SITE 24. 370 m. Lower montane rain forest. 1 surface sample collected in 1970.

Sparse mosses were collected from the trunks of trees at the edge of a new clearing being made for a road which will descend the southern wall of the Inbrum River gorge from Bundi (Plate 20). The clearing is about 80 m above the point where the river will be bridged, and has been made in a virgin stand of rainforest which extends unbroken for several kilometres in all directions, except for a small area next to the river where a sawmill is operated. No plant collections were made at the site nor was help available from Chimbu informants. Hence the site remains unknown floristically, beyond the obvious occurrence of many Moraceae, Anacardiaceae, Urticaceae and Euphorbiaceae in an extremely varied tree layer. Structurally, the forest is about 25 m high, multistoried with a dense canopy of large-leafed trees and a sparse growth of saplings and shrubs, all festooned with lianes and epiphytes, particularly epiphytic ferns. A scattered ground layer of ferns also occurs, but the ground is mainly covered with litter without any mosses. In collecting the surface sample, it was extremely difficult to find sections of tree trunks free from the minute epiphytic ferns.

This forest forms a continuous belt about 15 km wide, between the grasslands at 150 m altitude near the Ramu River, and the lowest mixed oak forest, all along the base of the northern slopes of the Bismarck Range. The site itself, 27 km northeast of Mt Wilhelm summit, is the most distant of this study. It is of interest in assessing the spread of *Nothofagus* pollen down valley; the nearest *Nothofagus* trees are probably 8 km to the south.

Pollen trapping methods

The Tauber (1965,1967) traps used differed from the standard design in having a barrel length of 110 cm to retain rainwater. The opening in the aerodynamic collar had a surface area of 19.6 cm^2, and the barrel was about four times as wide so that an annual precipitation of 4,000 m could be accommodated. The traps were buried so that the openings were about 30 cm above ground level, or else set in rock

crevices or rafts to give the same clearance above the ground or water surface. This clearance was designed to prevent litter and soil being splashed into the trap but it also had the effect of preventing the lowest herb layer of the surrounding vegetation from making the same contribution to the pollen traps as it does to the surface samples.

Most traps were operated for one year, 1969-70, but a few were continued for a second year, 1970-71, and two extra sites were established for this year as well. As part of the study of regional pollen rains, four roofed traps were operated in the first year. These traps exclude rain deposited pollen (the 'rainout component' of Tauber) and were set in very open sites (1,11,19) where the 'trunkspace component' is not present and local pollen is minimal in order to examine the wind borne component of the regional pollen deposition. A third trap type was used to sample sediment in the lakes. The trap was a tube 50 cm long with a closed base and open top and was suspended from rafts at a depth of about 8 m to collect pollen settling out in the lakes.

The open traps were set out containing 2 cm depth of an aqueous solution of 20% glycerine and 2% mercuric chloride. After 12 months exposure most contained between 50 and 90 cm of water. No fungal growth occurred in the fluid but green algae were present in some traps constructed from translucent white rather than opaque pipe.

The open traps were visited one to two weeks after the 12 month period. The water above 35 cm was siphoned slowly away and discarded. Examination of the Millipore filter discs through which test samples had been filtered revealed no pollen in this water. The remaining water (which contained at least 52 weeks pollen, even if the discarded water contained some pollen still settling out) was then shaken vigorously and decanted into a large bottle. The trap was then washed out by jets of filtered water from a washbottle and the washings added to the previous collection. The entire contents of the roofed and sediment traps were collected. The bottles of water were allowed to stand for some days and the water was then filtered through 5μ Millipore filter discs using positive pressure. Clogging of filters was reduced by filtering the clear water above the sediment first and by presieving the rest through a 0.1 mm (100 μ) mesh. The filter discs had been expected to dissolve in mineral acid, but when tested

did not completely do so. Instead the filter discs and sediment were blended in a 'Ato-mix' blender with water and detergent, and the fragmentary remains of the discs were removed by sieving and then washed. Microscopic examination of glycerine-clarified disc fragments left after this treatment failed to reveal any pollen remaining on them, so fairly complete pollen recovery can be assumed. The sediment and the disc washings were centrifuged before chemical analysis. In the second year of trapping, the trap fluid samples were returned to the laboratory for the sieving and centrifuging.

After chemical treatment (as described in Chapter 6) the entire remaining trap sediment was transferred to preweighed vials and suspended in silicon oil. The vial plus sample was then weighed, together with a disposable micropipette. A slide was then prepared and the used pipette, vial and depleted sample reweighed. From these weighings the proportion of the total trap sample that had been transferred to the slide was calculated. In examining the slide the methods of Jørgensen (1967) were considered, although no mask was used on the eyepiece of the microscope. Pollen trap slides tend to be very free of debris and with careful counting it was hoped that the 'equatorial losses' described by Jørgensen would not occur. In a circular field the areas corresponding to the limbs of the 'equator' (where transect direction is 'polewards') tend to be examined for a very short time and pollen there may be missed so that the true width of a transect tends to be less than the field diameter, except for very prominent pollen types. Great care was taken to examine the field edges; pollen grains part-entering the 'western' limb were included while those on the 'eastern' limb were excluded from the count.

Transects were counted across the slide and were evenly spaced, but the ends were avoided to prevent problems deriving from differential pollen movement (cf Brookes and Thomas 1967). Again, the lack of debris compared with that found in fossil material showed that an even distribution of pollen on the slide was usually obtained, as remarkably little variation occurred between the results of individual transects. The number of transects multiplied by the width of the transects divided by the length of the coverslip gave the approximate proportion of the slide counted. This factor, when multiplied by the

sample proportion put on the slide, gives the proportion of the trap collection actually counted. Pollen counts can be multiplied by the latter to give estimated total trap collections. In this thesis, such figures have been divided by the area of the trap opening, 19.6 cm^2, (78.5 cm^2 for sediment traps) and expressed as pollen grains per square centimeter per year (gr cm^2 yr). This, then, is a count of absolute pollen deposition. However the trap does not act as a simple hole through which pollen falls; rather it is an area of slightly lower air pressure and non-turbulent flow into which pollen grains can settle from air-suspension. Trap efficiency will vary with the nature of the airflow over its surface, so estimated deposition figures from traps may well differ from the deposition rate onto a ground surface.

Surface samples

At all trap and fossil sites surface samples were collected; usually they were made up of tufts of mosses collected from within an area of 1 m^2. In the forests the mosses were taken from logs and treetrunks and in the grasslands the mosses were chosen carefully to exclude soil. In a few sites it was impossible to avoid collecting whole moss plants with some soil. On some of the fen sites, surface layers of litter and peat were analysed if mosses were not present. Although mosses are ubiquitous in the New Guinea mountains, care was needed to exclude epiphytic ferns and orchids which occupy the moss mats. The collected mosses were sealed in plastic bags with 400 ml of 70% ethanol and returned to the laboratory. There the entire sample was placed in a beaker and water was added, in which the mosses were squeezed. Then the moss mat was wrung out over a sieve and the sediment and fluid expressed were centrifuged. More complicated methods (such as blending the moss or treating it with NaOH) have been tried but an increase in debris seems to result; more than adequate amounts of pollen can be obtained by the simple method. The treatment of the sediment and preparation of slides was the same as for the trap sediments, but in counting no estimate of the total pollen was made.

Vegetation measurement

Any method of local vegetation measurement is satisfactory if it can provide relative percentage values for each component species.

In general a measure of cover for each species is to be preferred because for most species the cover is correlated with flowering opportunity and it can be measured for all types of plant communities. It is most conveniently measured in non-forest communities, however, and in forests with multistoried canopies, a directly related measurement such as percentage basal area can be used.

Wade (1968) had found that 4 m square plots exceeded the minimal area of non-forest communities on Mt Wilhelm, and 10 m square plots approached the minimum area within cloud forest. For the pollen deposition study a point quadrat method was used in non-forest plots, with one hundred points being dispersed in a circle of radius 8.5 m (25ft) with the pollen trap and surface sample as its centre. A species was scored if it was struck once (or more than once) by any pin, and percentage cover for each species is given by the number of scores. This is an absolute value measuring the cover of the species relative to the sample area, irrespective of other vegetation. To make the figures relative for comparison with pollen spectra, percentage of total cover (C) is calculated:

$$C = \frac{\text{Number of hits on pollen source}}{\text{Total number of hits on all pollen sources}} \times 100$$

In herbaceous communities, or the layer below 1 m in taller communities, a pin was dropped into the vegetation and examined for hits. A grid was used to locate the position of each pin to within 2 m and it was then dropped at random. For tall shrubs the pin was raised and hits recorded. Where a single thin canopy existed, hits were estimated by eye, vertically above the pin.

For forest sites an area of 15 m (40ft) radius was used. Where a dense interlaced canopy or multistoried tree layer existed (sites 17, 20,21) all trees with trunk circumference greater than 25 cm at 150 cm from the ground (c.b.h.) were measured. A cumulative basal area for each species was established for the plot and percentage total basal area calculated in a manner analogous to the percentage cover.

In all plots a species list was compiled of plants missed by the pins or not measured. Sites 2,12,22,23 and 24 were not quantitatively assessed and no pollen trapping was done there, but species lists were made for all sites except 24. Wade and McVean (1969)

gave association lists for the plant communities above 3,100 m and these supplement the lists for the pollen study sites. Most identifications were made in the field although uncertain species were checked with herbarium specimens. Forest species were identified by Chimbu assistants chosen for their specialist botanical knowledge; repeated tests failed to show errors except for a few species which were combined under a single native name. Voucher specimens corresponding to their identifications were collected and identified against herbarium material. As a general observation, their level of identification roughly parallels that needed by a pollen analyst; for example, all species of *Saurauia* are given the same local name, although differences are acknowledged between species. After a while, we mutually agreed on artificial 'native species' to add to their generic names. For example, Dagga no.1 for *Decaspermum lorentzii* and Dagga no.2 for *D. forbesii*. For many trees their names are quite specific, but for herbs their taxonomy is less exact. Fortunately, the herbaceous flora is botanically far better known and more easily identified by more orthodox methods.

CHAPTER 5

MODERN POLLEN DEPOSITION: RESULTS AND DISCUSSION

Presentation of results

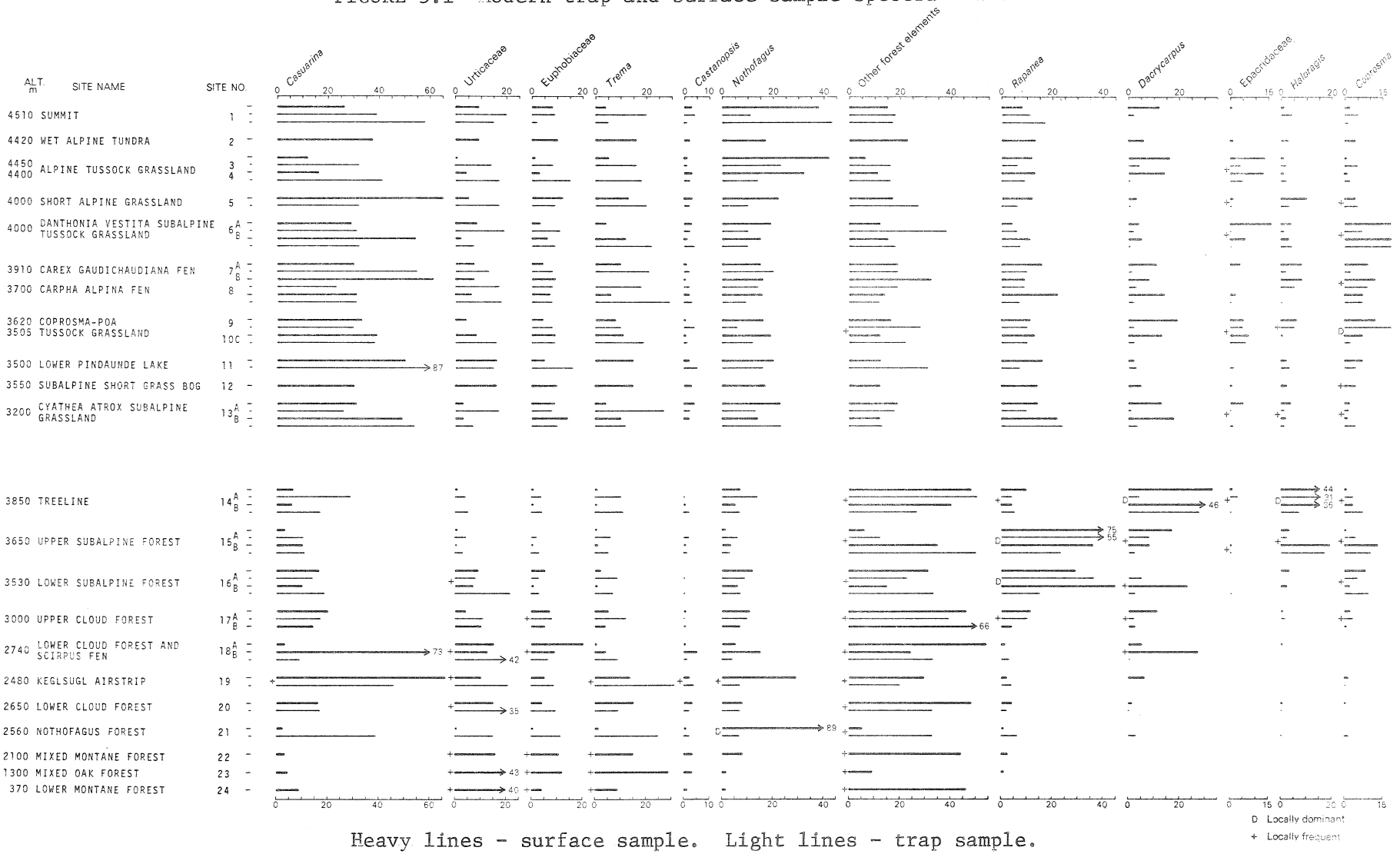
The results of the modern pollen samples will be examined in two ways. First, the absolute depositions and spectra will be compared in order to 'fingerprint' different communities and field situations and to discover regional and altitudinal variation. Secondly, individual pollen sources will be assessed for representation, dispersibility and productivity. The results are set out in Table 5.1 which lists the pollen deposited in open traps at the 19 trap sites, and in a summary diagram (Fig 5.1) which shows spectra of selected pollen types from traps and surface samples at the 24 sites. Both the table and diagram can be used to provide all the depositions or spectra for a given site, or to provide the distribution of a given pollen type over all sites on Mt Wilhelm. The full table of percentages for all pollen types is given in Appendix 3, and the table and diagram are repeated there.

Table 5.7 presents representation values and selected absolute pollen depositions for each significant pollen type, and summarise the ecological significance placed on each type. The vegetational analyses are given in Appendix 1 where they may be compared to the pollen results, computed on a pollen sum consisting only of local elements to give local representation values. All other percentages are based on a sum of all woody plants excluding *Casuarina* and *Cyathea*, for reasons which are discussed later.

Reliability

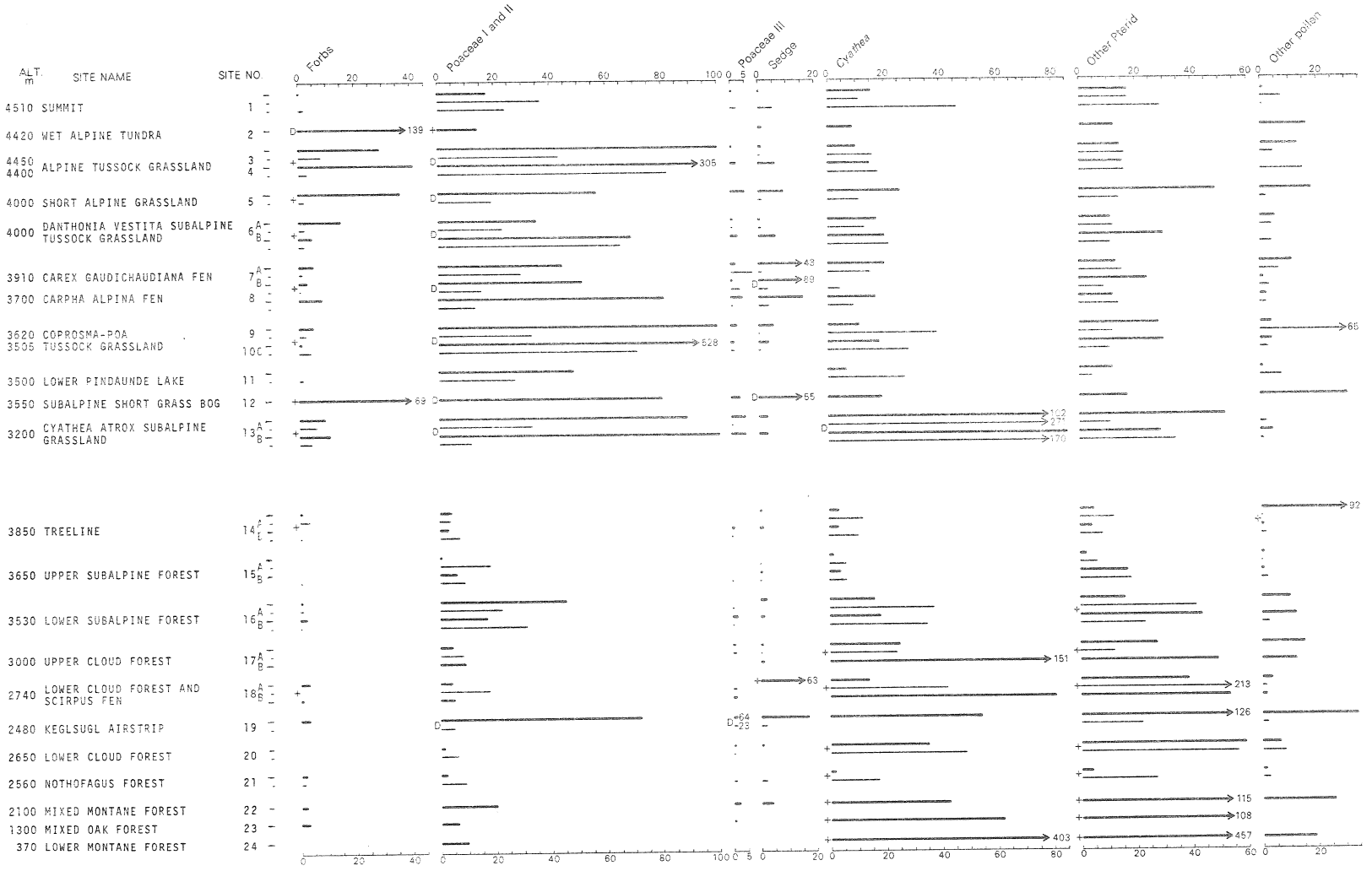
The results must first be considered together to assess the reliability of the pollen spectra and trap deposition totals so that the significance of any trends or variation can be estimated. Firstly, one can consider the variation between spectra obtained from the trap and surface sample at each site, and between spectra obtained from groups of sites that were close together in similar vegetation. These comparisons are shown in Fig 5.1. In both the above cases, similar results might be expected. However some variation would be likely

FIGURE 5.1 Modern trap and surface sample spectra - WOODY PLANTS



Heavy lines - surface sample. Light lines - trap sample.

FIGURE 5.1 (cont.) Modern trap and surface sample spectra - HERBS AND FERNS



Percentages based on woody plant (excluding *Casuarina*) pollen sum.

TABLE 5.1

Pollen deposition on Mt Wilhelm

gr cm^2 yr

	1			3	4	5	6			7		8	9	10		11			
	A MT	B MT	B MT II	MT	MT	MT	A MT	B MT	B MT II	A MT	B MT	MT	MT	A MT *	C MT	MT	MT II	A MU	B MU
Casuarina	160	170	35	250	260	500	330	200	400	280	140	470	140	670	220	310	210	360	220
Dodonaea	5	+		10		30	15	20	5	20	5	45	25	80	5	5		40	5
Urticaceae-Moraceae	85	45	5	120	110	280	210	50	80	70	100	300	30	430	95	50	100	200	110
Euphorbiaceae	40	5		70	90	150	120	65	45	45	45	130	40	130	60	60	30	140	100
Saurauia comp.	5			5	5	30	15	20	+	5	10	15	5	10	10		+	35	5
Ulmaceae	90	30	5	140	120	330	200	150	120	120	120	470	60	220	130	75	100	330	200
Castanopsis-Lith.	20	5	+	5	10	30	20	25	15	10	10	45	20	25	10	20	5	40	20
Nothofagus	45	120	5	190	70	160	120	70	140	110	90	140	35	240	70	60	50	260	240
Timonius		+						+		+								10	
Prunus comp.		+								+	+			10	5			40	10
Ascarina comp.	15	5		35	10	60	35	35		20	30	45		35	20	15	+	20	30
Cunoniaceae	5	5	+		10		20			5	+	10	5	10				10	
Elaeocarpus comp.	10	5	+	20	20	80	40	15	+	25	15	65	5	35	15		5	50	50
Myrtaceae	10	+	+	5	10	30	5	5		5	+	25	+	35	5	5	5	15	15
Papuacedrus	+		+	5	5	10	5	5	5		+	20			10		20	20	5
Phyllocladus	+	+	+	10	5	10	20			5			10		15			5	
Podocarpus	+	5	+	+		5	30		5							5		5	15
Rutaceae I		+					5		+	5	5			25	10			15	10
Euodiella												+			5				
Asteraceae-Shrub	+		+	20	5	*135*	*10*		*10*	+	+		+	25	5	5	+		+
Rapanea	45	50	10	45	55	100	65	50	130	50	55	110	55	160	60	25	60	250	140
Dacrycarpus	5	+		30	5	10	25	+	15	5	20	35	10	25	10	10	10	100	75
Polyosma																			+
Quintinia	+				5	25	5		5	10	5	10		160	10		5	10	
Symplocos	+		+										+					10	5
Eurya sim.																			
Ericaceae II + III		+	+	+	5	5	5	+	+			5	*90*	*60*	*10*			5	5
Styphelia sim.		+		*30*	*30*	*5*	*5*	+	*15*			5	*25*	*1020*	*35*	5	+	20	5
Haloragis	20		+	15	15	55	15	30	10	10	30	10	25			10	+	130	70
Coprosma	20	5	+	40	15	80	*80*	*120*	*110*	15	55	120	*100*	*60*	*10*	15	5	90	40
Drimys sim.							10	5		5	5				5			10	15
Apiaceae				*10*	+	*5*			+									5	
Asteraceae-Herb				*10*	*5*			*5*	+		+			*10*	*15*			5	
Caryophyllaceae		+		*5*							+		+						
Ranunculus		5		*15*	*5*			*10*		*5*			*10*	*10*	*10*	5		5	5
Other Dicots	30		+	50	120	100	65	35	20	30	20	70	380	25	15	25	+	100	30
Astelia	+			*25*	*10*	*5*	*20*	+		+								5	
Poaceae	160	80	15	*360*	*580*	*220*	*260*	*440*	*60*	*200*	*110*	*220*	*180*	*4900*	*430*	60	65	420	170
Cyperaceae		15		*5*		*25*	*10*			*5*	*20*	*45*	+		+				
Cyathea sim.	45	130	70	140	110	180	140	150	140	100	25	150	*220*	*460*	*170*	100	40	210	230
Pteris	10	+			5		5		+	10	10		20	25	15		5	10	
Lycopodium	+	5	+		10	*10*	*5*	*10*	*5*	10		5	+		*10*	5	+	5	5
Monolete psilate	20	35	45	60	45	110	80	40	60	20	15	100	25	50	40	15	20	90	70
Belvisia	5	5	+			5	5	5	+	+		5			10		5	5	
Microsorium sim.	+		+					5	5	+	5		5	10	5			10	10
Other pteridophyte spores	30	35	+	60	35	110	40	15	10	15	25	120	15	80	5			90	20

Numbers in italics indicate important local sources are present. Mean regional deposition calculated

* Excessive catch; ?possible contamination. MT - modern trap sample. UT - underwater sediment trap.

II Traps operated in 1970-71. All other traps 1969-1970.

TABLE 5.1 (cont.)

gr cm^2 yr

13 A MT	13 B MT	14 A MT	14 B MT	15 A MT	15 B MT	16 A MT	16 B MT	17 MT	18 MT II	19 A MT *?	19 B MT *?	19 MT II	20 MT	21 MT II	1969-70 Mean regional deposition	Standard deviation
370	260	300	210	220	190	130	240	380	160	*1100*	*420*	*190*	280	810	260	99
	15	+	10	35		15		25	15	*75*	*25*	*5*	30	20	15	9
240	40	40	60	100	50	80	280	*270*	*770*	*560*	*110*	*80*	*620*	320	115	90
120	50	40	50	50	45	30	35	*200*	*110*	*230*	*170*	*20*	*160*	*240*	65	37
15	10	30	5	15	5	20	15	*40*	*30*	*70*	*5*		*25*	*15*	10	8
400	65	100	150	190	80	85	85	280	180	*830*	*80*	*200*	180	520	160	110
30		5	20	60	20	10	5	20	25	100	40		30	50	20	13
190	120	140	100	160	55	80	85	230	70	190	120	40	130	*400*	110	51
	5	+	5			5		*50*	*50*		*360*		*10*	+	+	
						25	*20*	*5*	*25*	10	10		*40*		+	
40	5	5	15	50	25	25	30	*55*	*15*	60	35	10	*30*	5	25	16
10			5	5					*15*	10		+			55	5
65		10	15	10	5	5	5	*60*	*90*	*90*	*60*	*15*	*50*	*130*	30	23
5	5	+	20	30	25	5	5	*170*	*140*	*70*	*50*		*60*	+	10	10
10	15	+	5	20	25	15	5	*65*	*40*		25		*40*	30	5	
	5	+			5				5	10	10				+	
	5			5	10	5	5	*130*	+	10	20		10		+	
			5	5		*35*	*5*		*130*	*160*	*440*		*50*	*80*	+	
								+								
		15	*25*		*15*	*50*	*180*	*5*			15				+	
150	120	*45*	*70*	*1470*	*390*	*350*	*190*	*240*	*60*	90	90	15	*40*	*130*	70	34
15	15	*45*	*370*	*230*	*40*	*45*	*25*	*60*	*5*		15		15	15	15	10
						10		*5*					*10*	5		
25		+	20	*50*	*260*	*20*	*5*	*40*	20	10			10	10	+	
10	5		15				5	*40*	*15*				*210*		+	
		25	*90*		*5*									5		
30	*5*	*70*	*50*	*55*	*170*	*10*	*130*	*10*	*25*	10	45		*45*	5	+	
5	*5*	*30*	*5*				5								+	
15	5	*320*	*90*	*55*	*290*			30			10		+	+	15	14
20	*20*	*30*	*90*	*110*	*170*	*45*	*120*	*80*		10	15	+		*30*		
5		15	40	20	20			15		10			10		+	
		+									10					
			5	5	5											
				10											+	
90	*20*	+				*5*					5			10		
50	+	40	30	30	40	10	40	230	40	90	215	25	180	80	NA	
					5											
480	*60*	*45*	*110*	*490*	*140*	*220*	*530*	*190*	*110*	*590*	*400*	*85*	*125*	*200*	125	55
				5	*5*			5		10	10	5		25		
3900	*860*	120	130	160	100	*360*	*440*	*530*	*1500*	220	390	30	*880*	*350*	120	41
	5	+			*5*	*200*	*80*			25	25	+		5	+	
25	*25*	*5*	*10*		*10*	*5*	*5*				10	+	*30*		+	
90	100	40	40	*80*	*180*	*110*	*50*	*100*	*610*	320	130	25	*170*	*430*	50	33
		10	*10*	*5*	*5*	*10*	*20*	*20*	*10*	50	10		*40*	*25*	+	
5	5						5	20	*40*	40	25	5	10	30	+	
40	35	65	40	70	115	70	130	150	320	170	70	50	770	65	NA	

on non-italic figures only, and sites marked * or II are excluded.
See Table 5.4 for summaries of pollen counts, local vs. regional pollen etc.
See Fig. 5.1 for site identifications, Ch.4 for site descriptions.

between trap and surface sample at any given site, because of intrinsic differences between trap and surface collection of pollen, while sites close together might vary because of minor differences in vegetation and microclimate.

For 'regional' pollen types the results are close, pollen percentages agreeing within 10% in most cases for surface samples within site groups. *Casuarina* is an exception, in that although it has no local sources in sites 1-13, within group variations of up to 30% occur. With local or extralocal sources, somewhat greater fluctuations occur, and these often take the form of occasional very high percentages. Hence there is very little ecological distinction to be drawn between, for example, 80% Poaceae and 305% Poaceae.

The trap results are more erratic and tend to show great within grouping variation. An interesting feature is that there is a systematic variation between trap and surface sample results for most sites. For example, *Casuarina*, *Trema*, Urticaceae and Moraceae have higher percentages in traps than in surface samples while *Nothofagus*, *Dacrycarpus*, *Haloragis*, *Coprosma* and Poaceae have higher percentages in surface samples than in traps. There are several possible reasons for this. Differential destruction of pollen may occur in the surface samples and this would result in different spectra. If this were the main cause, then in the surface samples there should be a range of slightly to severely eroded pollen of the types that occur less frequently than in the trap samples. Coetzee (1967) has proposed differential pollen destruction as a possible explanation for low Poaceae values in surface samples on Mt Kenya, suggesting that intense insolation by the morning sun was responsible. The Mt Wilhelm samples show no evidence of differential destruction and the continually moist environment with blanket peat and continuous mossy layers is ideal for pollen preservation.

Yearly variation in pollen deposition could mean that several years of deposition in traps would be necessary to average out to moss polster percentages. Four open traps were exposed for a second year, 1970-71, to test the annual variation. Table 5.2 gives the results for some pollen totals for the two years trapping at each site as well as percentages for the two trap series and for the equivalent surface samples.

TABLE 5.2

Modern pollen deposition: Comparison between years

(Full data in Appendix 3)

Site		Surface sample				Trap 1969-70				Trap 1970-71			
Selected pollen type		1	6B	11B	19	1	6B	11A	19*	1	6B	11A	19
Casuarina	PDR					165	200	310	1050	35	400	200	180
	%	27	51	47	66	39	29	87	43	89	55	51	48
Trema	PDR					55	145	75	830	5	120	100	200
	%	5	13	15	14	20	22	20	31	15	16	25	48
Nothofagus	PDR					50	70	60	190	6	140	50	40
	%	37	15	20	29	11	10	16	7	15	19	13	10
Poaceae	PDR					120	420	60	600	15	60	70	80
	%	17	71	48	202	36	65	16	30	38	9	16	22

*Some soil found in trap.

Although no clear pattern emerges, between year variation usually exceeds the between site variation. The percentages of the trap samples are particularly affected by the total within sum pollen deposition, and a wide variation in this did occur, 1969-70 having higher total deposition in most cases than 1970-71. The earlier year was a drier than average one, certainly drier than 1970-71, for the Upper Chimbu-Pindaunde region. Hence the general hypothesis that surface sample spectra represent an integration of a variable yearly deposition is quite feasible. In this respect it is interesting to compare the sediment from a water tank at the Pindaunde field station (site 11B). This has built up over the seven years from 1966-72, and has been continually submerged so that conditions analogous to a pollen trap prevailed, although more rainout component from the catchment roof probably entered the tank. The spectrum resembles that of surface samples rather than traps, including the nearby raft trap on the lower Pindaunde Lake (11A).

The relative age of surface samples may be a factor in the variation between surface samples and trap results. Thin mats of moss prised from rocks at sites 1 and 3, for example, may represent a very long period of accumulation, while surface litter (site 19) probably

represents only one or two years. Surface sediments (11A and 18A) certainly include a 'fossil' element. In general, samples representing a long period of time, or 'fossil' to the extent of including material up to 50 years old, show low *Casuarina* and high *Nothofagus* values, relative to traps at the same site. Examples of this include sites 1,3,4,14 and possibly 21. Presumably the continuing change in the vegetation, mainly due to the extension of garden areas into primary forest, is responsible.

A systematic difference between trap and surface samples certainly occurs for local, small, herbaceous species. These have far higher percentages in the surface samples than in the traps (see FORBS, POACEAE, SEDGES in Fig 5.1). This is because the bulk of pollen from these species never becomes airborne but is washed into the moss mat by rain. For these types the differences between trap and surface percentages help to determine representation locally and extralocally and to assess the significance of, for example, 30% Poaceae in a fossil spectrum. So, in studying the fossil spectra, a local, probably waterborne, surface transport component must be considered as well as the three windborne components (trunkspace, canopy and regional) of Tauber (1965).

An attempt was made, using roofed traps at three sites (1,11,19), to determine the proportion of rainout to wind deposited pollen. The differences between roofed traps and adjacent open traps should give an idea of the relative importance of these two deposition methods. Table 5.3 shows the results obtained. It is clear that the rainout component accounts for 60-95% of all pollen deposited. As the proportion is higher for the summit and for pollen from distant sources (eg *Casuarina* and *Nothofagus* at the summit) it is likely that the most distant pollen sources contribute little pollen to the surface airflow, although their pollen may be present in the regional air mass in low concentrations. The high rainout component is probably due to the high frequency of afternoon rain, which tends to clean the air on a daily basis and to carry pollen back to ground level. The pollen concentration in the air can usually only build up during a few hours of dispersal and is probably low. In the morning the surface air is warmed and rises, mixing pollen into the ascending air mass. Clouds form and rain falls in the afternoon. The rain tends to sweep all the pollen from the air. The roofed pollen trap does not have access to the many hundreds of metres depth of air that is swept by the raindrops. The

TABLE 5.3

Modern pollen deposition: Comparison between roofed and unroofed traps

(Full data in Appendix 3)

Site	Summit		Lake raft			Keglsugl	
Selected pollen type	Open	Roofed	PDR Open	gr cm^2 yr Roofed A	Roofed B	Open	Roofed
Casuarina	165	5	310	20	45	1,050	200
Urticaceae	85	+	55	25	25	560	5
Trema	90	5	75	20	20	830	90
Nothofagus	45	5	60	20	50	190	25
Rapanea	45	2	25	5	20	90	2
Poaceae	160	5	60	25	15	600	250
Cyathea sim.	45	5	100	30	45	220	70
Total PDR	900	40	900	220	290	4,500	710
'Rainout' %	95		75	68		84	

*Some soil found in open trap.

evening descending air probably carries very little pollen, as often all plants and flowers are wet and there may be little surface turbulence.

Some of these factors will be discussed further. However, the following conclusions relate to the technique of modern sample analysis on Mt Wilhelm.

1. Trap samples from a single year only approximate to the spectra derived from surface samples, which represent a longer deposition time. The absolute trap results should therefore be considered in relation to the closeness of fit between the trap and surface spectra.

2. Trap results are variable and the absolute values cannot be used precisely, but rather as indicators of possible average pollen deposition rates.

3. Traps do not collect pollen transported by surface runoff and this component is possibly very important in certain sites, especially swamp areas suitable for pollen analysis.

4. On Mt Wilhelm most regional pollen is deposited as a rainout component.

Comparison of sites

Table 5.4 summarises the major elements of Table 5.1, showing total deposition, regional, local and extralocal deposition. The total pollen deposition in the open traps varied from 750-6,450 gr cm^2 yr (Table 5.4). These figures may be compared with a range from 1,300 gr cm^2 yr to 14,500 gr cm^2 yr for similar traps in 14 temperate communities at Wilsons Promontory, Victoria (Hope 1968) and with figures of 200-800 gr cm^2 yr for traps in open sites near tropical rainforest in northern Queensland (A.P. Kershaw personal communication). Other unpublished studies with Tauber traps in natural vegetation are under way in Australia; Tauber (1967) himself has reported catches of 2,700-9,100 gr cm^2 yr for traps on a lake close to forest in Denmark. However most other records of pollen deposition have been made using different methods (eg Potter and Rowley 1960, Hyde 1952, Ritchie and Lichti-Federovich 1967).

On the basis of the figures available, it seems that Mt Wilhelm vegetation has a pollen productivity greater than the Queensland lowland tropical rainforest but somewhat less than that of the vegetation of Wilsons Promontory and the Danish forests. Both Danish and Queensland figures are based on lake-borne traps which do not collect local pollen. The sites most like these are the lower Pindaunde Lake (Site 11) on Mt Wilhelm and a *Juncus maritimus* salt marsh at Wilsons Promontory, with deposition rates of 800 and 1,300 gr cm^2 yr respectively. The Danish figures are thus much higher than those for Australasia.

Some open sites, particularly the lake and the summit, have low totals, but other sites in which the trap opening was well clear of the local vegetation canopy (eg 5 and 8) received more than 2,500 gr cm^2 yr. However almost all the very high catches (more than 4,000 gr cm^2 yr) were obtained from traps overtopped by vegetation. For example, site 13A was overtopped by *Cyathea* fronds, but 13B was not. The only exception to this is samples 19A and 19B, which were in an open position above a short grass sward. Soil material found in these open traps suggests that contamination occurred. Not all traps beneath canopies show high totals, although all exceed 2,000 gr cm^2 yr. Those traps with very high totals tend not to contain just one pollen type in large quantity, but to have higher amounts of most elements, especially regional elements, than neighbouring traps.

TABLE 5.4

Summary of pollen trap results

	1			3	4	5	6			7		8	9	10			11			13		14		15		16		17	18	19			20	21
	A MT	B MT	B MT II	MT	MT	MT	A MT	B MT	B MT II	A MT	B MT	MT	MT	A MT	C MT	MT	MT II	A MU	B MU	A MT	B MT	A MT	B MT	A MT	B MT	A MT	B MT	MT	MT II	A MT	B MT	MT II	MT	MT II
TOTAL POLLEN COUNT	497	274	245	531	473	640	566	526	583	672	588	613	551	787	391	181	375	623	522	1220	530	485	513	634	550	454	524	590	709	651	618	270	554	648
SAMPLE PROPORTION COUNTED (%)	2.8	1.8	5.9	1.5	1.4	1.1	1.4	1.7	2.1	2.8	3.0	1.1	1.8	0.4	1.3	1.0	2.5	0.2	0.3	1.0	1.3	1.5	1.4	0.9	1.1	1.1	1.0	0.8	0.8	0.6	0.9	1.8	0.7	0.8
TOTAL REGIONAL PDR	750	700	200	1250	1150	2250	1600	900	1200	950	850	2000	450	1900	650	500	550	1500	1000	1400	600	700	700	1000	650	600	600	1200	450	1950	2100	200	650	1550
TOTAL EXTRA-LOCAL PDR	150	100	20	100	50	150	20	30	20	70	200	500	300	1000	350	350	200	1700	900	450	300	70	80	650	250	600	950	70	-	3100	1300	500	-	-
TOTAL LOCAL PDR	-	-	-	450	750	500	500	650	200	200	150	300	850	6150	550	-	-	-	-	4600	1000	800	150	2150	1600	950	1100	2550	4150	460	350	80	3600	1550
TOTAL DEPOSITION	900	800	200	1800	1800	3000	2050	1550	1450	1200	1000	2800	1550	9050	1550	900	750	3200	1950	6450	1850	1650	1900	3800	2500	2100	2650	3750	4600	5500	3550	600	4250	4100
WITHIN SUM PDR	430	260	40	820	620	1650	1100	680	730	530	610	1650	560	2800	590	360	420	1950	1200	1450	510	1020	1350	2550	1700	970	1250	2350	1850	2650	1750	580	1800	2100
% OF TOTAL	48	33	19	46	35	56	54	43	51	44	62	59	36	31	39	41	53	61	61	22	27	62	70	72	69	46	48	62	40	48	44	50	43	51

PDR values are rounded off and are given as gr cm^2 yr

It can be seen that the regional deposition shows a much greater agreement than total deposition between sites, most falling in the range of 500-700 gr cm^2 yr. This occurs despite the fact that the sites do not all have the same elements in their regional pollen spectra. The herbaceous sites such as 3 and 4 tend to have a larger number of pollen taxa in their regional spectra than do the forest sites. Those sites with total regional pollen of more than 1,000 gr cm^2 yr probably contain litter that has collected airborne pollen, and have high regional/local proportions. The only exceptions are sites 5 and 8, which contained no litter but which show high regional levels and low local and extralocal components. These two sites are on the crest of the Bogunolto Ridge, exposed to up-valley air from two valleys, both leading from the Upper Chimbu. It is possible that such ridge crest positions are very favourable for the deposition of wind-borne pollen in the traps and that the regional pollen deposition is high in such cases. It is lower in sheltered sites such as those on the floor of the Pindaunde Valley (9,11,13). The lake traps, in particular, had low total and regional deposition. It is likely that laminar air flow over the lake surface allows pollen to be trapped by the water surface, so that relatively little reaches the centre. Roofed traps were not set out in closed communities but the possibility exists that the proportion of rainout/windborne pollen would be lower there. There is no definite diminution in the regional pollen deposition with altitude or distance from forest vegetation, nor does the northern transect show significant differences in the regional component from sites at comparable altitudes in the Pindaunde-Upper Chimbu transect, although the variability of the trap results may conceal some minor differences.

Community structure

The local community influences the pollen catch totals by the fall of litter, including anthers from overhanging flowers and pollen impacted onto litter. The local pollen deposition is higher in closed communities than in open sites; this could be attributed simply to a higher pollen productivity in these communities, but it is more likely that direct airfall (in still air) of pollen and flower parts and deposition of a trunkspace component are most important. This is supported by the fact that there was a very low catch of small herbaceous elements even where these were good pollen producers and

common elements in the trap area eg *Ranunculus*; pollen producers below the level of the trap opening were usually not well represented. The tussock grasses also show that the height of the plant relative to the trap opening is important; in *Deschampsia klossii* subalpine tussock grassland, where the trap was not overtopped by grass (even though tall tussocks were growing close by), the grass pollen catches were 400-600 gr cm^2 yr (sites 3,4,6,10C,13A). At site 10A, however, the grass is over one metre tall and overtopped the trap; there the catch was 4,900 gr cm^2 yr.

Filtration of pollen might be expected in dense communities, resulting in lower PDR of regional elements there. However as noted earlier, regional pollen totals can be higher in traps overtopped by vegetation, and the range of values is similar for open and closed communities. Pollen is probably impacted onto branches and leaves and is collected in the traps by subsequent litter fall and washout. The rainout component is probably not effectively filtered, and contributes to the lack of clear filtration (in the sense of removal of pollen from the system). Tauber (1967) showed that filtration was extremely effective in deciduous forests, and Hope (1968) found evidence for a reduction in regional pollen of 20-35% in closed communities. This does not seem to occur in New Guinea although Powell (1970a p.130) has suggested that filtering may have caused the low regional percentages in forest as opposed to open sites at Mt Hagen. An equivalent depression of regional percentages occurs on Mt Wilhelm and is caused by high local deposition in closed communities.

The modern pollen spectra

The community structure and the relative importance of the different pollen transport mechanisms has a great effect on pollen totals and hence on pollen spectra. There is a striking contrast between the grasslands and other open sites (1-13, 19) and the shrubland-forest sites, both for woody plant pollen percentages and for herb pollen and fern spore percentages. For the woody plant pollen the open sites are far more 'regional' than the closed sites. For example, *Nothofagus* always exceeds 15% and reaches to 42% in open sites, while in all forest sites, except those actually containing beech trees, values of less than 10% are found. This tendency is

present for the pollen of most woody plant taxa, which have relatively consistent, higher values in the open sites, but low values in closed sites except where there is a local source. The pollen percentages of herbaceous taxa tend to be related to local presence or absence of sources at all sites. The ferns, however, are similar to the woody plants.

Although it might be suspected that the 'regional' nature of the spectra from open sites is due to the absence of filtration, and to better transport of woody pollen away from the forests, in absolute terms there is no real difference in pollen deposition of regional elements at different types of sites. However, the local production of pollen in open sites tends to be much lower than for forest sites. Thus the regional pollen makes up a greater proportion of the total pollen and, because it forms most of the pollen sum, relatively consistent percentages of regional elements are found in the open sites. The higher pollen production of the forests depresses all percentages, since much of the local production there is of types within the pollen sum. No shrubs in open sites exceed 20% (except for *Styphelia* in site 10A where it was due to litter fall) but the pollen of regionally dominant tree species can reach 50-80%. Because of the relatively lower pollen sum totals, the percentages of local herbaceous elements in open sites can exceed 300%, but this does not reflect a greater local productivity (or deposition) than for woody taxa.

The sites can be classified on the basis of two complementary attributes: the proportion of local and extralocal deposition to regional deposition; and the proportion of local and extralocal deposition forming part of the pollen sum.

Group A includes sites 1,2,7,8,11 and possibly 19. These have very low local and extralocal production and less than 15% of this is woody taxa pollen included in the pollen sum.

Group B includes sites 3,4,5,6,9,10,12 and possibly also 22,23 and 24. These have moderate to high local and extralocal production, but relatively little of it contributes to the pollen sum.

Group C includes sites 14,15,16,17,18,20 and 21. These have high local pollen production, and about 70% of it is of woody plant taxa in the pollen sum.

No sites were found to have low local production, mainly of woody plant pollen.

These results can be applied to the interpretation of changes from spectrum to spectrum in a sediment sequence. The local and extralocal vegetation is first assessed, using the characteristic percentages of certain pollen types, which will be defined later. If no change in the Group of the inferred vegetation has occurred, then the local and extralocal PDR can be assumed to have been relatively stable, even if, for example, local grassland communities have altered, or if extralocal subalpine forest has been replaced by cloud forest. In these cases, changes in the percentages of regional elements probably reflect real changes in the regional vegetation. Where the local or extralocal vegetation is replaced by vegetation of a different Group, (for example if an extralocal forest moves out over a grassland site) the total PDR and the pollen sum PDR will be altered. The regional pollen percentages will all be depressed even though no real regional vegetation change has taken place. Regional vegetation change can only be reliably interpreted using data from sections in a site in which the Group of the local and extralocal vegetation has been stable. The results from several sites may be needed for the complete reconstruction of a long sequence of regional vegetation change.

The individual surface sample spectra from each site can be regarded as identifying that vegetation, in terms of both the characteristic percentages of pollen types present that have local sources and the effect the community pollen production has on the non-local elements. Plant communities which never colonise bogs or fens are not directly applicable to interpreting pollen diagrams, but it is necessary to know their local pollen spectra in order to determine whether a community was extralocal to a fossil site. The characteristic spectra of the 24 sites can be obtained from Fig 5.1. In general the completely open communities (which tend to be alpine) have moderate to low levels of most components, and forbs are very low or absent, as these do not produce part of the regional pollen deposition. The

grasslands (alpine and subalpine communities) also show moderate values for most woody taxa pollen types, but have very high grass totals and usually a characteristic suite of shrub and forb pollen types, although these may not have very high percentages. For example, significant levels of *Styphelia* and *Coprosma* (these levels will be defined later for each pollen type) are found only in subalpine grasslands and in mires which have these grasslands as the extralocal communities (sites 6-10). The mires can be differentiated as a local community by the presence of more than 10% sedge pollen, although it is not usually possible to say if a mire is present as a significant extralocal community.

The forest sites are characterised by the pollen types of the dominant tree species. The higher altitude forests have high levels of *Dacrycarpus* or *Rapanea* and the lower altitude forests show significant amounts of certain pollen types. For example, low levels of Elaeocarpaceae and Myrtaceae together indicate the local presence of cloud forest. With decrease in altitude there is a general increase in *Cyathea*, levels above 30% indicating local presence. Where very high total Pteridophyte values occur, the site is certainly below the level of the subalpine forests. The lower montane rainforest (site 24) has a spectrum almost entirely made up of fern (and liverwort) spores, with Urticaceae/Moraceae as the major within sum pollen type.

An important trend in the spectra is seen when the sources of a pollen type are restricted to a certain altitudinal belt. Pollen from such sources will be found more frequently above the belt than below it. *Nothofagus* is a good example, since its pollen occurs in large amounts at all sites up to the summit and contributes moderate percentages at most of them, although the farthest is over 5 km from the nearest source. Sites 22, 23 and 24, all below the *Nothofagus* belt, appear to have a much lower deposition of *Nothofagus* pollen, although no further away from the sources than the high altitude sites. The same trend can be seen for *Rapanea* and *Dacrycarpus*. The probable mechanism involved is the tendency to morning uplift and afternoon rain, described previously, which would hinder substantial downslope pollen transport by wind. For the slopes of Mt Wilhelm, then, pollen comes from vegetation near the deposition site or lower than it, and higher communities are not usually represented. This process is enhanced by the reduction in local pollen productivity of the higher sites. Hence vegetation reconstruction from

pollen evidence covers local and lower vegetation, although data on these communities can permit inferences about conditions at higher altitudes.

Forest - open community transition

The results of the trap and surface sample transect from the subalpine forest, through *Coprosma - Poa saruwagetica* subalpine grassland, to the lower Pindaunde Lake and the second transect from the open mire at Komanimambuno into lower montane forest are summarised in Table 5.5 and 5.6 (full percentages are given in Appendix 3).

Subalpine forest to the lower Pindaunde Lake The two major forest components, *Rapanea* and *Dacrycarpus*, gave variable results. If only surface samples are considered, the forest edge samples (10A,B) show the highest levels for *Dacrycarpus* and the within-forest samples the highest levels for *Rapanea*. The values of *Rapanea* and *Dacrycarpus* are higher in both the forest and the grassland traps than they are in the lake trap, which shows a similar decrease in both, while regional pollen increases there. Although grass pollen does travel into the forest, it does not penetrate in quantity whereas tree pollen percentages are maintained some distance outside the forest. The lake sample has even lower percentages of grass pollen than any of the land sites. The results of this transect suggest that forest areas have an influence of 'local' dimensions on the spectra of grassland communities up to 50 m distant, although by 200 m the forest is clearly extralocal. The grasslands, although exporting pollen across the forest boundary, show far lower percentages there because of the high woody taxa pollen sum.

Komanimambuno At Komanimambuno the length of the transect (30 m) is not much greater than the height of the surrounding forest, so it is really a forest to forest-edge transect. Surface samples 18A and 18B and trap 18B were situated in an open part of the mire with low shrubs scattered around, though not covering the sites. Surface sample 18C was on the edge of the mire, open on one side but overtopped by shrub canopy. Surface sample 18D was within the forest. The four sites were about 8 m apart. There is a general reduction in *Casuarina* towards the forest (18A is probably partly 'fossil') but

TABLE 5.5

Subalpine forest - grassland - lake Transition

Pindaunde

Site	Forest				Grassland						Lake			
Selected pollen type	16A		16B		10A		10B		10C		11A		11UA		11UB	
	PDR	%	PDR	%	PDR	%	PDR	%	PDR	%	PDR	%	PDR	%	PDR	%
	A. Trap catches and spectra															
Casuarina	125	13	240	19	670	24	-*	17	220	37	310	87	360	18	215	18
Trema	80	9	90	7	220	8	-	8	125	19	75	20	330	16	200	16
Nothofagus	80	8	90	7	250	9	-	7	70	12	60	16	260	13	240	20
Rapanea	350	36	200	15	160	6	-	49	60	10	25	7	250	13	150	12
Dacrycarpus	50	5	30	2	20	1	-	1	15	2	10	3	100	6	70	6
Poaceae	220	22	530	31	4900	174	-	95	430	71	60	16	420	20	170	15
Cyathea sim.	360	37	440	34	460	16	-	6	170	29	100	27	200	11	230	19
Total PDR	2000	-	2700	-	9100		-		1500	-	900	-	3200	-	2000	-
	B. Surface sample percentages															
Casuarina	16		10		10		12		50		8**					
Trema	2		1		2		3		9		2					
Nothofagus	12		6		8		13		19		16					
Rapanea	29		46		18		23		13		32					
Dacrycarpus	11		23		35		37		13		22					
Poaceae	45		17		233		97		528		25					
Cyathea sim.	16		18		31		18		18		4					

* PDR values not calculated because of sample spillage.

** Lake mud, may be fossil (MS 11A)

TABLE 5.6

Forest edge - mire Transition

Komanimambuno

Site	Mire-sedges A	Mire-dry land B			Forest edge C	Forest D
Selected pollen type	Peat %	Trap PDR	%	Moss %	Moss %	Moss %
Casuarina	3	160	9	71	33	39
Urt.-Moraceae	15	770	42	13	8	13
Macaranga	17	110	5	8	8	6
Trema	1	170	9	4	6	7
Nothofagus	5	70	4	15	11	8
Cunoniaceae	3	10	+	+	3	2
Elaeocarpaceae	27	90	4	4	7	13
Dacrycarpus	5	5	+	27	13	5
Poaceae	3	110	5	28	13	11
Sedges	63	-	-	-	-	-
Cyathea sim.	14	1500	81	42	15	26
Total PDR		4600				

otherwise the levels of local forest elements, such as *Macaranga*, *Dacrycarpus*, *Prunus*, Elaeocarpaceae, Cunoniaceae and Myrtaceae, are erratic. This may reflect actual local differences in the sections of forest nearest each site. Some penetration of Poaceae into the forest occurs and some fern spores may be derived from the tree ferns on the margin of the mire. Only 18A sampled the sedge mat of the open mire and here alone high Cyperaceae totals were present. Because of the shelter offered by the forest surrounding the small gap, the 'open' sites behaved like the forest sites, the regional elements tending to be depressed and the woody elements still reflecting local vegetation. There is probably a considerable variation in the total pollen deposition between sites.

The results of these two studies of forest boundary transition zones suggest that some local transport mechanisms are effective for at least 40 m beyond the forest edge. This results in high

forest-dominant percentages in the non-forest spectra, often exceeding the percentages of the same elements within the forest. The presence of moderate to high non-forest pollen type percentages is the only means of distinguishing the near-boundary spectra from within forest spectra. The effect on regional elements is intermediate between group B and group C characteristics.

Underwater sediment traps in the Pindaunde Lakes

The two sediment traps have spectra similar to that of the open raft trap on the lower Pindaunde Lake, but the PDR values for all elements in the former are twice as great (Tables 5.1, 5.5). These traps evidently are not just collecting the airborne and rainout pollen falling on the water, but must be trapping a substantial waterborne component. This is probably derived from vegetation in the vicinity of the lake. The percentage of grass pollen is lower than in the raft trap, although the grass PDR is higher, probably because the tree canopy spreads out over the water whereas the grasslands only occupy the shore.

The experiment with the stained *Lycopodium* spores was inconclusive; none were recovered from a sediment sample collected from an underwater trap in the upper Pindaunde Lake (result not shown) nor from the underwater traps in the lower lake. This suggests that the upper lake acts as an efficient settling tank and that only the restricted catchment of the lower lake need be considered as a source of waterborne pollen. This is borne out by the resemblance between the open raft trap spectrum and those of the underwater traps.

Representation of individual pollen types

An assessment of pollen sources in terms of pollen productivity, dispersion, transport and deposition can be made by using the data summarised in Table 5.1 and Fig 5.1. By comparing the distributions of each pollen type at all the sites studied with the distributions of the pollen source, or sources, overall, the average regional pollen deposition rate can be calculated. A regional spectrum can then be calculated from these rates for all pollen types that occur at many sites where there are no local sources. As discussed previously, the true regional spectrum changes slightly with altitude because more components are added from alpine and subalpine sources (eg *Haloragis*), the pollen of which does not descend. The local representation of each

pollen source can be determined by comparing the vegetational percentage of the source to the local deposition of the pollen type, both being adjusted, as described in Chapter 3, to be as comparable as possible. The percentage of each local source in the vegetation is divided into the pollen percentage based on a sum of local source pollen adjusted by subtracting the regional pollen deposition of pollen with local sources.

Table 5.7 sets out all pollen types in the order adopted for the fossil pollen diagrams, which conforms to a rough ecological and altitudinal sorting of the sources. Where more than one source exists and they occupy different habitats, the one in which the pollen source is most important is used. (Eg Urticaceae-Moraceae is treated as a tree of disturbed areas and cloud forest, even though urticaceous sources are present at all altitudes. In the higher communities, when allowance is made for regional deposition, the local Urticaceae sources are negligible, whereas high pollen percentages are found in the garden areas.)

The table also gives the most probable sources of each pollen type and information about the ecology and altitudes of occurrence from Johns and Stephens (1971). The local representation for pollen sources which were found in each site has been calculated from the vegetation percentage and pollen percentage based on a local sum. The total deposition is also given. From a consideration of field data, the *local presence percentage* (LP%) has been calculated. This is the percentage, below which local presence at a site cannot be assumed and above which local presence is likely. It is a generalisation and cannot be used alone to interpret fossil spectra because the pollen sums can differ or special conditions may apply. The average regional depositions at the summit and at the lower Pindaunde Lake are placed last in Table 5.7 as are the regional spectra. These could, theoretically, be compared to regional vegetation percentages to give regional R values but no quantitative regional vegetation survey has been carried out and there are problems of compensating for extralocal presence of sources. The regional data provided do distinguish those elements which are dispersed and transported well, in contrast to elements which may reach high local and extralocal levels but do not form part of the regional pollen deposition. Additional data, particularly on garden and montane forest sources, has been provided by Powell (1970a).

TABLE 5.7

Pollen types and sources

No.	Pollen taxa	Probable sources in field area	Source ecology	Alt. range x100m	Veg. %	LOCAL PDR	LOCAL %	LOCAL R_l	REGIONAL LP%	REGIONAL Summit PDR	REGIONAL Summit %	REGIONAL Pindaunde PDR	REGIONAL Pindaunde %
		(a) Garden and disturbed forest elements											
1	*Casuarina*	*C. oligodon*	Planted tree	<24					50	165	20	250	25
2	*Acalypha*	*Acalypha* spp.	Regrowth tree	<26					2	+	x	+	x
3	*Dodonea*	*D. viscosa*	Planted low tree	<25					2	5	x	5	x
5	*Urticaceae-Moraceae*	(a) *Ficus* spp., *Elatostema*, *Pipturus*	Trees and shrubs of gardens	<36	2	300	15	8	15	75	9	75	8
		(b) *Pilea* sp.	Creeping herb of grasslands	30-44	1	+	+	<1.0	-				
6	*Maesa*	*M.* spp.	Montane forest tree/shrub	<31					2	+	x	+	x
9	*Macaranga* comp.	*Macaranga*, *Meliosma* spp.	Montane forest trees	<31					12	25	3	85	9
10	*Homalanthus*	*H.* spp.	Montane forest and gardens	<31					2	2	x	2	x
11	*Phyllanthus*	*P. flaviflorus*	Montane forest garden tree	<28					1				
15	Sapindaceae	Not known	Lower forest trees	<25					NA	+	x		
16	*Saurauia* comp.	*S.* spp.	Montane forest shrubs	<32					2	1	x	2	x
18	*Celtis*	*Celtis* spp.	Mixed forest ?gardens	<22					NA	5	x	2	x
19	*Trema*	*Trema* spp.	Small tree of disturbed areas	<24					30	90	11	110	11
		(b) Primary montane forests											
21	*Castanopsis* sim.	*Castanopsis accumanitissima*	Dominant tree of mixed forest	<23					25	15	2	20	2
22	*Nothofagus*	*N.* spp.	Dominant tree of *Nothofagus* forest	20-27	97	≈1400	90	1	80	80	10	60-120	6-12

No.	Pollen taxa	Probable sources in field area	Source ecology	Alt. range x100m	Veg. %	LOCAL PDR	LOCAL %	LOCAL R_l	LP%	REGIONAL Summit PDR	REGIONAL Summit %	REGIONAL Pindaunde PDR	REGIONAL Pindaunde %
23	*Timonius*	*T. belensis*	Large tree of cloud forests	<30	1	5	1	1	+	+	x	+	x
24	*Claoxylon*	*C. muscisilvae*	Tree of lower cloud forest	<28					2				
25													
25	Araliaceae	*Schefflera chimbuensis*	Tree of subalpine forest	33-37	4	-	<1	<0.2	+				
26	*Prunus* sim.	*P. pullei* and other spp.	Large trees of cloud forest	<36	59	-	13	0.2	1			+	x
27	*Ascarina* comp.	*A. philippinensis*	Large tree of cloud forest	<32	6		2	0.4	2	15	2	25	3
28	Cunoniaceae	*Caldcluvia* spp. *Weinmannia* sp.	Dominant trees of lower cloud forest	<29	16	-	-	<0.1	2	2	x	2	x
29	*Elaeocarpus* comp.	(a) *Elaeocarpus* spp. *Sericolea* spp.	Shrubs and trees of lower cloud forest	<32	3	60	2	0.7	4))	10	1	5	x
		(b) *Sericolea decandra*	Tree of subalpine forest	33-36	-	not significant			)				
33	Myrtaceae	(a) *Decaspermum* spp.	Trees of cloud forest	<35	47	40	2	<0.1	5				
		(b) *Xanthomyrtus* sp.	Tree of cloud and subalpine forests	<35	21	170	16	0.8	5	10	1	10	1
34	*Papuacedrus*	*P. papuana*	Tree of cloud forest	25-30	21	-	2	0.1	1	+	x	+	x
35	*Phyllocladus*	*P. hypophyllus*	Tree of mixed forest	<25					5	2	x	2	x
36	*Podocarpus*	*Podocarpus* spp.	Dominant tree of cloud forest	25-35	3	120	2	0.7	5	2	x	2	x
38	Proteaceae	Source not known	Climbers and shrubs	<31		not significant			1			+	x
39	Rutaceae	*Acronychia* spp. + *Xanthoxylum* sp.	Trees and shrubs of cloud forest	<35	4	50	3-17	0.7-4.0	2	+	x	+	x
40	*Euodiella*	*E. hooglandii*	Tree of cloud forest	<33	+	+	+		1	+	x	+	x
		(c) Subalpine forest elements											
41	Asteraceae I	Most species incl. *Tetramolopium*	Alpine and subalpine shrubs, herbs & trees	<28						5	x	5	x
42	Asteraceae II	inc. *Anaphalis* spp.	Subalpine grassland shrubs	27-44	1.5	15	x	0.3		+	x	+	x

TABLE 5.7

Pollen types and sources

No.	Pollen taxa	Probable sources in field area	Source ecology	Alt. range x100m	Veg. %	LOCAL PDR	LOCAL %	LOCAL R_l	LP%	REGIONAL Summit PDR	REGIONAL Summit %	REGIONAL Pindaunde PDR	REGIONAL Pindaunde %
		(c) Subalpine forest elements (cont'd)											
43	Asteraceae III	incl. some *Senecio* spp.	Subalpine forest tree	33-36	4	140	8	2.0					
44	*Rapanea*	*Rapanea vaccinioides*	Dominant tree of upper subalpine forest	30-39	20	400	40-75	1.6-3.6		45	6	50	5
46	*Dacrycarpus*	*D. compactus*, *D. cinctus*	Dominant tree of sub-alpine and cloud forests	27-39	10		12-18	1.1-1.8		10	1		10
47	*Polyosma*	*P.* spp. incl. *P. subalpina*	Shrubs of forest	26-37	1.5	10	0.7	<0.	+				
48	*Quintinia*	*Q.* spp.	Shrubs of forest	29-39									
49	*Symplocos*	Many *S.* spp.	Important trees and shrubs	25-40	11	200	14	1.4	2	2	x	+	x
		(d) Subalpine shrubs											
50	*Eurya* sim.	*E. brassii*	Treeline shrub	35-41	5	25	1-50	0.2-10.0	+				
51	*Styphelia* sim.	(a) *Trochocarpa* spp.	Shrub and herbs	34-42	9	+		<0.1					
		(b) *Styphelia suaveolens*	Major subalpine and alpine shrub	32-45	15	10	5-7	0.3-0.5	1	+	x	+	x
52	Ericaceae I	Some *Rhododendron* spp., *Gaultheria* sp.	Subalpine shrubs	25	41	17	50	0.2	1	2	x	+	x
53	Ericaceae II	*Vaccinium amblyandrum* and *Dimorphanthera* spp.	Subalpine shrubs and trees	25-37	28	60	10	0.3	1	+	x	+	x
54	Ericaceae III	Other *Vaccinium* and some *Rhododendron* spp.	Forest spp. including lianes	?<35		+			1				
55	*Haloragis*	*H. halconensis*	Forest edge shrub	27-40	16	150	25-47	1.5-3.0		15	2	10	1
56	*Coprosma*	(a) *C. papuensis*	Forest shrub and climber	28-38	16	110	2-6	0.2-0.4	4	15	2	15	2
		(b) *C. divergens*	Subalpine shrub	33-42	5	110	20-28	4.0-5.6					