Eric.)	7	<i>Deschampsia klossii</i>	"	78
<i>Lactuca laevigata</i>	(Aster.)	8	<i>Deyeuxia arundinacea</i>	"	1
<i>Sagina papuana</i>	(Caryophyll.)	3	<i>Dichelachne rara</i>	"	13
<i>Ranunculus pseudolowii</i>	(Ranunc.)	17	<i>Hierochloe redolens</i>	"	6
<i>Acaena anserinifolia</i>	(Ros.)	1	<i>Poa saruwagetica</i>	"	18
<i>Potentilla papuana</i>	"	6	<i>Carex</i> sp.	(Cyp.)	16
<i>Epilobium keysseri</i>	(Onag.)	1	<i>Scirpus subtilissimus</i>	"	3
<i>Viola kjellbergi</i>	(Viol.)	2			

<u>Pollen source</u>	<u>%Cover</u>	<u>Local trap</u>	<u>Pollen % surface</u>	<u>Local trap</u>	<u>R₁ values surface</u>
Asteraceae	2	-	-	<0.5	<0.5
<i>Styphelia</i> sim.	2	1	2	0.5	1.0
Ericaceae	4	x	-	<0.3	<0.2
Liguliflorae	4	-	x	<0.2	<0.3
Caryophyllaceae	2	-	-	<0.5	<0.5
<i>Ranunculus</i>	9	2	4	0.2	0.5
<i>Potentilla</i>	3	-	-	<0.3	<0.3
<i>Viola</i>	1	-	-	<0.5	<0.5
Poaceae	74	6	51	0.1	0.7
Cyperaceae	11	-	1	<0.1	0.1
<i>Cyathea</i> comp.	x	91	42	>1.0	>1.0

SITE 14A Northern slope, Imbuka ridge 3,850 m
 Local vegetation Upper subalpine forest, *Gleichenia bolanica* fern community, *Danthonia vestita* subalpine grassland
 Extra-local *Danthonia vestita* subalpine grassland

Species list. 8 m radius quadrat. 100 points.

<i>Anaphalis mariae</i>	(Aster.)	5	<i>Coprosma divergens</i>	(Rub.)	13
<i>Olearia spectabilis</i>	"	16	<i>C. papuensis</i>	"	11
<i>Tetramolopium macrum</i>	"	3	<i>Drapetes ericoides</i>	(Thym.)	2
<i>Rapanea vaccinioides</i>	(Myrs.)	3	<i>Eurya brassii</i>	(The.)	11
<i>Dacrycarpus compactus</i>	(Podocarp.)	15	<i>Potentilla papuana</i>	(Ros.)	3
<i>Symplocos</i> sp.	(Symp.)	3	<i>Astelia papuana</i>	(Lil.)	17
<i>Styphelia suaveolens</i>	(Epacrid.)	12	<i>Danthonia vestita</i>	(Poac.)	3
<i>Trochocarpa decockii</i>	"	9	<i>Deyeuxia brassii</i>	"	2
<i>Dimorphanthera microphylla</i>	(Eric.)	2	<i>Dichelachne rara</i>	"	2
<i>Rhododendron gaultherifolium</i>	"	5	<i>Monostachya oreoboloides</i>	"	1
<i>Vaccinium amblyandrum</i>	"	7	<i>Carex</i> sp.	(Cyp.)	3
<i>Haloragis halconensis</i>	(Halorag.)	30	<i>Schoenus curvulus</i>	"	39
			<i>Giulianettia</i> sp.	(Orchid.)	6
			<i>Gleichenia bolanica</i>	(Gleich.)	6
			<i>Lycopodium</i> sp.	(Lycopod.)	3

Pollen source	%Cover	Local trap	Pollen% surface	Local trap	R _L values surface
Asteraceae	13	2	-	0.2	<0.1
<i>Rapanea</i>	2	7	5	4.1	2.5
<i>Dacrycarpus</i>	8	7	18	0.8	2.3
<i>Symplocos</i>	2	-	x		<0.5
<i>Styphelia</i> sim.	11	5	x	0.5	<0.1
Ericaceae	7	10	1	1.4	<0.2
<i>Haloragis</i>	16	47	24	3.0	1.5
<i>Coprosma</i>	13	5	x	0.4	<0.1
<i>Drapetes</i>	1	-	-		
<i>Eurya</i> sim.	6	3	49	0.5	8.6
<i>Potentilla</i>	2	-	-		
<i>Astelia</i>	9	-	x		0.1
Poaceae	4	7	2	1.5	0.5
Cyperaceae	23		x		<0.1
<i>Gleichenia</i> comp.	3	8	1	2.7	0.3
<i>Lycopodium</i>	2	x	-	<0.5	

SITE 14B Northern slope, Imbuka ridge 3,810 m
 Local vegetation Upper subalpine forest
 Extra-local *Danthonia vestita* subalpine grassland, *Gleichenia bolanica* fern community

Species list. 8 m radius quadrat. 100 points.

<i>Anaphalis mariae</i>	(Aster.)	5	<i>Dimorphanthera microphylla</i>	(Eric.)	5
<i>Olearia spectabilis</i>	"	4	<i>Gaultheria mundula</i>	"	10
<i>Rapanea vaccinioides</i>	(Myrs.)	24	<i>Rhododendron</i> sp.	"	4
<i>Dacrycarpus compactus</i>	(Podocarp.)	16	<i>Vaccinium keysseri</i>	"	13
<i>Symplocos</i> sp.	(Symp.)	14	<i>Vaccinium amblyandrum</i>	"	4
<i>Styphelia suaveolens</i>	(Epacrid.)	11	<i>Haloragis halconensis</i>	(Halorag.)	29
<i>Trochocarpa dispersa</i>	"	9	<i>Coprosma divergens</i>	(Rub.)	7

SITE 14B (cont'd)

<i>C. papuensis</i>	(Rub.)	30	<i>Anthoxanthum angustum</i>	(Poac.)	2
<i>Detzneria tubata</i>	(Scroph.)	P	<i>Danthonia vestita</i>	"	2
<i>Eurya brassii</i>	(The.)	12	<i>Monostachya oreoboloides</i>	"	1
<i>Oreomyrrhis</i> sp.	(Apiac.)	1	Poaceae		2
<i>Potentilla foersteriana</i>	(Ros.)	2	<i>Carex</i> sp.	(Cyp.)	4
<i>Libertia pulchella</i>	(Irid.)	1	<i>Schoenus curvulus</i>	"	40
<i>Oxalis magellanica</i>	(Oxal.)	1	<i>Giulianettia</i> sp.	(Orchid)	P
<i>Astelia papuana</i>	(Lil.)	5	<i>Cyathea percrassa</i>	(Cyath.)	1
			<i>Gleichenia bolanica</i>	(Gleich.)	6

Pollen source	%Cover	Local trap	Pollen% surface	Local trap	R _L values surface
Asteraceae	4	3	-	0.7	
<i>Rapanea</i>	11	7	5	0.6	0.4
<i>Dacrycarpus</i>	7	36	47	5.1	6.5
<i>Styphelia</i> sim.	9	x	-	<0.1	<0.1
Ericaceae	8	5	1	0.6	0.2
<i>Haloragis</i>	13	9	36	0.7	2.8
<i>Coprosma</i>	17	9	3	0.5	0.2
<i>Eurya</i>	5	8	x	1.6	0.2
Poaceae	3	10	3	3.3	1.1
Cyperaceae	20		1	<0.1	<0.1
<i>Cyathea</i> comp.	x	12	2	>5.0	>4.0
<i>Gleichenia</i> comp.	3	1	1	0.4	0.3

SITE 15A Western side of the upper Pindaunde lake 3,640 m

Local vegetation Upper subalpine forest

Extra-local As above, forest edge 40 m distant

Species list. 8 m radius quadrat. 100 points

<i>Olearia floccosa</i>	(Aster)	1	<i>Coprosma papuensis</i>	(Rub.)	25
<i>O. spectabilis</i>	"	3	<i>Drimys piperita</i>	(Wint.)	11
<i>Tetramolopium</i>	"	1	<i>Sagina papuana</i>	(Caryophyll.)	1
<i>Rapanea vaccinioides</i>	(Myrs.)	48	<i>Rubus</i> sp.	(Ros.)	10
<i>Dacrycarpus compactus</i>	(Podocarp.)	23	<i>Libertia pulchella</i>	(Irid.)	P
<i>Amaracarpus caeruleus</i>	(Rub.)	20	<i>Oxalis magellanica</i>	(Oxal.)	4
<i>Trochocarpa dispersa</i>	(Epacrid.)	18	<i>Poa languidor</i>		P
<i>Dimorphanthera microphylla</i>	(Eric.)		<i>Schoenus curvulus</i>	(Cyp.)	1
<i>Rhododendron gaultherifolium</i>	"	12	<i>Uncinia</i> sp.	"	26
<i>R. womersleyi</i>	"	1	<i>Giulianettia</i> sp.	(Orchid)	57
<i>Vaccinium keysseri</i>	"	9	<i>Gleichenia bolanica</i>	(Gleich.)	8
<i>Haloragis halconensis</i>	(Halorag.)	29	<i>Grammatis</i> spp.	(Gramm.)	2
			<i>Pteris</i> sp.	(Pterid.)	1

Pollen source	%Cover	Local trap	Pollen% surface	Local trap	R _L values surface
Asteraceae	2		x		0.5
<i>Rapanea</i>	20	73	75	3.6	3.8
<i>Dacrycarpus</i>	10	12	18	12.	1.8
<i>Amaracarpus</i>	8	-	-	Nil	Nil
<i>Styphelia</i> sim. (<i>Trochocarpa</i>)	8	-	x	<0.1	<0.1
Ericaceae	18	3	2	0.2	0.1
<i>Haloragis</i>	12	3	3	0.3	0.3
<i>Coprosma</i>	10	6	x	0.6	<0.1

SITE 15A (cont'd)

<u>Pollen source</u>	<u>%Cover</u>	<u>Local trap</u>	<u>Pollen% surface</u>	<u>Local trap</u>	<u>R_L values surface</u>
<i>Drimys</i>	5	1	x	0.2	<0.2
<i>Rubus</i>	4	-	-	Nil	Nil
<i>Giulianettia</i>	24	-	-	Nil	Nil
Poaceae	x	26	x		
Cyperaceae	11	x	x	<0.1	<0.1
<i>Gleichenia</i>	3	2	-	0.6	
<i>Grammitis</i> sim.	1	1	x	1.0	
<i>Pteris</i>	x	-	x		

SITE 15B Western side of the upper Pindaunde lake 3,640 m

Local vegetation Upper subalpine forest

Extra-local Grasslands in forest gaps

Species list. 8 m radius quadrat. 100 points.

<i>Anaphalis mariae</i>	(Aster.)	4	<i>Coprosma papuensis</i> (Rub.)	30
<i>Olearia spectabilis</i>	"	15	<i>Drimys piperita</i> (Wint.)	9
<i>Rapanea vaccinioides</i>	(Myrs.)	39	<i>Eurya brassii</i> (The.)	2
<i>Dacrycarpus compactus</i>	(Podocarp.)	17	<i>Rubus</i> sp. (Ros.)	2
<i>Quintinia</i> sp.	(Sax.)	1	<i>Libertia pulchella</i> (Irid.)	2
<i>Amaracarpus caerulens</i>	(Rub.)	28	<i>Uncinia</i> sp. (Cyp.)	34
<i>Styphelia suaveolens</i>	(Epacrid.)	7	<i>Giulianettia</i> sp. (Orchid.)	45
<i>Trochocarpa dispersa</i>	"	6	<i>Cyathea percrassa</i> (Cyath.)	1
<i>Dimorphanthera microphylla</i>	(Eric.)	10	<i>Grammitis</i> spp. (Gramm.)	1
<i>Rhododendron gaultherifolium</i>	"	19	<i>Lycopodium</i> sp. (Lycopod.)	P
<i>Vaccinium keysseri</i>	"	33	<i>Pteris</i> sp. (Pterid.)	1
<i>Haloragis halconensis</i>	(Halorag.)	27	<i>Selliguea</i> sp. (Polypod.)	7

<u>Pollen source</u>	<u>%Cover</u>	<u>Local trap</u>	<u>Pollen% surface</u>	<u>Local trap</u>	<u>R_L values surface</u>
Asteraceae	9	1	-	<0.1	<0.1
<i>Rapanea</i>	18	27	37	1.5	2.1
<i>Dacrycarpus</i>	8	3	9	0.3	1.1
<i>Quintinia</i>	x	19	4	>5.0	>5.0
<i>Styphelia</i> sim.	6	x	x	0.2	0.2
Ericaceae	28	12	10	0.4	0.4
<i>Haloragis</i>	12	21	20	1.7	1.7
<i>Coprosma</i>	14	12	14	0.9	1.0
<i>Drimys</i> sim.	4	1		0.3	<0.2
<i>Cyathea</i> comp.	x	2	3		
<i>Pteris</i>	x	x			
<i>Grammitis</i>	x	2	3		

SITE 16A South side of lower Pindaunde lake 3,530 m

Local vegetation Lower subalpine forest, slightly disturbed

Extra-local Forest edge 23 m distant

Species list. 8 m radius quadrat. 100 points

SITE 16A (cont'd)

<i>Pipturus</i> sp.	(Urt.)	1	<i>Sagina papuana</i>	(Caryophyll.)	3
<i>Schefflera chimbuensis</i>	(Aral.)	6	<i>Acaena anserinifolia</i>	(Ros.)	7
<i>Prunus pullei</i>	(Ros.)	2	<i>Rubus</i> sp.	"	P
<i>Acronychia pullei</i>	(Rut.)	26	<i>Trigonotis</i> sp.	(Borag.)	2
<i>Timonius belensis</i>	(Rub.)	1	<i>Polygonum</i> sp.	(Polygon.)	5
<i>Amaracarpus caeruleus</i>	"	32	<i>Oxalis magellanica</i>	(Oxal.)	2
<i>Olearia spectabilis</i>	(Aster.)	36	<i>Parahebe albiflora</i>	(Scroph.)	2
<i>Senecio</i> sp.	"	6	<i>Poa languidor</i>	(Poac.)	20
<i>Rapanea vaccinioides</i>	(Myrs.)	6	<i>Carex celebica</i>	(Cyp.)	14
<i>Polyosma subalpina</i>	(Sax.)	4	<i>Cyathea perciliata</i>	(Cyath.)	9
<i>Dimorphanthera microphylla</i>	(Eric.)	48	<i>Grammitis</i> sp.	(Gramm.)	10
<i>D. collinsii</i>	"	6	<i>Selliguea</i> sp.	(Polypod.)	2
<i>Vaccinium keysseri</i>	"	44	<i>Pteris</i> sp.	(Pterid.)	16
<i>Coprosma papuensis</i>	(Rub.)	10			

Pollen source	%Cover	Local trap	Pollen% surface	Local trap	R values surface
Urticaceae	x	6	8	<1.0*	<1.0*
Araliaceae	2	x	1	0.1	0.6
<i>Prunus</i>	x	2	-		
<i>Acronychia</i>	10	3	7	0.3	0.7
<i>Timonius</i>	x	x	-		
Asteraceae	16	4	4	0.2	0.2
<i>Rapanea</i>	2	25	26	<10.0*	<10.0*
<i>Polyosma</i>	2	x	-	0.5	
Ericaceae	37	x	-	<0.1	<0.1
<i>Coprosma</i>	4	3	7	0.8	1.8
Caryophyllaceae	1	-	-		
Poaceae	8	16	39	2.1*	5.2*
Cyperaceae	5	-	2	<0.2	0.3
<i>Cyathea</i> comp.	3	25	4	7.3	1.3
<i>Grammitis</i> sim.	4	2	-	0.5	
<i>Pteris</i>	6	15	3	2.4	0.4

* Probably an extra-local component.

SITE 16B South of lower Pindaunde lake 3,530 m

Local vegetation Lower subalpine forest, forest edge

Extra-local *Coprosma-Poa saruwagetica* tussock grassland

Species list. 8 m radius quadrat. 100 points.

<i>Pipterus</i> sp.	(Urtic.)	4	<i>D. collinsii</i>	(Eric.)	3
<i>Schefflera chimbuensis</i>	(Aral.)	11	<i>Vaccinium keysseri</i>	"	26
<i>Acronychia pullei</i>	(Rut.)	2	<i>Coprosma papuensis</i>	(Rub.)	41
<i>Amaracarpus caeruleus</i>	(Rub.)	17	<i>Drimys piperita</i>	(Wint.)	1
<i>Anaphalis mariae</i>	(Aster.)	4	<i>Hydrocotyle sibthorpioides</i>	(Apiac.)	4
<i>Olearia spectabilis</i>	"	29	<i>Lactuca</i> sp.	(Aster.)	1
<i>Senecio</i> sp.	"	9	<i>Sagina papuana</i>	(Caryophyll.)	1
<i>Rapanea vaccinioides</i>	(Myrs.)	5	<i>Ranunculus</i> sp.	(Ranunc.)	2
<i>Dacrycarpus compactus</i>	(Podocarp.)	3	<i>Acaena anserinifolia</i>	(Ros.)	7
<i>Polyosma subalpina</i>	(Sax.)	4	<i>Rubus</i> sp.	"	17
<i>Styphelia suaveolens</i>	(Epacrid.)	P	<i>Geranium potentilloides</i>	(Geran.)	2
<i>Dimorphanthera microphylla</i>	(Eric.)	30	<i>Epilobium keysseri</i>	(Onag.)	1

SITE 16B (cont'd)

<i>Parahebe albiflora</i>	(Scroph.)	3	<i>Schoenus curvulus</i>	(Cyp.)	1
<i>Deschampsia klossii</i>	(Poac.)	1	<i>Cyathea</i> sp.	(Cyath.)	13
<i>Hierochloe redolens</i>	"	6	<i>Grammitis</i> sp.	(Gramm.)	2
<i>Poa languidor</i>	"	2	<i>Selliguea</i> sp.	(Palypod.)	3
<i>P. saruwagetica</i>	"	40	<i>Pteris</i> sp.	(Pterid.)	4

Pollen source	%Cover	Local trap	Pollen% surface	Local R trap	values surface
Urticaceae	2	11*	5*	7.5	3.0
Araliaceae	4	-	x	<0.2	<0.2
Rutaceae I	x	-	4		<1.0
Asteraceae	16	10	4	0.6	0.2
<i>Rapanea</i>	2	10	29*	5.3	15.1
<i>Dacrycarpus</i>	1	1	15*	13.	13.4
<i>Polyosma</i>	2	-	-	<0.5	<0.5
Ericaceae	24	7	3	0.3	0.1
<i>Coprosma</i>	16	6	1	0.4	<0.1
<i>Acaena</i>	3	-	-	<0.3	<0.3
Poaceae	19	21	14	1.1	0.7
<i>Cyathea</i>	5	23	7	4.6	1.4
<i>Grammitis</i>	x	x	x		
<i>Selliguea</i>	1	1	-		
<i>Pteris</i>	2	4	16	2.0	8.0

* Probably includes an extra-local component.

SITE 17A, 17B Keglsugl-Pindaunde track 3,040 m, 2,960 m
Vegetation Upper cloud forest.

Species List. 15.2 m quadrat. Trees and shrubs with trunk circumference >20 cm at 1.5 m above ground and a few common smaller plants noted. Sum of basal areas of all individuals of a species given. Frequency indicated by number of individuals in the quadrat or + = occasional, ++ = common, +++ = abundant.

		17A		17B	
		Freq.	Basal area cm ²	Freq.	Basal area cm ²
<i>Streblus urophyllus</i>	(Mor.)	+		2	26
<i>Breynia</i> sp.	(Euphorb.)				
<i>Macaranga</i> sp.	"	1	32	+	
<i>Homalanthus arfakiensis</i>	"	+		1	32
<i>Saurauia</i>	(Saur.)	++		+	
<i>Harmsiopanax</i> sp.	(Aral.)			++	
<i>Schefflera chimbuensis</i>	"	3	151	1	76
<i>Cryptocarya</i> sp.	(Laur.)			6	713
<i>Schuermansia henningsii</i>	(Och.)			1	477
<i>Timonius belensis</i>	(Rub.)	5	4,660	3	58
<i>Prunus schlechteri</i>	(Ros.)	4	3,222	7	11,237
<i>Ascarina philippinensis</i>	(Chloranth.)	9	1,611	11	1,238
<i>Elaeocarpus polydactylus</i>	(Elaeocarp.)	2	484		
<i>Decaspermum forbseii</i>	(Myrt.)	9	3,449		
<i>D. lorentzii</i>	"	2	598	2	92
<i>Syzygium</i> sp.	"	1		+	
<i>Xanthomyrtus</i> sp.	"	+			

SITE 17A, 17B (Cont'd)

		17A		17B	
		Freq.	Basal area cm ²	Freq.	Basal area cm ²
<i>Papuacedrus papuana</i>	(Cupress.)	1	154	2	3,923
<i>Podocarpus pilgeri</i>	(Podocarp.)	8	454	2	
<i>Achronychia</i> sp. A	(Rut.)	1	32	1	1,516
A. sp. B	"			+	
<i>Euodiella hooglandii</i>	"	++		1	50
<i>Pittosporum berberidoides</i>	(Pittos.)	14	82		
<i>P. ramiflorum</i>	"	5	986		
<i>Olearia</i> sp.	(Aster.)	2	147	8	235
<i>Rapanea vaccinioides</i>	(Myrs.)	8	1,249		
<i>Rapanea</i> sp.	"			4	32
<i>Dacrycarpus cinctus</i>	(Podocarp.)	+			
<i>Symplocos</i> sp. A	(Symp.)	3	39		
S. sp. B	"	8	3,118	4	288
<i>Dimorphanthera</i> sp.	(Eric.)	4	158	+	
<i>Steghanthera</i> sp.	(Monim.)			3	67
<i>Meliosma</i> sp.	(Sab.)			+	
<i>Planchonella macropoda</i>	(Sapot.)			1	183
<i>Bubbia calothyrsa</i>	(Wint.)	2	82		
<i>Drimys piperita</i>	"			3	247
<i>Jasminum</i> sp.	(Olea.)	+			
<i>Amaracarpus brassii</i>	(Rub.)	+++		+++	
<i>Psychotria</i> sp.	"			+++	
<i>Alpinia</i> sp.	(Zing.)	+			
Cyperaceae		+			
<i>Cyathea aeneifolia</i>	(Cyath.)	6	203	13	1,702
<i>C. atrospinosa</i>	"			+	
<i>C. percrassa</i>	"	+			
Hymenophyllaceae		+++		+++	
<i>Belvisia</i>	(Polypod.)	++		++	

Basal area 28.2 m² ha 17A
 31.1 m² ha 17B

Pollen source	Basal area%		Local Pollen%			Local R _z values		
	17A	17B	trap	surface		trap	surface	
				17A	17B		17A	17B
Urticaceae-Moraceae	x	x	17*	5*	4*	>1.0	>1.0	>1.0
<i>Macaranga</i> comp.	x	x	11*	5*	-	>1.0		
<i>Homalanthus</i>	x	x	2	3	x	>1.0	>1.0	
<i>Saurauia</i> comp.	x	1	3	-	3			
<i>Prunus</i>	17	59	x	11	13	<0.1	0.7	0.3
<i>Timonius</i>	24	x	3	6	1	0.1	0.3	
<i>Ascarina</i>	8	7	4	4	2	0.5	0.5	0.3
<i>Elaeocarpus</i> comp.	3	x	4	2	1	1.3	0.7	
Myrtaceae	21	x	9	17	x	0.4	0.8	
<i>Papuacedrus</i>	x	21	4	x	2			0.1
<i>Podocarpus</i>	2	x	8	2	x	4.0	1.0	
Rutaceae I	x	8	x	-	-			<0.1
<i>Euodiella</i>	x	x	1	-	x			
Asteraceae	x	1	x	x	x			
<i>Rapanea</i>	6	x	16	14	2	2.7	2.3	
<i>Dacrycarpus</i>	x	x	4*	14*	1			
<i>Symplocos</i>	16	2	3	5	7	0.2	0.3	3.5
<i>Cyathea</i>	1+	9+	36	28	66	>10.0	>10.0	>7.0
<i>Belvisia</i>	x	x	2	x	3			
Unknown	-	-	12	12	x			

SITE 17A, 17B (cont'd)

Note. No trap sample at Site 17B

* Probably mainly extra-local and regional

+ Relative cover probably very high as *Cyathea* spp. form an almost continuous canopy at both sites; i.e. cover/Basal area ratio much greater than for trees.

SITE 18 Komanimambuno Mire. Fossil site. 2,740 m

Local vegetation *Pandanus giulianettii* - *Scirpus subtilissimus* mire.

Extra-local Shrubby growth on the mire and lower cloud forest.

Species list A. 8 m radius quadrat. 100 points.

<i>Euphorbia plumerioides</i>	(Euphorb.)	1	<i>Ranunculus pseudolowii</i>	(Ranunc.)	6
<i>Homalanthus novoguineensis</i>	"	1	<i>Parahebe</i> sp.	(Scroph.)	2
<i>Saurauia</i> sp.	(Saur.)	1	<i>Alpinia</i> sp.	(Zing.)	7
<i>Timonius belensis</i>	(Rub.)	5	<i>Agrostis</i> sp.	(Poac.)	7
<i>Phyllanthus flaviflorus</i>	(Euphorb.)	4	<i>Deschampsia klossii</i>	"	4
<i>Schefflera</i> sp.	(Aral.)	1	<i>Nastus productus</i>	"	1
<i>Ascarina philippinensis</i>	(Chloranth.)	P	Orchidaceae (3 spp.)		12
<i>Caldcluvia nymanii</i>	(Cunon.)	1	<i>Carex atrosanguinea</i>	(Cyp.)	2
<i>Elaeocarpus polydactylus</i>	(Elaeocarp.)	1	<i>Scirpus inundatus</i>	"	3
<i>Elaeocarpus ptilanthus</i>	"	2	<i>S. subtilissimus</i>	"	65
<i>Decaspermum</i> sp.	(Myrt.)	1	<i>Juncus effusus</i>	(Junc.)	13
<i>Syzygium</i> sp.	"	1	<i>J. prismatocarpus</i>	"	2
<i>Papuacedrus papuana</i>	(Cupress.)	1	<i>Dryopteris</i> sp.	(Aspid.)	3
<i>Pandanus giulianettii</i>	(Pandan.)	18	<i>Blechnum</i> sp.	(Blech.)	1
Monimiaceae		1	<i>Cyathea macgregorii</i>	(Cyath.)	1
<i>Pittosporum ramiflorum</i>	(Pittos.)		<i>C. pachyrachis</i>	"	1
<i>Arrhenechthites novoguineensis</i>	(Aster.)	2	<i>Ctenopteris</i> sp.	(Gramm.)	1
<i>Rapanea</i> sp. A	(Myrs.)	2	<i>Lycopodium cf. macgregorii</i>	(Lycopod)	1
<i>Dacrycarpus cinctus</i>	(Podocarp.)	6	<i>Plagiogyria glauca</i>	(Plagiogyr.)	P
<i>Dimorphanthera denticulifera</i>	(Eric.)	5	<i>Belvisia</i> sp.	(Polypod.)	2
<i>Coprosma papuensis</i>	(Rub.)	1	<i>Microsorium</i> sp.	"	1
<i>Gunnera macrophylla</i>	(Halorag.)	3	<i>Selliguea</i> sp.	"	P
Caryophyllaceae		2			

No comparisons of cover with local pollen are made because of the probable large extra-local component for most pollen types. Many of the local tree species are stunted and sterile.

Species list B. Additional species noted on mire area, or in forest margins. Very incomplete especially with regard to pteridophytes.

TREES

<i>Caldcluvia brassii</i>	(Cunon.)	<i>Fagraea salticola</i>	(Logan.)
<i>Schizomeria</i> sp.	"	<i>Geniostoma arfakense</i>	"
<i>Weinmannia trichophora</i>	"	<i>Levieria</i> sp.	(Monim.)
<i>Sericolea</i> 2 spp.	(Elaeocarp.)	<i>Ficus casuaroides</i>	(Mor.)
<i>Claoxylon coriaceo-lanatum</i>	(Euphorb.)	<i>Maesa</i> sp.	(Myrs.)
<i>Homalanthus nervosus</i>	"	<i>Decaspermum</i> sp.	(Myrt.)
<i>Macaranga</i> 2 spp.	"	<i>Xanthomyrtus</i> sp.	"
<i>Cryptocarya</i> sp.	(Laur.)	<i>Dacrycarpus imbricatus</i>	(Podocarp.)

SITE 18 (cont'd)

<i>Podocarpus pilgeri</i>	(Podocarp.)	<i>Saurauia</i> 2 spp.	(Saur.)
<i>Prunus schlechteri</i>	(Ros.)	<i>Carpodetus major</i>	(Sax.)
<i>Acronychia</i> 2 spp.	(Rut.)	<i>Turpinia pentandra</i>	(Staphyl.)
<i>Euodiella hooglandii</i>	"	<i>Symplocos</i> sp.	(Symp.)

SHRUBS

<i>Perrottetia alpestris</i>	(Celast.)	<i>Schuermansia henningsii</i>	(Och.)
<i>Daphniphyllum gracile</i>	(Daphniphyll.)	<i>Jasminum</i> sp.	(Olea.)
<i>Rhododendron maïus</i>	(Eric.)	<i>Rubus fraxinifolius</i>	(Ros.)
<i>Cyrtandra</i> sp.	(Gesner.)	<i>Lucinaea</i> sp.	(Rub.)
<i>Buddleja asiatica</i>	(Logan.)	<i>Psychotria</i> 2 spp.	"
<i>Rapanea</i> 3 spp.	(Myrs.)	<i>Planchonella macropoda</i>	(Sapot.)
		<i>Drimys piperita</i>	(Wint.)

HERBS AND FERNS

<i>Scaevola oppositifolia</i>	(Good.)	<i>Potentilla papuana</i>	(Ros.)
Orchidaceae 5 spp.		<i>Marattia</i> sp.	(Maratt.)

SITE 19 Eastern end, Keglsugl airstrip 2,420 m

Local vegetation Mown short continuous grassland.

Extra-local Site about 25 m north of airstrip margin, where tall grassland is prominent.

Only local species. *Pennisetum clandestinum* (Poac.)

SITE 20 200 m south of Mondia gap (Iwam pass) 2,650 m

Vegetation Lower cloud forest.

Species list. 15.2 m radius quadrat. Trees and shrubs with trunk circumference >20 cm at 1.5 m above ground. As for Site 17. Basal area 11.1 m² ha.

		Freq.	Basal area cm ²
<i>Breynia collaris</i>	(Euphorb.)	6	821
<i>Prunus</i> sp.	(Ros.)	4	120
<i>Ascarina philippinensis</i>	(Chloranth.)	1	32
<i>Weinmannia</i> sp.	(Cunon.)	4	833
<i>Elaeocarpus polydactylus</i>	(Elaeocarp.)	1	64
<i>Sericolea</i> sp.	"	+	
<i>Decaspermum forbesii</i>	(Myrt.)	2	2,083
<i>D. lorentzii</i>	"	4	359
<i>Pandanus giulianettii</i>	(Pandan.)	7	2,083
<i>Papuacedrus papuana</i>	(Cupress.)	+	
<i>Zanthoxylum conspersipunctatum</i>	(Rut.)	1	218
<i>Schuermansia henningsii</i>	(Och.)	1	64
<i>Cryptocarya</i> sp.	(Laur.)	2	36
<i>Perrottetia alpestris</i>	(Celast.)	1	32
<i>Symplocos</i> sp.	(Symp.)	11	551
<i>Dimorphanthera</i> sp.	(Eric.)	+	
<i>Vaccinium</i> sp.	(Eric.)	+	
<i>Psychotria</i> sp.	(Rub.)	++	
<i>Bubbia</i> sp.	(Wint.)	+	
<i>Alpinia</i> sp.	(Zing.)	+	
<i>Cyathea aeneifolia</i>	(Cyath.)	9	841
Unknown 'Mond'		12	2,024

SITE 20 (cont'd)

<u>Pollen source</u>	<u>Basal area%</u>	<u>Local Pollen.</u> <u>trap</u>	<u>surface</u>	<u>Local R_t values</u> <u>trap</u>	<u>surface</u>
<i>Macaranga</i> comp.	16	10	4	0.6	0.3
<i>Prunus</i>	2	3	3	1.1	1.4
<i>Ascarina</i>	x	2	x		
Cunoniaceae	16	-	-	<0.1	<0.1
<i>Elaeocarpus</i> somp.	1	3	6	>1.0	>1.0
<i>Pandanus</i>	41	-	-	Nil	Nil
Myrtaceae	47	4	2	0.1	>0.1
Rutaceae I	4	3	17	0.7	4.2
<i>Symplocos</i>	11	14	21	1.3	1.9
<i>Cyathea</i>	17	60	46	3.6	2.8

SITE 21 1 km north of Mondia gap (Iwam pass.) 2,560 m

Vegetation *Nothofagus* cf. *pullei* forest

Species list. 15.2 m radius quadrat. Trees and shrubs with trunk
circumference 20 cm at 1.5 m above ground. As for
Site 17. Basal area 47.9 m² ha.

	Freq.	Basal area cm ²
<i>Nothofagus</i> cf. <i>pullei</i> (Fag.)	3	34,975
<i>Caldcluvia</i> sp. (Cunon.)	1	1,016

<u>Pollen source</u>	<u>Basal area%</u>	<u>Local Pollen</u> <u>trap</u>	<u>surface</u>	<u>Local R value</u> <u>trap</u>	<u>surface</u>
<i>Nothofagus</i>	97	100	100		
Cunoniaceae	3				

Other species within 25 m.

TREES - SHRUBS

<i>Ascarina philippinensis</i>	(Chloranth.)
<i>Elaeocarpus ptilanthus</i>	(Elaeocarp.)
<i>Elaeocarpus</i> sp.	"
<i>Sericolea</i> sp.	"
<i>Steganthera</i> sp.	(Monim.)
<i>Streblus urophyllus</i>	(Mor.)
<i>Maesa</i> sp.	(Myrs.)
<i>Rapanea</i> sp.	"
<i>Syzygium</i> sp.	(Myrt.)
<i>Schuurmansia henningsii</i>	(Och.)
<i>Pandanus giulianettii</i>	(Pandan.)
<i>Dacrycarpus imbricatus</i>	(Podocarp.)
<i>Coprosma papuensis</i>	(Rub.)
<i>Saurauia</i> sp.	(Saur.)
<i>Drimys piperita</i>	(Wint.)

HERBS - FERNS

<i>Carex magellanica</i>	(Cyp.)
<i>Schoenus curvulus</i>	"
<i>Plectranthus</i> sp.	(Lam.)
<i>Cordyline</i> sp.	(Lil.)
<i>Agrostis avenacea</i>	(Poac.)
<i>Deschampsia klossii</i>	"
<i>Nastus productus</i>	"
<i>Poa</i> sp.	"
<i>Ranunculus pseudolowii</i>	(Ranunc.)
<i>Elatostema</i> sp.	(Urt.)
<i>Blechnum</i> sp.	(Blech.)
<i>Cyathea aeneifolia</i>	(Cyath.)
<i>C. pachyrachis</i>	"
<i>Gleichenia</i> sp.	(Gleich.)

SITE 22 Mondia - Bundi track 2,100 m

SITE 23 Mondia - Bundi track 1,300 m

Vegetation Partially disturbed mixed mountain forest. Oak at the lower site.

Species lists. Very incomplete.

TREES		22	23		22	23
<i>Schefflera</i>	(Aral.)	+		<i>Ficus</i> sp. 1	(Mor.)	+
<i>Caldcluvia</i>	(Cunon.)	+		<i>Ficus</i> 2 spp.	"	+
<i>Pullea</i>	(Cunon.)	+		<i>Streblus urophyllus</i>	"	+
<i>Dillenia</i>	(Dillen.)	+	+	<i>Maesa</i> sp.	(Myrs.)	+
<i>Elaeocarpus ptilanthus</i>	(Elaeo-+)	+	+	<i>Syzygium</i> 3 spp.	(Myrt.)	+
<i>Elaeocarpus</i> sp.	carp.)+	+	+	<i>Schuurmansia</i>	(Och.)	+
<i>Breynia</i> sp.	(Euphorb.)	+		<i>henningsii</i>		
<i>Claoxylon</i> sp.	"		+	<i>Pandanus giulianettii</i>	(Pandan.)	+
<i>Homolanthus</i>	"	+	+	<i>Pandanus</i> sp.	"	+
<i>novoguineensis</i>				<i>Podocarpus amarus</i>	(Podocarp.)	+
<i>Macaranga pleioneura</i>	"		+	<i>Alphitonia incana</i>	(Rham.)	+
<i>Macaranga</i> 2 spp.	"	+	+	<i>Mussaenda</i> sp.	(Rub.)	+
<i>Albizia fulva</i>	(Fab.)	+	+	<i>Timonius</i> sp.	"	+
<i>Castanopsis</i>	(Fag.)	+	+	<i>Zanthoxylum</i>	(Rut.)	+
<i>acuminatissima</i>				<i>conspicupunctatum</i>		
Monimiaceae		+		<i>Meliosma</i> sp.	(Sab.)	+
<i>Ficus augusta</i>	(Mor.)	+	+	<i>Planchonella macropoda</i>	(Sapot.)	+
<i>Ficus dammeropsis</i>	"	+	+	<i>Symplocos</i> sp.	(Symp.)	+
<i>Ficus pungens</i>	"	+	+	<i>Saurauia</i> 3 spp.	(Saur.)	+
				<i>Bubbia</i> sp.	(Wint.)	+
				<i>Drimys piperita</i>	"	+
SHRUBS				FERNS		
<i>Olearia</i> sp.	(Aster.)	+		<i>Cyathea</i> sp.	(Cyath.)	+
<i>Sida</i> sp.	(Malv.)	+		Gleicheniaceae		+
<i>Piper</i> sp.	(Pip.)	+	+	<i>Lycopodium</i> 2 spp.	(Lycopod.)	+
<i>Miscanthus floridulus</i>	(Poac.)	+	+	<i>Selaginella</i> sp.	(Selagin.)	+
<i>Cypholophus</i> sp.		+				
<i>Pipturus</i> sp.	(Urt.)	+				
Zingiberaceae		+	+			

SITE 24 400 m south of Inbrum river bridge. 370 m

Vegetation Lower montane rainforest.

No species list.

+ Represented	? Possible correlation	- No ash layer
. No cores of this age	++ Close to ^{14}C date horizon	

Every volcanic ash layer seems to be represented in at least two sites, and those at about 12,100, 8,600, 7,600, 3,700-4,100 and 600 BP are present in most sections of relevant age. There are so many ash layers that the definite correlation of undated ash layers in uncontrolled cores (e.g. Badmenangidongwa) would be premature. Comparative studies of the ash layers (mineralogy, glass refractive indices heavy element analyses, electron probe analysis) would be needed to set up a tephrochronology.

The ages of ashfalls less than 13,000 years old from other highland sites are of interest in relation to Table A2.1. In the Mt Hagen area 90 km west of Mt Wilhelm, Powell (1970a) has obtained dates from peat overlain by ash of $4,900 \pm 90$ BP (ANU - 252, Manton Site) and $2,280 \pm 90$ BP (ANU - 277, Draepi Site). A very young ash, perhaps 300 years old, has been found at Kuk, 10 km from Mt Hagen township (R. Blong personal communication), overlying several older ashes, including one of *ca* 700 BP while the lowest two are more than 16,000 years old. Flenley (1967) investigated Lake Birip, a crater lake near Wabag. He concluded that the lake formed soon after eruptions had ceased sometime before 2,000 - 2,500 BP. Two ash layers have been deposited in lake sediments formed since that time, and he dated these at 1,900 and less than 300 BP.

The western Papua New Guinea highlands ash layers formed at about 4,900, 2,300 - 1,900 and 700 BP may be regionally correlated with Mt Wilhelm ash layers of 5,000, 2,600, 1,800 and 600 BP age. However the ash of about 300 BP age does not appear to be represented on Mt Wilhelm, with the possible exception of the topmost ash layer in Brass Tarn.

The source or sources of the Mt Wilhelm ashes are unknown. Mt Giluwe and Mt Hagen were responsible for extensive ash falls in the Pleistocene, and Blake and Löffler (1971) have described small, well preserved, parasitic craters which may represent post-glacial eruption craters. The Birip volcano was probably active within the last 10,000 years, but is very small. Doma peaks, near Tari, is the largest dormant volcanic area in the western part of Papua New Guinea. Mr G.A. Taylor (personal communication) suggested that Mt Yelia, a presently dormant but solfatic volcano 185 km southwest of Mt Wilhelm is a likely source. He considered that presently active volcanoes, similar distances to the north from Mt Wilhelm, for example Karkar, Manam and Long Islands, were

not ash sources. Mt Lamington, a large volcano 440 km east south east of Mt Wilhelm, has a long record of massive ash eruptions. These have occurred many times over the last 26,000 years (White, Crook and Ruxton 1970, Ruxton 1966) with at least six separate ash falls occurring between 12,800 to 4,200 BP. This volcano seems rather too far away for the thick lenses of ash at Mt Wilhelm to be attributed to it. For the same reason the active New Britain volcanoes (550-750 km east of Mt Wilhelm) seem unlikely as sources of ash, but neither can definitely be ruled out.

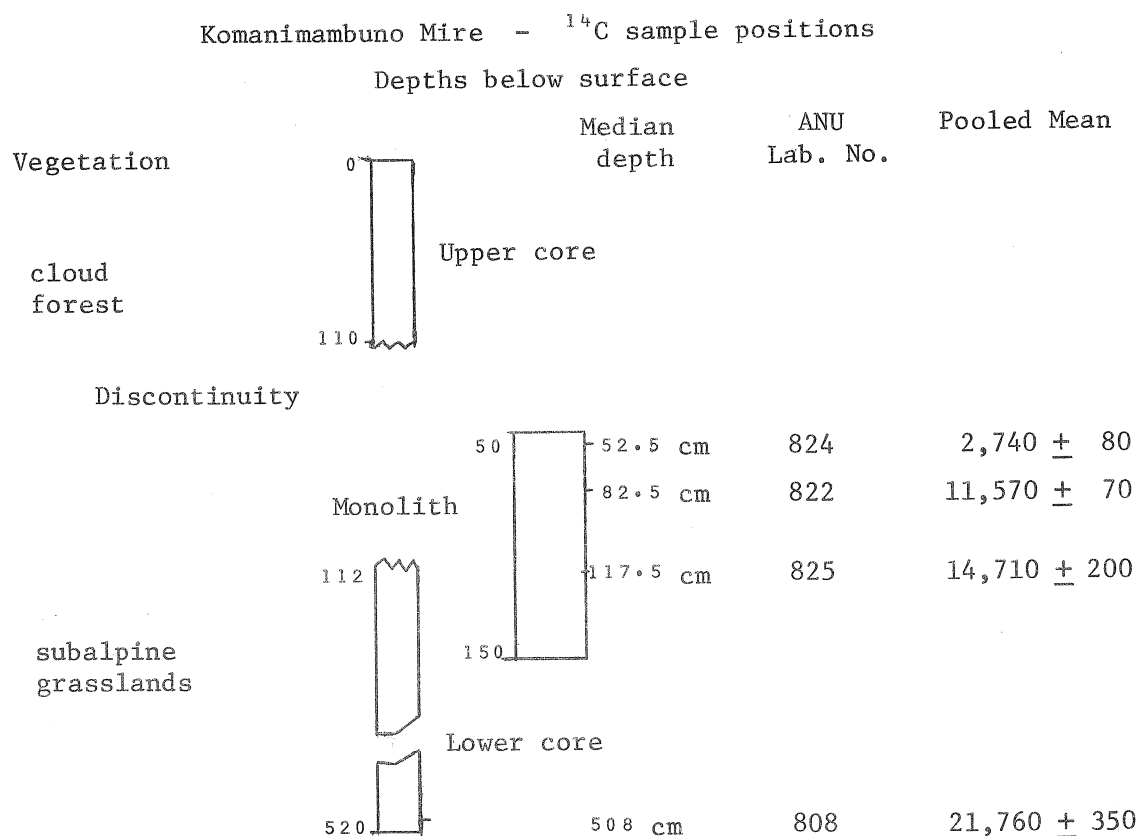
Tephrochronology promises to be extremely valuable in eastern New Guinea, and Mt Wilhelm could be a useful control area for a regional tephrochronological framework because of the occurrence of easily dateable gyttja sections, which are relatively free from problems of deposition of reworked ash.

¹⁴C dating of peats penetrated by younger roots

The dating of material from Komanimambuno Mire (Chapter 10) presented problems because the peats at less than 150 cm from the surface were penetrated by woody roots up to 1 cm in diameter. The roots could not be related to living plants, but pollen analysis of the peats below 70 cm suggested that shrubless grasslands had been continuously present on the site. It is thus probable that the roots post-date the peat formation by a considerable time and that ages based on whole samples might be younger than the formation of the peat. No oxidation or evidence of soil forming processes were found in the profile and the peat probably formed at, or above, the local water table by litter accumulation from local vegetation. The presence of the roots suggests that the environment was not strongly reducing and it is possible that the water table fluctuated, occasionally aerating the peat. Pollen types typical of the lower peats are only found as traces above 75 cm. Since about 80 per cent of the peat particles are smaller than 150 μ , and the same order of size as pollen, it seems unlikely that

reworking of older peats has occurred. Thus contamination of the samples by older material is unlikely.

Three 5 cm sections were cut from a peat monolith extending from 50 cm to 150 cm.



ANU 822 was chosen for detailed study because although the peat at 85 cm had formed under shrubless, subalpine bog conditions many woody roots were present which were presumably much younger than the peat. A subsample of the section 80-85 cm was dated without pre-treatment, and five additional fractions of the section underwent different treatments.

ANU No.	Age	Treatment
822 A	$11,610 \pm 155$	No pretreatment, no large roots included
822 D	$11,890 \pm 120$	NaOH insoluble fraction
822 C1	$11,250 \pm 120$	Humic acid, NaOH sol., HCl insol. fraction
822 C2	$11,540 \pm 120$	Repeat count of 822 C1
822 B	$4,130 \pm 170$	Fibrous matter >1mm. Humic acid and wax free
822 F	$9,740 \pm 160$	Fulvic acid, NaOH sol., HCl sol. fraction
822 W	$2,760 \pm 410$	Waxes (Benzene + ethanol soluble fraction)
A+D	$11,780 \pm 95$	Pooled Mean X
C1+C2	$11,390 \pm 90$	" Y
A+C1+C2+D	$11,570 \pm 70$	" Z