MINISTERE DES AFFAIRES CULTURELLES

TRAVAUX SCIENTIFIQUES
DU MUSEE NATIONAL D'HISTOIRE NATURELLE
DE LUXEMBOURG

21

Ecology and Vegetation of Mt Trikora New Guinea (Irian Jaya / Indonesia)

by

Jean-Marie MANGEN

Luxembourg, 1993

Cover: The north face of Mt Trikora (4725 m): looking south from Somalak valley, altitude 3800 m

Musée national d'histoire naturelle de Luxembourg
Marché-aux-Poissons
L-2345 Luxembourg

MINISTERE DES AFFAIRES CULTURELLES

TRAVAUX SCIENTIFIQUES
DU MUSEE NATIONAL D'HISTOIRE NATURELLE
DE LUXEMBOURG

21

Ecology and Vegetation of Mt Trikora

New Guinea (Irian Jaya / Indonesia)

by

Jean-Marie MANGEN

Luxembourg, 1993

« ... I know of no part of the world, the exploration of which is so flattering to the imagination, so likely to be fruitful in interesting results, whether to the naturalist, the ethonologist or the geographer, and altogether so well calculated to gratify the enlivened curiosity of an adventurous explorer, as the interior of New Guinea ... »

J. Beete Jukes, H. M. S. 'Fly', 1942

(in: New Guinea, The last Unknown, Gavin Souter, 1963, p. 19)

To the Dani Papuans

of the Baliem Valley

Contents

Acknowledgements

The research for this work on the subalpine and alpine vegetation of Mt Trikora would not have been possible without the help of many people, either in New Guinea itself, or in Bogor (Indonesia), Toulouse (France), Leiden (The Netherlands) and Luxembourg. Hence I wish to acknowledge all the persons who contributed in any way to the fullfillment of this task. I am particularly grateful to Dr. F. Blasco, who enabled this work by accepting me as a student in the 'Institut de la Carte Internationale de la Végétation' in Toulouse, France.

Furthermore, I would like to thank with heart and hand the staff members and botanists of the Rijksherbarium for their valuable help in identifying the plants collected, in particular Max van Balgooy for permanent and unreserved advice and guidance in the determinations. I am also greatly indebted to the readers of the manuscript, i.e. J.P.Pascal (Toulouse) for the original french text and W.Vink (Leiden) for the present publication.

For the identifications of fossils, I am grateful to A.Blondeau ('Université Pierre et Marie Curie', Paris) and J.Magnié ('Université Paul Sabatier', Toulouse), and P.Buurman (Wageningen, The Netherlands) for his help with iron concretions from Mt Trikora.The soil samples have been analysed by A.Puraye ('Laboratoire de Contrôle et d'Essais des Services techniques de l'Agriculture,' Luxembourg) and the meteorological data from the Baliem Valley have been kindly provided by M. J.K.Tanawani from Wamena.

Many thanks also to the scientists and staff of the 'Musée national d'histoire naturelle de Luxembourg' for their help on all occasions. During my visits in Indonesia, I made many friends to whom I am indebted for hospitality. I want to express my heartly thanks to all of them and especially to Mr. and Mrs. Purnajaya (Bogor) as well as to Mr. and Mrs. Zaini (Wamena). My field trips to New Guinea will remain engraved in my mind forever, due in particular to the help and kindness of the people of the Baliem Valley, who contributed to the success of the field work by innumerable tasks.

Finally, I would like to thank my wife Nadine and my children, to whom this work has asked many sacrifices, especially during my absence for field work.

Trav. sci. Mus. nat. hist. nat. Luxemb. 21, 1993

Ecology and Vegetation of Mt Trikora, New Guinea (Irian Jaya)

by

Jean-Marie MANGEN

Abstract

Chapter I: After a presentation of the main geographical features, the author retraces the history of the scientific exploration of Mt Trikora, New Guinea (Irian Jaya), and describes the altitudinal zonation of the vegetation.

Chapter II: The physical environment is described; geology and geomorphology, soils and climate (regional, local) are analysed and commented.

Chapter III: The study of the vegetation of the subalpine and alpine zones (> 3000 m) is based on 86 phytosociological plots. 26 different vegetation communities have been recognized. The subalpine vegetation is divided into forests (2 types), shrublands (2), heaths (2), grasslands (2), herblands (1), mire associations (5) and open rocky slope communities (3). In the alpine zone, the author distinguishes and describes alpine heath formations (1), grasslands (1), herbfields (1) and mires (2); the rock surfaces and alpine screes (2) are also studied.

Chapter IV: In the last part, the flora of Mt Trikora is compared to those of other mountains in New Guinea and to Mt Kinabalu, Borneo. The author comments some hypotheses on the origin and distribution of the subalpine and alpine vegetation in New Guinea.

Appendices : The reader may find meteorological data from Wamena (Baliem Valley), a list of plants collected by the author in the Baliem Valley and beneath Mt Trikora trail below 3000 m, a list of plants collected by Brass et al. and by the author above 3000 m, a table comparing the geographical distribution of genera in the highlands of New Guinea; and finally a physiographical scetch map of Mt Trikora and surroundings.

Résumé

Chapitre I: Après une présentation du contexte géographique, l'auteur retrace l'historique de l'exploration scientifique du Mt Trikora. Il donne ensuite l'étagement en altitude de la végétation.

Chapitre II: Les facteurs géologique et climatique régionaux et locaux, ainsi que pédologiques sont étudiés et commentés.

Chapitre III: L'étude de la végétation porte sur les étages subalpin et alpin (> 3000 m). 86 relevés phytosociologiques ont été effectués sur des placettes de taille variable selon les types de formation. En tout, 26 communautés végétales différentes ont été reconnues. La végétation subalpine est subdivisée en formations ligneuses, formations herbacées et groupements rupicoles. L'auteur analyse ainsi parmi les formations ligneuses, une forêt de transition à *Libocedrus papuana* , la forêt subalpine dominée par des *Ericaceae* , 2 types de fourrés altimontains et 2 types de landes. Les formations herbacées comprennent 2 types de savanes, une pelouse discontinue basse, 5 types de bas marais et 2 mouillières. Trois groupements rupicoles ont été retenus. Dans l'étage alpin sont reconnus et décrits une lande basse, et 4 formations herbacées (savanes, pelouse basses, et mouillières). Les groupements rupicoles et ceux des pierriers/éboulis (2 types) sont également étudiés.

Chapitre IV: La dernière partie analyse les affinités et particularités phytogéographiques de la flore du Mt Trikora. Les données sont comparées avec celles d'autres massifs montagneux de Nouvelle-Guinée, et celle du Mt Kinabalu, à Bornéo. L'auteur commente certaines hypothèses sur l'origine et la distribution de la végétation altimontaine en Nouvelle-Guinée.

Annexes: Le lecteur trouvera des données météorologiques de la station de Wamena (vallée de Baliem), une liste des plantes récoltées par l'auteur dans la vallée de Baliem ainsi que sur le sentier du Mt Trikora (< 3000 m), une liste des plantes récoltées par Brass et al. et par l'auteur à plus de 3000 m, un tableau comparant la distribution de genres sur d'autres massifs de Nouvelle-Guinée et finalement une carte de la région étudiée.

Original french title/ titre original: Mangen J.-M., 1986: Etude phytogéographique et écologique du Mt Trikora, Nouvelle-Guinée. -Thèse de doctorat de 3e cycle: Ecologie, Université Paul Sabatier, Toulouse III, France, N° 3351, 162 p.

Preface

The present booklet deals with the study of the ecology and vegetation above 3000 m on Mt Trikora, Irian Jaya, Indonesia. When starting my work on the tropical high mountain ecosystems of south-east Asia, New Guinea was only a vague concept to me. My first steps in tropical ecology have been made in the 'Institut de la Carte Internationale de la Végétation' of Professor Legris in Toulouse / France. During several travels to Indonesia, the desire to do botanical work in New Guinea rose more and more in myself. I chose Mt Trikora because of the facilities I could expect in the Baliem Valley, Wamena being a city big enough to provide easily food and porters.

After a first visit to the Jayawijaya mountains in 1982, I have been literally fascinated by the people and the natural environment encountered. Back to Europe, I contacted the Rijksherbarium in Leiden for help and became acquainted there with a number of scientists who shared this same fascination. Marius Jacobs and C.G.G.J. van Steenis encouraged me to go on in my research. Later on, Wim Vink, Jan Frits Veldkamp, Max van Balgooy and many others helped me a lot with my work. The results of the investigations done during three field trips, in 1982, 1983 and 1984, have been summed-up in a doctorate thesis presented in 1986 at University Paul Sabatier of Toulouse / France. With a considerable delay, in part due to my work as a high school teacher, the translation of the french thesis is at last ready.

The starting point of my field trips has always been Wamena, a little town in the Baliem valley. From there, the summit area could be reached within three days walking, some Dani papuans carrying food and equipment. No precise map was available. Only a local guide and U.S.A.F. air photographs helped me to find my way. The Mt Trikora track follows for about 50 km the Wamena River up to its sources. After having crossed the gardens of the Dani papuans, the party reaches the upper limit of gardening at 2400 m, next to the village of Elarek (see sketch map in appendix VI). A difficult walk on fallen stems, through montane rainforest, leads us to a big intramontane basin at 3000 m altitude. The area of our investigations reaches from this high valley to the summit ridge of Mt Trikora at about 4500 m.

More than 1100 numbers of plants have been collected and dried on the spot. 86 phytosociological plots enabled me to give a picture of the vegetation cover of the higher parts of the mountain. Finally, soil and rock samples have been analysed to explain the distribution of the vegetation units. After observations in the field and air photograph analysis, a topographical scetch map has been drawn (appendix VI).

The main difficulty, apart from getting a 'Surat Jalan' from the local authorities, has been the correct identification of the species. Indeed, the present study has shown to me that expert-centers for taxononic identification and research like the Rijksherbarium in Leiden, are indispensable for world-wide research on biodiversity. They should benifit more than ever from national as well as international support. Without taxonomic work, no applications in medical, agricultural and environmental domains will be profitable or even possible. Inventoring the botanical diversity of New Guinea should therefore be pursued, as it is essential to the sustainable use of the natural resources of this island.

CHAPTER I: General presentation

I. The area and its exploration

The island of New Guinea, at the eastern border of the indonesian archipelago, is the second greatest island in the world after Greenland. Its total surface is about 785.000 square km. From an ethnical point of view, it can be included in Melanesia, as its inhabitants, the papuans, are dark skinned and have frizzy black hair. Geographically speaking the island is part of the australian continental shelf (Sahul shelf).

The first foreign visitors to New Guinea have probably been sailors from the sumatran kingdom of Shrivijaya, in the eight century A.D. Later on chineese traders also had contact with the dark frizzy haired people of this island.

The discovery by Europeans dates back to 1527, when Jorge de Meneses, the portugese governor of the Moluccas landed in New Guinea. Since long ago indeed, the island had awakened the interest of the portugese, spanish and dutch navigators rivalling for trade and in search of unknown country and wealth. Meneses called its new discovery 'Ilhas dos Papuas' after the malay expression 'orang papuwa' which means frizzy haired people.

Later the island received the name 'Nova Guinea' because of the resemblance of its inhabitants with those of west Africa. The actual name 'Irian Jaya' given to the land west of the meridian 141° E has its origin in a word from the island of Biak, meaning 'hot climate'. It has been used for the first time in 1946 by a papuan headsman during negotiations with dutch representatives. When in 1963 the western half of New Guinea became an indonesian province, first 'Irian Barat' (West Irian) and finally 'Irian Jaya' (Glorious Irian) was used to name this easternmost province.

But let's look back to earlier times in the exploration history of New Guinea. When in 1623, the dutch navigator Jan Carstensz sailed along the south coast

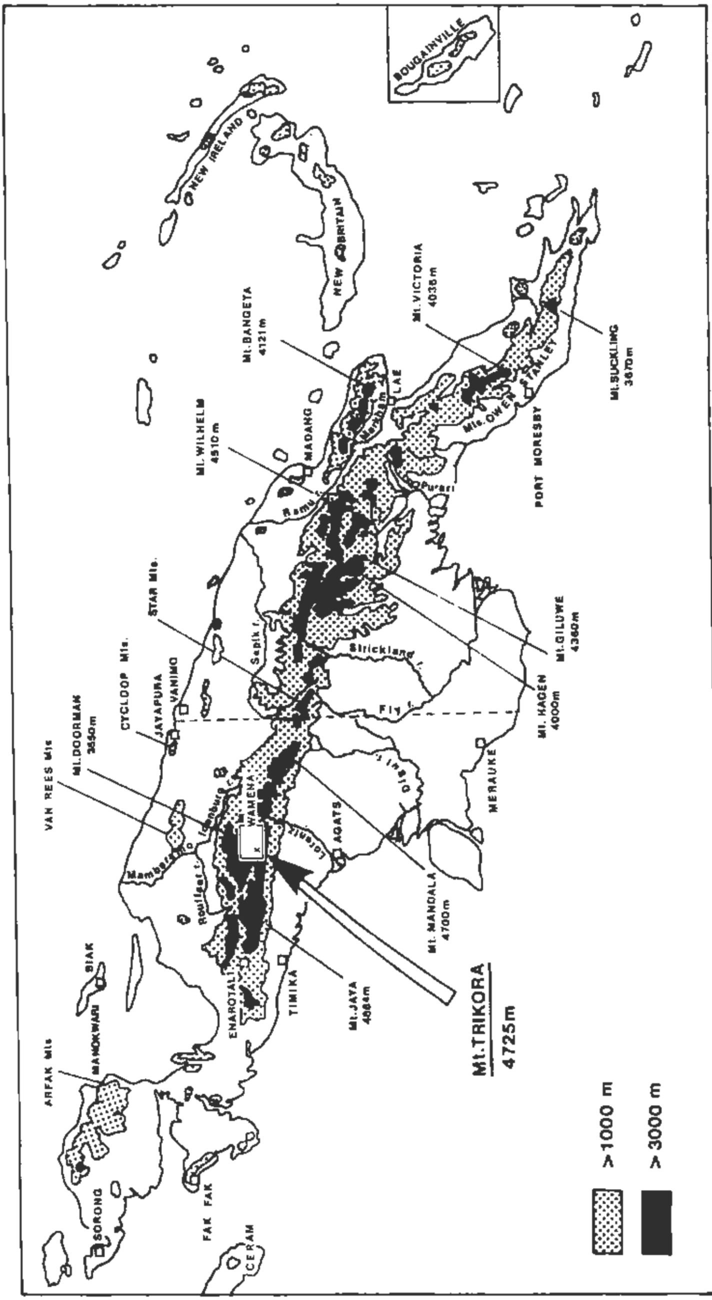


Fig. 1: Topographic map of New Guinea (modified after Paijmans, 1976)

of the island, he could for the first time catch a glimpse of the snow-capped mountains in the interior of New Guinea. As he wrote down, this was indeed « ... a singular sight, being so near the linie equinoctial ...».

As could be found out later, the topography of New Guinea is very irregular. A long east-west orientated mountain chain culminating in Mt Jaya (Mt.Carstensz) at 4880 m, seperates the island into two parts over more than 1000 km (fig.1).

The southern slopes of this mountain chain fall nearly vertically down to sea-level in a narrow, 50 km broad piedmont area. Huge flood plains covered by primary forests extend to the south coast. The northern parts of these mountains are more gradually sloping down to sea-level. A lower coastal chain to the north separates the interior lowlands from the sea. Mt Trikora, the area dealt with in this booklet, is situated in the central range of Irian Jaya, the so called Jayawijaya Mts. or 'Pegunungan Maoke', between 4°05'-4°20' S and 138°30'-139° E.

In Irian Jaya several peaks are still covered by eternal snow, i.e. the Mt.Engga (Idenburg, 4378 m), Mt Jaya (Carstensz, 4880 m) and Mt Mandala (Juliana, 4680 m). Mt Trikora (Wilhelmina, 4725 m, 4°17'S-138°40'E), is presently free of eternal snow. In Papua New Guinea the mountain chain is less high and culminates in Mt Wilhelm (4510 m).

The discovery of Mt Trikora itself dates back to 1904. The mountain had been seen first by the captain of the 'Valk', a dutch ship exploring the rivers of the south coast. It was called 'Mt Wilhelmina' in honor of the queen of the Netherlands.

The exploration of this part of the mountain chain really started in 1907, when the dutch government decided on a military exploration program which lasted 7 years and involved approximately 800 men. H.A.Lorentz was the first to try the get to the eternal snow by travelling upstream the river now called after him, until reaching the foothills of the main chain. But, weekened by hunger and illness the expedition was forced back to the coast.

Meanwhile an english party, sponsored by the British Ornithologists Union, also planned to reach the snowtops of New Guinea further west in the Sudirman range, a challenge inacceptable for Lorentz. With the threat of being beaten by the english, he hurriedly organized a second expedition in

PLATE 2

The noth face of Mt Trikora

september 1909. This time Lorentz had recruited 82 Dyak porters from Borneo to exclude desertion. At that time we may read that government officials had fun when hearing that Lorentz employed 'headhunters from Borneo to visit the headhunters of New Guinea' as related by C.Souter (1963) in his chronicle of the island.

Taking advantage of his earlier experience Lorentz progressed well. Two months after having left the coast, he and seven of his companions reached the eternal snow of Mt Trikora, on November 9th, 1909. Unfortunately bad weather prevented them from reaching the summit itself. Nevertheless, from the summit ridge they discovered about 15 km to the north a big lake. They called it lake Habbema, after lieutenant D.Habbema in command of the troops responsible for the security of the expedition.

Of course their joy was great and all of them were proud as it was dutchmen who were the first to reach the snowcapped mountains of New Guinea. But their euphoria was of short duration. Climbing down to their 4000 m bivouac, Lorentz fell, got heavily wounded with two ribs broken. As he was unable to move on its own, the party stayed another 10 days in this camp, where low temperatures and snowfall made life difficult. Furthermore, one of the Dayaks got lost and died in the cold.

On November the 21st, 1909 they started walking back to the coast. Another porter and a soldier had died before they finally left their base camp at the mouth of the Lorentz river on March 1st, 1910. Before leaving the Casuarina coast, Lorentz visited the unsuccessful british expedition, who had tried further west to get to the top of Mt Jaya. The british expedition's medical officer and botanist, Dr.A.F.R. Wollaston wrote later in his diary that « Mr.Lorentz looked like a man hardly returned from dead, ... and his spirits were in better condition than his body. » (Souter, 1963).

In August 1912 a third military expedition, this time under the lead of A.Franssen-Herderschee, started again from the south coast and reached for the first time the summit of Mt Trikora on February 21st, 1913.

The first world war made an end to this first wave of expeditions to the eternal snow of New Guinea. The next expedition with Mt Trikora as a target, was led by J.H.K.Kremer in 1921. This was the biggest expedition ever organised by the dutch to New Guinea. Some 800 men contributed to the attempt reaching this mountain from the north via the Mamberamo and Idenburg rivers and walking south. On their way the anthropologist P.Wirtz and the geologist P.F.Hubrecht crossed the westernmost part of the Baliem river. Hubrecht, who had been a member of the Franssen-Herderschee team in 1913, should be the first man ever having crossed the island.

Indeed, December the 4th, 1921, the expedition managed to get to the top of Mt Trikora once more. Hubrecht noted that the extent of eternal snow seemed to have diminished already. They found a big erratic block of ice (10 m3) that had been detached from the snow cap. This probably occurred during an important earthquake on October 10th of the same year. On their way back they passed lake Habbema, a lake that should play a major role in the further exploration of the area.

Up to that date all the expeditions had advanced by boat or on foot, wich of course occasioned big logistic problems. In 1936, A.H.Colijn, used an amphibious aircraft to parachute supplies (Colijn, 1937) and he reached with relative facility for the first time the snowfields of Ngga Pulu (4860 m) in the Mt Jaya group. The pyramid of Mt Jaya itself, hidden by the clouds, could not be reached. By doing so this expedition had shown that the time of huge exeditions, with hundreds of porters, was definitely over. The highest point in New Guinea was later only reached in 1962 by the austrian alpinist H.Harrer and his small team (Harrer, 1963). During the 1936 expedition, the geologist J.J.Dozy discovered the Ertsberg copper ore deposit (Dozy, 1939) estimated in 1968 at 33 millions of tons. This unique mineral deposit is being quarried since march 1973 by Freeport Indonesia Inc. (Hope, 1976).

Shortly before World War II, the exploration of the area between the Idenburg river and Mt Trikora should come up with one of the biggest discoveries for New Guinea. In 1938, a mixed american-dutch expedition sponsored by Richard Archbold had chosen lake Habbema as a base in the mountains. This was the third Archbold expedition in New Guinea and it was organised for a complete investigation of the flora and fauna of the north slopes of the Snow Mountains, i.e. from the Idenburg river till the highest parts of Mt Trikora.

All in all about 200 persons were involved and among the scientists engaged were E.Meyer-Drees, forester, and L.J.Brass, botanist. The Guba, a twin-engined amphibic aircraft assured transportation of the supplies wafted to the parties on foot. During one of the numerous reconnaissance flights, Archbold discovered on June 23d, 1938, the Great Baliem valley or 'Grand valley' as they called it, « a valley of 60.000 population seen for the first time by white man » (Archbold, 1941). This big intramontane valley, also called the 'Shangri-la' of New Guinea had been undiscovered, although the Kremer expedition had crossed the headriver of the Baliem seventeen years earlier. The isolation of one of the last unknown papuan groups was thus broken up.

On July 15th, 1938, Archbold landed on lake Habbema (3225 m, ± 4 km long x 2 km wide), not an easy undertaking « since no plane had ever landed on the lake and none had taken off from water at so high an altitude.» (Archbold, 1941). Later on 105 persons and 200 tons of material have been sent on freighting flights from Jayapura (Hollandia) on the north coast, to this high altitude lake.

Apart from numerous collections of animals made by other members of the expedition, L.J.Brass and his companions collected a considerable amount of plants either around the lake itself (594 numbers) or between 3400 and ±4000 m on Mt Trikora (783 numbers). It should be the biggest collection ever made in this part of the world. As for many adventurers before him, Archbold had to give up the ascent of the summit due to bad weather. Again a considerable retreat of the snowfields was observed, since the first visit by Lorentz in 1909.

The Archbold expedition has been the last big one in the area. After the second world war, Indonesia became independant, with the western part of New Guinea remaining under dutch control until 1963. No scientific expedition had visited the area, only missionaries had continued exploring the Baliem valley. After 1954, when the valley was officially opened to evangelisation, missionaries of all sects turned up and G.Souter to comment on this period : « the monster Time which had pounced on Shangri-la in 1938 and 1945 had come again, and this time it had come to stay.» (G.Souter, 1963).

Only sporadic botanical collecting have been done since. In 1955, J.L.Gressit made a short stop in the Baliem. In 1961, R.Schodde collected in the valley and in 1966 A.J.G.H.Kostermans did the same but without searching in the higher parts of Mt Trikora. In June 1961 Chr.Versteegh from Forestry Dept. at Manokwari collected (121 numbers) at Wiligimaan in the Baliem. In 1976, a german pluridisciplinary expedition visited the foothills between Wamena and Mt Mandala in Eipo land. At that occasion P.Hiepko and W.Schultze-Motel made some collections around Wamena. Finally, an indonesian expedition organised by students from 'Mahitala Unpar' of Bandung in December-June 1983-1984, reached the summit of Mt Trikora and collected specimens in the surrounding highlands.

II. Main vegetation types and altitudinal zonation

New Guinea is an island of predilection to the botanist as the vegetation extends without interruption from sea level up to the eternal snow and ice. Nowhere else in southeast-Asia the mountains reach such extensiveness, but also nowhere else the study of these mountains is as difficult, as progression in the field is very hard.

But within this huge island, the mountains are the areas actually known best because since long ago the explorers have preferred the cold climate of the intramontane valleys to the humid and hot lowlands. This remains true for the indigenous people as well, who settled in the mountains, and thus today these valleys are densely populated and consequently heavily deforested.

During his travels through South America, Alexander von Humboldt was the first to recognize and to study plant distribution in relation with altitudinal change. In his book on plant geography (1807), Von Humboldt distinguishes seven altitudinal zones in the equatorial Andes, zones marvellously illustrated by colour drawings. Later on and mainly in the twentieth century, many botanists have studied vegetation zonation everywhere in the world (cf.Troll 1959, Hedberg 1964, van Steenis 1934, etc.).

For the mountains of the Indonesian archipelago, we may refer to the work of C.G.G.J.van Steenis (1934, 1972), who made a detailed study of the altitudinal zonation of vegetation in the area and proposed a general classification that is largely accepted nowadays.

Discussion around this subject has been and is still going on and is clearly not a matter of consensus so far. Based on structural and floristic criteria, the study of altitudinal zonation of plants still raises some problems, i.e. the demarcation lines and the transitions between the zones. This of course seems normal to me, as the delimitation of such zones is a rather artificial undertaking and thus always causes a rupture in a continuum.

When we accept such demarcations, we still have to be conscious that the altitudinal distribution of vegetation units is varying strongly from one mountain area to the other, or even from one valley to the other. This means that whatever demarcations we choose, we have to establish the altitudinal limits not too strictly. If we try to do so, we will come up with as many classifications as we have studies on the subject!

Van Steenis' zonation for Malesia (cf.fig.2) is based on a detailed floristical analysis, a method that could of course not be applied in our case because the flora of New Guinea is not known well enough. The only well explored mountain areas are Mt Wilhelm and Mt Jaya, but still only at higher altitudes. This fact of course sends us back to the many propositions already made (cf. fig. 2) and we have to try to compare these with our own observations. As for conveniance it is very useful to have an altitudinal zonation, especially if a comparison between different mountains is aimed at, I will try to define such a zonation on Mt Trikora, starting with my own observations made in the Baliem valley and gradually going up till the summit of Mt Trikora. With the help of areal photographs, I have been able to recognize the distribution of the main vegetation types between the Baliem valley and the summit of Mt Trikora.

1. Lowland zone

As far the lowlands and the colline subzone (after van Steenis, 1934) are concerned, I have no personal observations and thus refer to indications from literature. It appears that the limit between the lowland forests and the montane zone is oscillating between 1000 and 1500 m (fig.2), although precise demarcations are not yet established.

2. Montane zone

The montane zone in the area concerned is formed by closed evergreen forest with a large altitudinal extension. Actually this zone is subdivided into subzones i.e. Lower Montane Zone from 1000(-1500) - 2700(-2800) m and Upper Montane Zone between 2700(-2800) and 3000(-3400)m. The limit between these two zones is based on structural and floristic patterns easily observable on Mt Trikora.

2.1 Lower montane zone

Due to lack of time, I have unfortunately not been able to make a detailed study of this zone. In the following account, I will nevertheless try to give a concise description of the montane forest, using my own observations and

MALESIA	NEW GUINEA						
van Steenis 1934 1959	Lane - Poole 1925 (in Hynes 1973)	Brass 1941,1956,	Robbins 1960, 1961	Grubb 1973	Smith 1974 (mod.)	van Royen 1980	
				above 3900 m	nival		
						4700 m	
above 4500 m nival zone				grassland	sparse vegetation		(3000-)3300-4100 (- 4600) m
4000 - 4500 m		3900 m - permanent snow	above 3900 m	3600 - 3900 m upper subalpine forest		4300 m	alpine zone
alpine zone		alpine grasslands	alpine grasslands	3350 - 3600 m lower subalpine forest	grasslands		
2400 - 4000 m subalpine zone	above 3350 m high mountain forests	3000 - 4050 m subalpine forests	2750 - 3800 m montane rain forests	3000 - 3500 m	natural / manmade	3810 m	(3000-)3360-3900 (- 4200) m subalpine zone
1000 - 1500 m submontane subzone	2250 - 3350 m mossy forests	1500 - 3200 m mossy forests		upper mountain forest			(2600)3000-3450 (- 3800) m upper montane zone
1000 - 2400 m montane zone	1700 - 2250 m mid-mountain forests	850 - 3100 m beech forests	1000 - 2750 m lower montane rain forest	1500 - 3000 m lower montane forest	mountain forests	2500 m	
500 - 1000 m colline subzone	300 - 1700 m foothill forests	480 - 2350 m mid-mountain forests			secondary / gardens		
0-1000 m tropical zone	0 - 300 m lowland rain forest	0 - 2400 m rain forests	0 - 1000 m lowland rain forest	0-(900-1500) m lowland rain forest			

Fig. 2: Altitudinal zonation of the vegetation in New Guinea

collections as well as the description given by Brass (1941). Starting point of all my visits on Mt Trikora was the village of Wamena. This is situated at 1550m in the big Baliem Valley, a valley strongly populated and thus nearly completely deforested. The rapidly increasing number of new settlers (transmigrants) from other parts of Indonesia is of course speeding up this evolution, and already now the human pressure on the environment is at its upper limit of tolerance. Nevertheless, some forest relics survive in some areas of the valley and show evidence of former forest cover. Scattered patches of trees are composed by *Araucaria cunninghamii* (390), *Lithocarpus sp.* (391), *Glochidion sp.*6 (392), *Macaranga sp.2* (394) and *Eugenia sp.*(395).

Near the village of Jiwika on karst hillocks north-east of Wamena, on the edge of the Baliem valley (at 1600 m), in a disturbed forest of about 15 m height, I have collected the following species: *Castanopsis sp.*(362), *Eugenia sp.*(363, 357), *Saurauia sp.*(343), *Wendlandia paniculata* (349), *Lauraceae* non id. (359), *Monimiaceae* non id. (344), *Acanthaceae* non id. (346), *Ficus sp.*(348), *Vaccinium acrobracteatum* (348b), *Dimorphantera amblyornidii var.steinii* (352), *Dimorphantera obtusifolia* (351a), *Rhamnus nipalensis* (350), *Garcinia sp.*(351b), *Acalypha sp.*(354), *Diospyros sp.* (355), *Timonius sp.*(356), *Psychotria sp.*(360, 366), *Prunus sp.* (361), *Pittosporum ramiflorum* (365), *Parsonsia* cf. *alboflavescens* (353), *Macrosolen cochinchinensis* var. *cochinchinensis* (345), and *Selaginella caulescens* (347). This remnant of lower montane forest is crossed by a heavily used trail leading to one of the few salt wells in the Baliem valley.

To the south-east of Wamena, the karst hills have been completely deforested and are actually covered by a secundary scrub, 2-5 m high. In such a scrub near the trail leading from Wamena to Pugima village, the following species occur: *Octomyrtus pleiopetala* (150), *Ilex sp.* (152), *Dodonea angustifolia* (154), *Wendlandia sp.*(156), *Grevillea papuana* (157), *Geniostoma anterotrichum* var. *archboldianum* (158), *Rhamnus nipalensis* (159), *Evodia sp.* (162), *Glochidion sp.*(163, 166), *Pittosporum cf. ramiflorum* (164), *Pleomele sp.* (165), *Piper gibbilimbum* (167), *Acalypha hellwighii* cf.var. *mollis* (168) and the epiphytic hemiparasites *Amyema strongylophyllum* (151) and *Cladomyza kaniensis* (160). On these hills, replantations with *Pinus sp.* have been tried but without success.

Along the banks of the Baliem river a galery forest of *Gymnostoma sp.*(368), 25-30 m high, give a good shelter and fire wood for the Dani papuans. The originally boggy valley bottom has been drained and is now occupied by an extensive mosaic of gardens alternating with fallow land (plate 3). The Dani cultivate a number of sweet potatoe varieties on small garden hill beds separated by one meter deep drains. Cultivating these gardens for 3 to 4 years, the Dani leave them fallow for a period of 8 to 10 years.

Pioneer species as *Pennisetum macrostachyum* (370), *Imperata cylindrica, Dianella ensifolia* (377), *Burmannia disticha* (351), the small yellow flowerered shrubs of *Rhododendron macgregorii, Acalypha hellwigii* var.*mollis* and all the species mentioned above in the secundary scrub on the karst hills occur abundantly. My observations made in the Baliem confirm what Brass supposed during his visit in 1939 Brass (1941). « ... it would seem that very extensive forests of oaks and *Castanopsis* once clothed the ridgy terrain of the valley bottom and extended up the slopes to elevations of approximately 2000-2200 m ».

Near Hetigima village the south-west border of the huge Baliem valley is delimited by rather steep limestone slopes reaching up to about 3700 altitude. These slopes are completely deforested up to 2200 m. Above that altitude *Nothofagus brassii* (387) and *Nothofagus grandis* (385) dominate a forest which is constantly covered by a thick cloud layer. Its lower limit surprisingly coincides with the upper limit of deforestation; the mountain crest always emerge from the clouds.

This forest, although dominated by the *Fagaceae*, harbour a number of other species i.e. *Acsmithia reticulata* (371), *Caldcluvia fulva* (383), *Wendlandia sp.*(379), *Glochidion sp.4*(382), *Glochidion sp.5*(386), *Castanopsis sp.*(384), *Timonius sp.*(381), the shrub *Xanthomyrtus montivaga* (372) an unidentified *Araliaceae* (387) and the fern *Thelypteris sp.*(374). In the Bele river valley, Brass (1941) has collected in a similar forest type, at an altitude of 2200 m, about 60 species of trees more than 25 cm in diameter among those 6 *Lauraceae*, 4 *Fagaceae*, 8 *Cunoniaceae*, 7 *Elaeocarpaceae*, 8 *Myrtaceae* (i.e. *Syzygium*) and 2 *Podocarpaceae*.

From the description given by Brass, it seems that the families *Sapotaceae, Staphyleaceae, Icacinaceae, Meliaceae, Chloranthaceae, Celastraceae, Oleaceae* and *Begoniaceae* are at their altitudinal limit in these forests. The same is valid for the genera *Aristotelia* (Brass 11526), *Sloanea* (Brass 11217), *Peperomia* (Brass 11227) and *Lindersia chrysantha* Merr.& Perry. Leaving the grand valley, the Mt Trikora trail crosses gardens and secundary scrub up to 2400 m near the village of Elarek (cf. scetch map, appendix VI). The cultivation of the sweet potatoes becomes difficult due to low temperature during night; it needs nearly two years to grow to half the size of those

The Baliem valley, a patchwork of gardens and villages

Pitcher of *Nepenthes maxima* Reinw.

Dimorphantera obtusifolia Sleumer, from the Baliem valley near Jiwika cultivated in the Grand valley. Beyond the gardens we find the typical lower montane forest, where *Nothofagus* is well represented and may even dominate.

Some abandoned gardens and forest clearings between 2000 and 2300 m bear a low secundary scrub vegetation with many *Ericaceae*, like *Rhododendron beyerinckianum* (322), the white flowered *Rhododendron herzogii* (327), yellow flowered *Rhododendron macgregoriae* (336), *Vaccinium convallariifolium* (318), and several *Melastomaceae: Medinilla rubiginosa* (321), *Medinilla sp.*(323), *Melastoma sp.*(339), the *Myrtaceae Metrosideros sp.*(329) and *Baeckia frutescens* (332), *further Fagraea bodenii* (319), *Carpodetus arboreus* (324), *Ilex versteegii* (325), *Saurauia sp.*3 (326), *Exocarpus pullei* (340), *Parsonsia cf.cyathocalyx* (337), *Ficus sp.*(341), the pitcher plant *Nepenthes maxima* (328), *Alpinia sp.* (333), *Lindsaya rigida* (335), and some terrestrials like *Burmannia disticha*, *Glossorhyncha sp.*(330), *Dendrobium sp.* and *Spathoglottis sp.* It is interesting to note that young trees, 2-3 m high, of *Nothofagus rubra* (317) and *Nothofagus sp.* (334) are colonizing this area, showing that natural regeneration of the primary forest is coming forth and that *Nothofagus* may play a role in that process.

The surrounding forest is a typical evergreen rainforest with two arboreal strata, the first canopy layer reaching 30m height and more, the understorey layer being at 10-20 m height. The canopy is closed and thus the shrub and herb layers poorly developed. Lianas and epiphytes are present but never very frequent. For further information about these lower montane rainforests, the works by Brass (1941), Grubb &Stevens (1985), Robbins (1960) and Paijmans (1976) may be consulted.

At 2700 m, the forest structure is changing slightly, the canopy gradually opening, thus enabling a denser undergrowth. *Nothofagus stylosa* van Steenis *sp.nov.* (280) is the dominant forest tree with 20-30 m height and up to 1.5 m in diameter! The second storey is formed by small trees of *Cryptocarya sp.* (286),*Saurauia sp.*(287),*Elaeocarpus sp.* (290),*Tetractomia tetrandrum* (289), *Evodia sp.*(291, 298), *Cyrtandra sp.*(293), *Timonius sp.*(294), *Prunus sp.*(296), *Helicia sp.* (303), *Ilex sp.*(304), *Zygogynum sp.* (306), *Rapanea sp.* (307), *Ficus sp.* (311, a genus that reaches here its uppermost limit), *Sphenostemon sp.* (312), *Rhododendron sp.*(310), and numerous *Pandanus sp.* (probably *Pandanus brosimos*) with stilted roots and valuable edible nuts that are collected by the papuans for supplementary food. In the shrub layer, 1-5 m high, I have collected *Homalanthus sp.*(288) growing gregariously on several places, *Breynia sp.* (283), *Macaranga sp.* (297), *Amaracarpus sp.* (299), *Cypholophus cf.vestitus* (284), *Lecanthus sp.*

Rainforest of the lower montane zone near the village of 'Wallaik'

Upper montane rainforest at 2700 m (a Dani tribesman giving the scale)

Umbrella shaped tree of the upper montane rainforest (approx. altitude of 2850 m)

(309), *Piper sp.* (285), *Cyrtandra sp.* (302), *Rhododendron sp.* (310), young individuals of *Dacrycarpus imbricatus* (279) and of *Podocarpus archboldii* (316b). *Freycinetia cf.sterrophylla* (282), *Strongylodon archboldianus* (316) and *Clematis phanerophlebia* (314) are the most prominent lianas.

2.2 Upper montane zone

Between 2700 and 2800 m altitude, the generic spectrum as well as the physiognomy of the forest changes. We enter a transition zone between lower and upper montane forest, where the gymnosperms become codominant or even dominant and where trees with nanophyllous leaves prevail. *Pandanus sp.* is here at its upper limit of growth (± 2700 m), an observation made all over New Guinea and confirming what Robbins (1958) noted for the Kubor Range, south west of Mt Wilhelm in Papua New Guinea : « Most characteristic of all is the fact that climbing bamboo and the tall screwpines of the lower montane forest are now absent ».

At 2850 m, *Podocarpus brassii* (256), *Dacrycarpus compactus* (261) and *Phyllocladus hypophyllus* (271) are the dominant forest trees. The shrub layer is composed by *Rhododendron villosulum* (254, 266), *Vaccinium brachygyne* (255), *Homalantus arfakensis* (252), *Carpodetus cf.major* (258), *Symplocos cochinchinensis ssp. leptophylla var.reginae* (250), *Symplocos sp.* (259), *Olearia sp.*(263), *Eurya brassii* (264), *Rapanea acrosticta* (267), *Rapanea cacuminum* (269, 275), *Prunus grisea var.grisea* (276), *Melicope/ Tetractomia sp.*(272), *Evodia sp.* (274), *Steganthera parvifolia* (268) and the treefern *Cyathea sp.* (265). Within the lianas we may mention *Palmeria hypargyrea* (257) and the bright red flowered *Tecomanthe volubilis* (249). On the ground, one meter thick hummocks of mosses, mixed with hepatics, cover the fallen trees or branches thus rendering a progression outside the trail nearly impossible.

The tree crowns often have a tortured appearance with the typical umbrella shape, evident signs of reduced growth due to cooler climate. Only one tree layer has been recognized at 15 m height, the forest having a rather open canopy. The epiphytes are becoming very common, all the tree trunks and branches being covered with mosses, hepatics and abundant *Hymenophyllum* ferns. This is the typical mossy forest described by Brass in 1941 and it corresponds to the 'Upper Montane Forest' described by Grubb & Stevens (1985) on Mt Kerigomma, Papua New Guinea.

Concluding we may say that, due to floristic and structural change in the forest, a demarcation separating the lower montane zone from the upper montane zone can be fixed at 2700-2800 m. In the transect where I collected the species mentioned above, I did not observe any *Nothofagus*. It seems that either this genus is disappearing slowly at higher altitudes or, and this is more plausible, that the soil conditions are more favorable to the gymnosperms.

The altitude seems not being a serious criterium, as a nearly pure stand of *Nothofagus stylosa* van Steenis *sp.nov* (229) has been observed on a ridge at 3050 m, bordering to the north-east the watershed basin separating the east running Wamena river, from the Baliem river running to the west.*Nothofagus*, with its showy red young leaves, is forming a dense closed forest 25 to 30 m high. In the understorey I could collect a number of species well represented also at higher altitudes: *Drimys piperita* entity *'reticulata'* (224a, 224b, 234), *Acronichia murina* (226), *Vaccinium spp.* (227, 236), *Diplycosia sp.* (230), *Dimorphantera alpina var. alpina* (232), *Rhododendron beyerinckianum* (223), *Trochocarpa nutans* (233), *Schefflera sp.* (228), *Edinandra sp.* (237) and young *Libocedrus papuana* (235). Within the epiphytes, we collected *Psychotria sp.* (225), the orchids *Glossorhyncha sp.* (238), *Octarrhena sp.* (239), *Ceratostylis sp.* (242), the ferns *Humata pusilla* (241) and *Hymenophyllum rubellum* (240) and the hemiparasitic shrub *Amyema wichmannii* (231). This forest, also occuring elsewere in New Guinea, probably prefers deep, well drained soils on ridge crests (Robbins, 1960) or, as reported by Brass (1941), on well protected slopes, and at variable altitudes.

3. Subalpine zone

After a two days' walk, first through gardens and then on the fallen or felled stems of the forest trees, the visitor to Mt Trikora emerges abruptly into the open at about 3000 m. From now on, huge grasslands with scattered groves of treeferns and a scrublike forest dominates the scenery of the higher parts of the mountain. Although upper montane forest, especially *Nothofagus* forest, may grow as high up as 3050 m, or *Libocedrus* forest even up to 3400 m, the greater part of vegetation cover consists of typical subalpine grasslands and related vegetation. Therefore I tend to take the altitude of 3000 (-3400) m as demarcation line between the upper montane zone and the subalpine zone on Mt Trikora. As shown in fig. 2, several other authors proposed a similar but variable limit at 3000 - 3400 m, although van Steenis (1934) takes the altitude of 2400 m as the upper limit of the montane zone for Malesia in general. I agree nevertheless with van Royen (1980) who proposes « ...the 3000 m contour line as the lowest altitude delimitating the high altitude regions ... The change from montane flora to subalpine and alpine flora takes place around that altitude ».

As in the following chapters I will try to describe in a more detailed way the vegetation of the subalpine and alpine zones, I do not develop this right now. The subalpine zone is caracterized by a mosaic of grasslands and treefern shrublands intermingled with what is called 'subalpine forest'.

The name 'forest' is not very accurate as most of the trees have a diameter close to 5 cm and thus lie well under the 10 cm limit taken by the foresters to specify a tree. It is more a dense ericaceous scrub than a forest but we will follow nevertheless van Steenis (1934) who notes that « In general a vegetation in which woody specimens of 2-5 m in height are present is still called a forest especially if that vegetation is closed ». We will thus for conveniance stick to the much employed term of 'subalpine forest'.

In the glacial valley north of the summit, the so called 'Somalak' valley (cf.map in appendix VI), this subalpine forest grows until 3850 m altitude. Higher up wc do not find any homogenous closed forest stand although 1.5-2 m high scrub grows up until 4050 m and thus marks the treeline.

4. Alpine zone

As defined in Europe, the zone between the eternal snowline and the treeline is called Alpine Zone, although the term 'alpine' does not always find a consensus among botanists working in the tropics.

Nevertheless this terminology has become common use in recent publications on New Guinea (Hope 1976, van Royen 1980), a reason why I will use it also for Mt Trikora, agreeing with van Steenis (1934) who says that « There is no reason why the nomenclature of the European Alps should not be accepted for the Himalayas and if that so why it should be avoided for the neighbouring Malaysian and other tropical mountains ».

The alpine zone, caracterized by grasslands, mires, open dwarf shrublands and mosslands, has a very small extent on Mt Trikora, with an upper limit situated between 4500 and 4600 m. Above that line we speak in terms of nival zone

5. Nival zone

Since the late 1960's, eternal snow has vanished from Mt Trikora (cf.chapter II), so that the observation of the limit of eternal snow is not possible anymore.

Nevertheless on Mt Jaya, Peterson et al.(1973) have seen the lower limit of the névé's at 4600 m and estimations made above Lae in Papua New Guinea (Barry, 1979) established the limit of eternal snow at about 4500 m. This latter value corresponds to the estimation by van Steenis (1934) for all of Malesia. I will accept this height for Mt Trikora as well, although it is not established with certainty.

6. Summary of the zonation on Mt Trikora

As a summary I propose the following vegetation zonation for the Jayawijaya Range (Pegunungan Maokc), i.e. the central mountain range of Irian Jaya, including thus the Baliem valley and Mt Trikora.

Vegetation zonation:

0 - 1000(-1500) m	Lowland Rain Forest and Hill Forests
1000(-1500) - 2700(-2850) m	Lower Montane Zone
2700(-2850) - 3000(-3400) m	Upper Montane Zone
3000(-3400) - 3850(-4050) m	Sub-Alpine Zone
3850(-4050) - 4500(-4600) m	Alpine zone
> 4500(-4600) m	Nival zone

CHAPTER II : The Physical Environment

I. Geology and geomorphology

1. Geology and geological evolution of New Guinea

New Guinea is characterised by huge alluvial coastal plains to the south and north, and a rugged central mountain range. It has a complex geological structure due to the interaction of the Australian and Pacific plates. Pieters (1982) distinguishes three major geological provinces i.e. a 'Platform' to the south and west, a deformed 'Mobile Belt' in the centre and a zone called 'Ophiolite and Volcanic Arc' to the north. In this paper we will use this subdivision and give a short account on the general geological structure of the island of New Guinea.

The highest peaks of the main range, the south slopes and part of the 'Vogelkop' peninsula are formed by a **Platform** of mixed origin. It comprised part of the australian continental crust and part of the paleozoic basement of the Tasman orogen, both unconformably overlain by sediments aging from the Carboniferous to the Holocene. The nature of the rocks forming the basement is known essentially by drillings, because they do not outcrop. Visser & Hermes (1962) see similarities between these rocks and the cambrian rocks in north Australia.

The flood plains in the south are formed by alluvium of Neogen and Quaternary age, whereas the south slopes and foothills are caracterised by a "thick sequence of rocks aging from Silurian or Devonian to Permian" (Pieters 1982), all more or less metamorphosed. These deposits are formed by clay-slates or shales, sandstones, conglomerates and volcanics.

Finally the highest parts of the main range, also part of the Platform, are constituted by a 2000 m thick sequence of sedimentary rocks comprising limestones intermingled with marles and sandstones, all deposited in a transgressive / regressive or open marine environment.

The northern slopes of the main range and the northern foothills are formed by a 50 km wide, strongly folded and uplifted belt. This **Mobile Belt** shows metamorphosed sendiments (blueschist faciès) deposited in a deep basin north of the australian continental platform during the Mesozoic until the late Eocene. In these little explored areas, the papuans quarried these type of rocks to obtain the highly appreciated raw material for their adzes. These rocks are in fault contact with ophiolite bodies, i.e. fragments of old oceanic crust overthrown on the continent (Allègre 1980).

Between the Meervlakte and the northern coast ranges the **Ophiolite and Volcanic Arc** zone. In the western half of the island, lower hilly terrain in the Van Rees Mts. and the Cycloop Mts. show a sequence of "rocks typical for an ancient volcanic island arc which probably developed some distance away from the Australian continent in late Eocene to early Miocene" (Pieters 1980). The presence of such ophiolites in the northern half of the island suggest the existance of a fossile subduction zone, an interesting point for the understanding of the geological evolution of New Guina.

This evolution began long ago wih the break up of Gondwanaland in Mesozoic times and with the australian plate drifting to the north-east (fig.3). After the separation of Australia/New Guinea from Antarctica in the early Eocene, this plate collided in the Miocene period with a volcanic arc causing the uplifting and folding of the hitherto submerged northern continental margin and thus giving rise to the central range of actual New Guinea (Hamilton 1979).

During this collision, ocean floor and the volcanic arc have been thrust over the northernmost continental margin, a theory supported by the actual presence of ophiolites north of the central range. Following this collision, the polarity of the subduction changed and thus showing the actual situation of pacific oceanic floor disappearing under the australian/New Guinea plate with a new volcanic arc forming to the north of New Guinea. Subsequent uplifting with strong erosion of these young mountains filled the adjacent basins with detrital sediments forming the actual coastal plains.

Finally we may note that quaternary volcanism does not exist in west New Guinea (Irian Jaya), whereas in the eastern part (Papua Niugini) Mt Giluwe and Mt Hagen are extinct volcanoes and Mt Wilhelm is a huge intrusif bloc of granodiorite, comparable to Mt Kinabalu in Borneo. Earthquakes have nevertheless also been registered in the western half of the island.

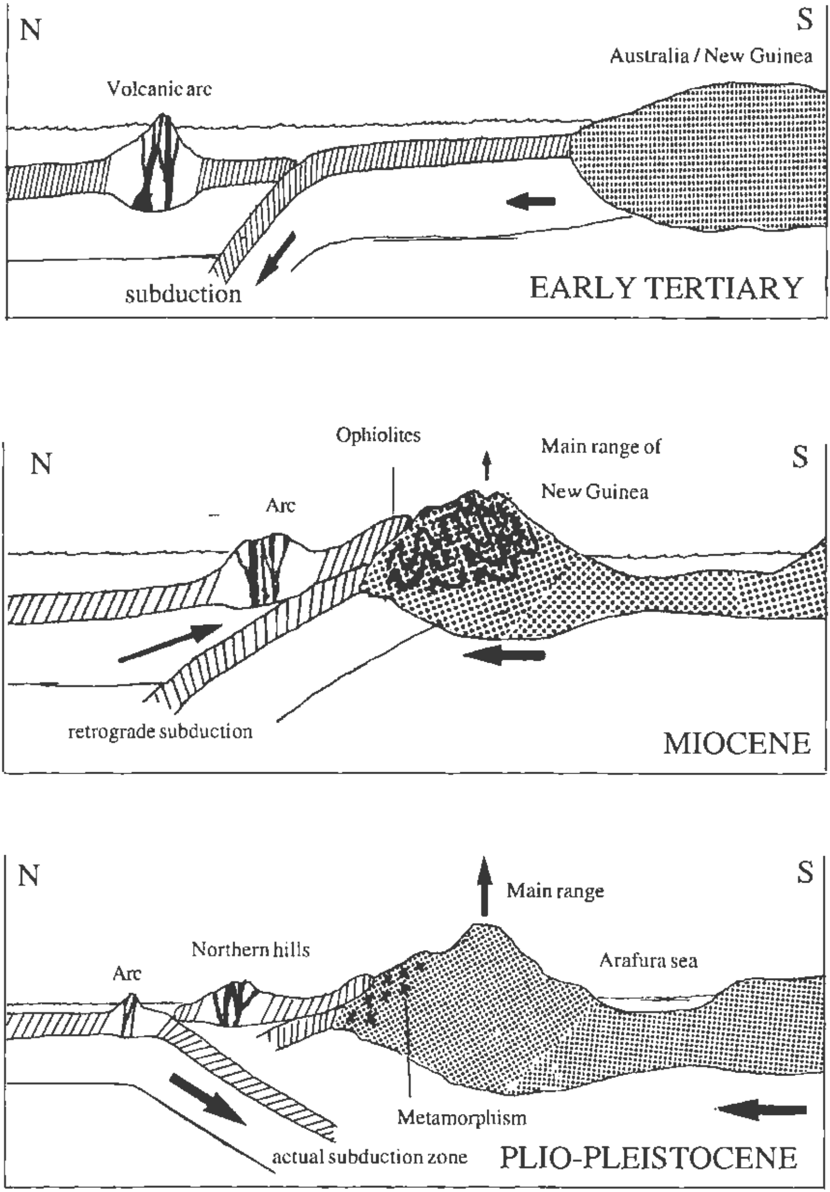


Fig. 3: Tectonical evolution of New Guinea.

2. Geology and geomorphology of Mt Trikora

In the following chapter we will give a short account of the geology and geomorphology of the summit area of Mt Trikora resulting in a geological cross-section of the summit. (fig. 4) For this analysis we relied on field observations, thin sections of rock samples and fossils taken from this area. Although no large scale map was available, valuable informations could be gathered from the map drawn by Visser & Hermes (1962).

In general we may say that from the Baliem Valley to the highest parts of the Snow Mountains (Pegunungan Maoke), sandstones are alternating with limestones. Extensive Karst areas occur in the Grand valley and numerous sinkholes may be seen in the higher parts of Mt Trikora. The summit itself shows a similar alternation of hard and soft rocks, strongly folded during the late tertiary orogenic activity. From south to north we may observe a succession of synclines and anticlines all more or less overturned. The highest part of Mt Trikora is an anticline slightly overturned to the north and submitted to strong glacial erosion. The lithology is mainly limestones, marls and sandstones.

Starting our cross-section at the very summit and looking north (fig.5), we first distinguish a foraminiferal limestone with *Alveolina (Lacazina)* as fossil content. These benthal fossils testify to a shallow carbonate platform facies of Eocene age. These layers rest without discontinuity on cristallin dolomitic limestone, themselves overlying a lumachelle of *Nummulites (Nummulites pengaronensis* Verbeek (forms A and B), *Nummulites cf. biapiculatus* Doncieux). Stratigraphically this sample belongs to the upper Eocene (P15-P17, Priabonien) or even lower Oligocene.

The so-called 'Hanging Valley', an east-west orientated valley between the summit and the 'False Peak' to the north has been cut into a sequence of softer marls, quartzitic limestones or sandstones less than one meter thick each, dipping south by 35-40°. The 'False Peak' shows also this alternation of soft and rough layers but is protected by a layer of crystalline limestone strongly weatherd by water and wind. Lapiaz with micro-furrons occur and may cause strong damage to hands and shoes, making field investigations very difficult and even dangerous.

The underlying sediments consist of pale greyish sandstones with a clayish

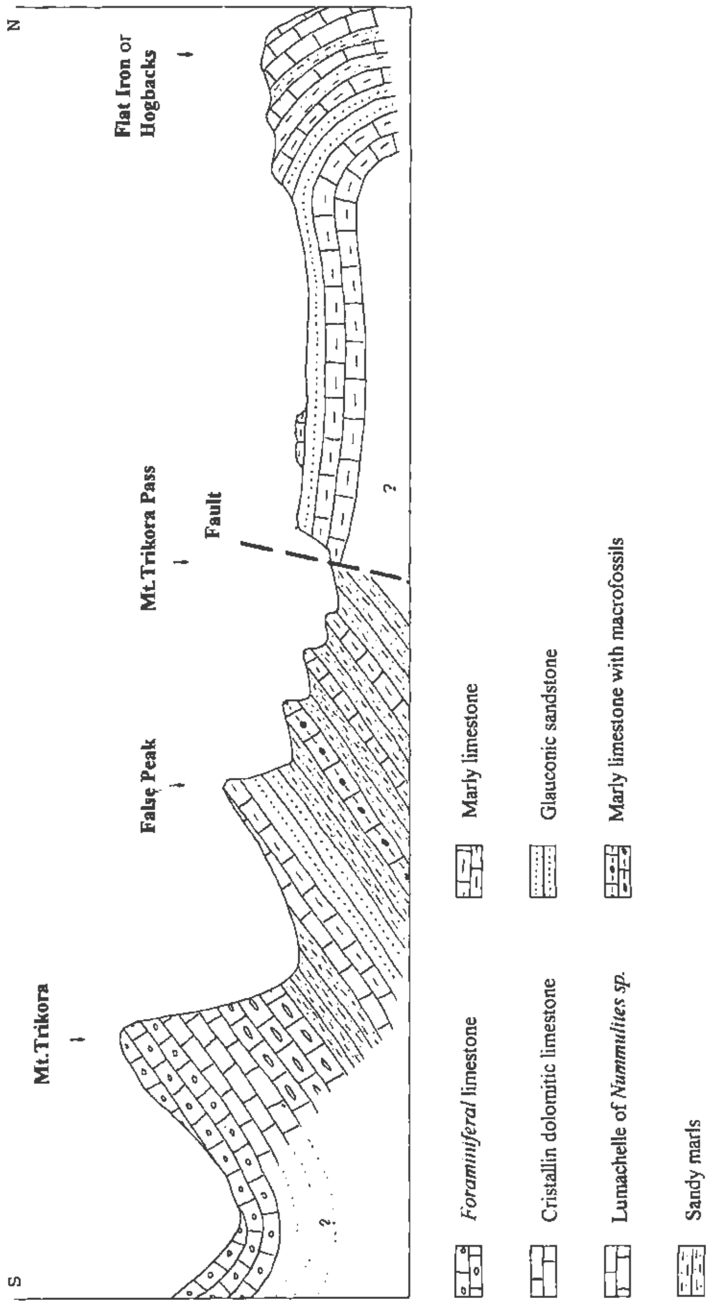


Fig. 4: Geological cross-section of Mt Trikora

matrix. The quartz grains are more or less rounded and smoothed. The absence of feldspar indicates a sorting in marine environment.

At the foot of the 'False Peak' old landslides expose layers crowded with macrofossils such as big oysters (*Ostrea sp.*), brachiopods (*Terebratula sp., Neithea subgenus Neitheopsis*) and sea-urchins (*Cidaris sp.*). The fossils indicate that these layers are quite older than the summit of Mt Trikora, i.e. being of upper Cretaceous (Cenomanian) age.

Coming down northwards to the huge Somalak valley, we pass over several terraces cut into marly or sandy limestones alternating with softer marls. On such a terrace outcrop, north-west of the 'False Peak', an area free of vegetation with numerous free-lying curious concretions (plate 5) could be observed. The section of some samples showed that these concretions "consist of calcite and goethite in concentric sections. The goethite probably formed from siderite (FeCO3 — FeOOH) by oxydation" (Dr.Ir.P.Buurman, Wageningen, pers. communication.). According to the specialist, these concretions are very much « built like oncoliths and other accumulations formed by algae » and may have been formed around organic debris. The particular rounded and concave or convexe shape may be due to shrinkage (dessication) cracks in larger units.

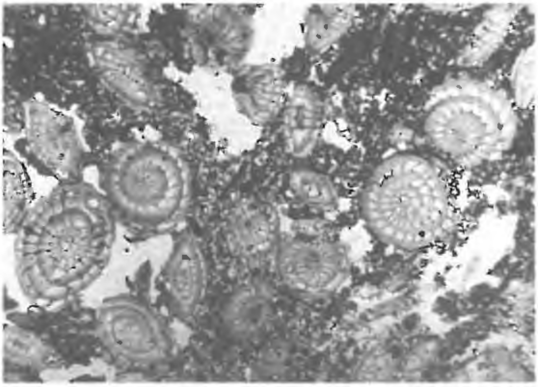
Finally the western edge of the Somalak valley is formed by a slightly inclined platform of strongly eroded arenitic rocks. Honey-combed structures indicate hollow weathering and 50 cm broad and 5 m deep joints occur all over the area. The analysis of a rock sample shows a fine-grained glauconic sandstone with a calcarous matrix (40-50 % quartzite, 5 % glauconite). The shape of the grains indicate good sorting. The glauconite, an association of clay minerals with a high content of Fe 3+, is formed in a marine environment of 50-100m deepness, with slow sedimentation. Current-bedding of five meters in thickness, occuring at Mt Trikora Pass, show some shallow water caracteristics.

The **geomorphological features** of the region dealt with in the present paper are present in the Baliem Valley or in the uplands of Mt Trikora itself.

At the north-eastern border of the broad Baliem Valley, the landscape is modelled by the chemical erosion of the limestone rocks present, resulting in a considerable extent of Karst landforms (cf. map, appendix VI). Large dolines alternate with rather steep pyramidal hills. Numerous caves due to very active underground drainage are typical for the north-eastern part of the Baliem. Some of the huge dolines are occupied by the villages and gardens of the Dani. These karst landforms can be seen even at higher altitudes

*Cidaris sp.*sea-urchin from the terraces north of the summit of Mt Trikora (± 3900 m)

Thin section of a lumachelle with *Nummulites spp.*



Ostrea sp. fossil oysters from terraces north of the summit of Mt Trikora (± 3900 m)

Lapiaz with micro-furrons from the 'False Peak'

Honey-combed structures and joints, arenitic rock-platform (3850 m), western edge of Somalk Valley

Cross-bedding at 'Trokora Pass', alt. ± 3750 m

Area free of vegetation with concretions.North face of Mt Trikora, ± 3900 m

Calcite and Goethite concretions (each ± 1 cm in diameter)

Cross section of a concretion disque (photo: P.Buurman) between 31000 and 3200 m altitude. Nevertheless Mt Trikora itself and the valleys north of it, can be considered as an area with « prominent structural control » (Löffler in Gressitt 1982), i.e. the landforms encountered are the result of a differential erosion of the more resistant limestone and sandstone rocks and the less resistant marls. This type of erosion is furthermore emphasized by the folding and faulting of the rocks, thus bringing the rock-beds in an inclined position with mostly southerly pendage of various degrees.

A second element in this landform modelling is the pronounced glacial erosion that occured during the Pleistocene glaciation. Traces of glacial activity are prominent all over the aerea north of the summit (USAF aerial photograph, plate 8). Glaciers have probably been descending north until reaching a huge intramontane basin at 3000-3100 m. The most evident landform elements have been shown on a sketch-map (in appendix) drawn from field observations and USAF aerial photographs.

Three major elements have to be considered: northernmost we distinguish two huge east-west orientated intramontane basins. Roughly parallel to the basins and south of them are several major ridges with Mt. Trikora culminating at 4725m. Finally we see that many south - north directed valleys cut across these ridges.

Starting in the north we distinguish a huge 8-10 km long by 3 km wide basin containing Habbema lake. This water surface is situated at 3225 m altitude in an area dominated by pale greyish sandstones alternating with limestone ridges with many medium sized sinkholes, reminding of the doline Karst from the Baliem valley. To the south a limestone ridge of 100 m in height seperates the Habbema valley from another broad upland basin, the Baliem-Wamena river valley, between 3000 - 3100 m.

Most of the rivers draining the waters of the north slopes of Mt Trikora converge into this basin and later on flow either east or north-west. Those running eastward can be considered as the source rivers of the Wamena river, which flows into the Baliem river near the town of Wamena . Those running westward will join with the waters coming from lake Habbema and will later be the Baliem river. This intramontane basin may thus be considered as a main watershed of the area.

A number of valleys extending north from the summit of Mt Trikora show typical glacial erosion features. Very prominent lateral moraines with ridges


Lake Habbema
Ibele
Wamena River
WATERSHED BASIN
Baliem River
Hogback
(Flat Iron)
Somalak
Shelter
SOMALAK VALLEY
Trikora
Pass

Somalak valley looking north to lake Habbema (U.S.A.F. aerial photograph, 1942)

Somalak valley looking north to lake Habbema (U.S.A.F. aerial photograph, 1942) more than 100 m high are present as far down as 3200 m. The typically U-shaped valleys show many glacially smoothed lateral rock faces and overdeepend swampy basins mostly covered by grasslands. The valley glaciers cut through structural ridges, leading to huge pyramidal hogback ridges with a very steep angle of dip of the strata. These so-called flat irons result from the erosion of an overturned anticline. They have probably been bolting the huge glacier valleys. It is in one of these glacier valleys that we established our base camp under a big rock overhang called Somalak rock shelter.

Walking up Somalak valley, we reach Trikora Pass at its most westerly border, a pass that gives way to a steep combe-like valley that is the result of a breached anticline with a hollowed-out core. Somalak valley, as well as most other valleys of the area end up in a huge semi-circular glacial cirque where the glaciers started their way downvalley. There we may see extensive homoclinal ridges dipping south with very variable angle. These terrace-like structures are mostly asymetrical with steep scarp slopes facing north and gentler southerly dipslopes. Many small rivers are cutting across these terraces.

Immediately south of Somalak, we reach the major scarp line including the summit of Mt Trikora which is part of a ridge with roughly east-west orientation. This summit ridge is flanked north and south by two parallell minor scarp lines of which the northern one culminates in the so-called 'False Peak'.

Between the False Peak and Mt Trikora summit, the softer rock beds have been eroded and thus an east-west orientated valley could develop at 4100m altitude. Vertical rock walls a few hundred meters in height (according to the available height indications for Mt Trikora, being 4725 m, these should be considerable !?), block the access to the summit for the unexpierenced traveller.

II. The soils on Mt Trikora

In the following chapter we will give a short account of the edaphic conditions for the summit zone of Mt Trikora. It has not been possible to make a precise soil survey of the region during the time available, therefore we concentrate on the uppermost horizons to provide background information for the following description of vegetation units. 26 Soil profiles have been studied and a number of samples have been taken back to Luxembourg for a concise chemical analysis. The results are summerized in table 1.

In New Guinea the lack of seasonality provides special conditions for soil formation which takes place all year round. The factors influencing most soil formation are topography, temperature and rainfall. Variation in rocktype seems to have little effect on the soils.

Low soil temperature, especially during night, reduces strongly any biological activity in the soil. Accumulation of humus and peat, due to decreasing mineralization at high altitudes, is a prominent feature in the New Guinea highlands. In the alpine zones, night frosts even stop all rotting processess.

High rainfall creates permanent leaching, compensated partly by strong evaporation at least on exposed terrain. The watertable is nearly always very close to the surface. In the following account I will distinguish between poorly differentiated lithosols and mineral or humus soils.

1. Lithosols

In the summit area of Mt Trikora, bare rock surfaces and screes have a considerable extent. Soil forming processes have only recently started.

1.1. Rendzinas

On the summit ridge of Mt Trikora, and immediately north of this ridge occur large limestone screes between 4000 and 4250. There we find shallow soils (10 cm thick) permanently overturned by cryoturbation. These screes are in constant movement, thus vegetation cover is very sparse, mostly tufts of *Deschampsia klossii*.

Table 1: Soils of Mt.Trikora: chemical and granulometric analysis

Plot N°	Vegetation Unit	Horizon	Granulometric composition (%)						Chemical analysis			
			Fine Gravel (mm) 2-1	Coarse Sand (mm) 1-0.25	Fine Sand (mm) 0.25-0.05	Sand Total	Silt	Clay	pH (KCl 0.1N)	C org %	N mg%	C/N
4	Deschampsia klossii tussock grassland	Ao	.	.	.	.	.	.	4.2	7.98	690.2	11.6
26	Deschampsia klossii tussock grassland	AoA1	0.18	4.4	61.5	66.02	9.99	23.99	6.1	3.05	253.4	12.0
		A2	0	4.6	61.9	66.49	9.68	23.83	4.3	7.88	623.0	12.6
20	Dwarf shrub heath on shallow soil	AoA1	0.23	10.9	63.3	74.35	18.67	6.98	4.0	3.35	252.0	13.3
24	Astelia alpina alpine herbfield	Ao	0	1.7	66.6	68.25	17.89	13.86	5.6	5.12	273.0	18.8
		A1	0.25	2.3	61.9	64.45	14.97	20.58	4.2	1.91	154.0	12.4
28	Alpine dwarf shrub heath	AoA1	1.2	5.9	75.9	82.96	12.57	4.47	5.1	1.08	63.0	17.1
		(A2)C	0.78	5.9	81.7	87.23	9.27	3.50	4.9	0.59	63.0	12.6
31	Dwarf shrub heath on shallow soil	Ao	0.11	4.5	78	82.55	13.55	3.90	4.2	10.24	581.0	17.6
		A1	0.2	4.5	43.7	48.34	29.26	22.40	4.2	3.27	154.0	21.2
79	Carex spp. open fen	A1	.	.	.	0.77	36.17	63.06	6.0	2.17	170.1	12.8
22	Subalpine rainforest	Ao	.	.	.	.	.	.	3.7	16.15	675.5	23.9
		A1	0.2	4.6	52.7	57.42	25.17	17.41	4.0	3.64	261.8	13.9
30	Subalpine rainforest	Ao	.	.	.	.	.	.	3.0	25.21	1407.0	17.9
32	Subalpine rainforest	Ao	.	.	.	.	.	.	3.0	23.64	1145.2	20.6
		A1	0.34	12.2	56.3	68.86	17.11	14.03	3.9	4.14	98.0	42.2
36	UM transition forest	Aoo	.	.	.	.	.	.	3.2	18.91	1299.2	14.6
		Ao	.	.	.	.	.	.	3.6	26.59	1064.0	25.0
		A1	0.54	10.6	38.1	49.15	29.43	21.42	4.0	3.54	141.4	25.0

39	UM transition forest	Ao	.	.	.	.	.	.	3.4	18.91	2163.0	8.7
		A1	0.24	7.9	56.6	64.79	26.58	8.63	4.2	3.93	133.0	29.5
42	Treefern shrubland	Aoo	.	2.9	29.9	32.70	43.69	23.61	3.2	16.74	1141.0	14.7
		AoA1	0.36	1.4	17.8	19.46	30.43	50.11	4.4	2.95	161.0	18.3
78	Subalpine rainforest	A1	.	.	.	0.26	41.90	57.84	5.9	5.46	362.6	15.1
81	Coprosma brassii-Styphelia s. heath	AoA1	0.89	5.6	17.3	23.81	38.84	37.35	7.3	6.74	370.3	18.2
		A2	0.39	5.6	17.1	23.15	44.41	32.44	7.6	1.58	101.5	15.6
5	Short grass bog	Bh	0	.	33.1	47.07	29.53	23.40	4.2	17.33	1099.0	15.8
		Bt	0	3.4	13.2	16.65	53.50	29.85	4.0	8.67	1134.0	7.6
12	Gleichenia vulcanica bog	AoA1	0.53	10.9	38.9	50.42	30.56	19.02	4.1	5.31	323.4	16.4
		Go	0.8	9.9	37.3	48.05	30.49	21.47	5.6	1.18	63.0	18.7
17	Astelia alpina subalpine bog	AoA1	0	0.8	12.9	13.73	40.80	45.47	5.8	4.83	224.0	21.6
		Go	(0	10.6	51.6	62.19	25.29	12.52	4.8	6.70	371.0	18.1)
33	Subalpine short grassland	AoA1	0.42	23.5	44.4	64.31	23.48	12.21	4.2	11.52	543.2	21.2
		Go	0.2	9.8	20.8	30.84	36.34	32.82	4.5	1.38	67.2	20.5
		Gr	0.53	16.4	26.5	43.50	32.92	23.58	4.2	0.98	49.0	20.0
84	Gleichenia vulcanica bog	AoA1	0.09	1.8	36.2	38.07	32.03	29.00	6.5	11.42	858.9	13.3
		Gr	0.94	17.5	31.1	49.59	23.11	27.30	7.2	1.67	93.8	17.8
13	Astelia alpina subalpine bog	Aoo	.	.	.	.	.	.	4.3	10.44	1561.0	6.7
37	Gahnia javanica tussock sedgeland	Aoo	.	.	.	.	.	.	3.5	20.19	638.4	31.6
		Ao	.	.	.	.	.	.	3.3	22.65	1981.0	11.4
86	Astelia alpina subalpine bog	Aoo	.	.		.	.	.	5.8	16.15	1936.2	8.3
7	Subalpine bog heath	Aoo	.	.	.	.	.	.	3.4	21.47	2716.0	7.9
		Ao	.	.	.	.	.	.	3.4	22.06	2159.5	10.2
11	Astelia alpina subalpine bog	AoA1	0	1.5	4.9	6.42	41.58	52.00	3.9	8.67	1078.0	8.0
		A2	0	1.1	5.2	6.20	47.57	46.23	4.2	8.47	627.2	13.5
14	Subalpine bog heath	AoA1	0	2.1	54.9	57.4	29.74	13.22	4.0	7.88	420.0	18.8
		A2	0	3.3	59.6	62.89	24.78	12.33	4.0	6.70	331.8	20.2

These soils show a typical AC profile with a top black humus layer (10YR 2/1.5; after 'Soil colour chart' by Munsell, revised by Oyama & Takema, 1967), constantly humid and with many weathered limestone rock fragments. As vegetation cover increases, the soil is evolving slowly with an A2-horizon appearing, thus resembling to a brunified rendzina as it could be observed in plot N' 26.

Plot N° 26 (21/08/1983): alpine tussock grassland

Site characteristics: old limestone scree at 4000 m, declivity 45°, moderate drainage.

Description:

AoA1	00-20 cm	black-brown (10YR 2/2) sandy Humus = Mull, granular structure
A2	20-30 cm	black-brown (10YR 3/2) sandy clay

1.2 Dolomitic rendzinas / para-rendzinas

On gentle marly- or sandy limestone slopes we observed shallow soils (10-20 cm thick) directly underlain by hard bedrock. These soils show a high amount of free sand as we can see from the analysis of the plots N°20, 24, 28 and 31.

Plot N° 20 (20/08/1983): subalpine dwarf shrub heath on shallow soil

Site characteristics: Somalak valley, sandy-limestone slope near Somalak rock overhang (base camp), 3640 m, declivity 20°

Description:

AoA1	00-15 cm	grey brown / grey orange (7.5YR 5.5/4) sandy Humus = Moder
C	> 15 cm	sandy to marly limestone bedrock

Plot N° 24 (21/08/1983): alpine herbfield

Site characteristics: 'false Peak', flat dolomitic limestone rock surface, 4100m, declivity 35°

Description:

Ao	00-5 cm	dark reddish brown (5YR 3/4), Humus = Mull
A1	5-15 cm	grey yellowish brown (10YR 4.5/4) sandy loam

C	>15 cm	bedrock

Plot N° 28 (21/08/1983): alpine dwarf shrub heath

Site characteristics: 'False Peak', grey sandstone with calcareous matrix, 4000m, declivity 45°, good drainage

Description:

AoA1	00-15 cm	strong orange brown (7.5YR 5.5/6) sand
(A2)C	> 15 cm	grey yellowish brown (10YR 5.5/4) sand/sandstone

Plot N° 31 (23/08/1983): subalpine dwarf shrub heath on shallow soil

Site characteristics: Somalak valley, marly-limestone flat rock surface above Somalak rock shelter, 3690 m, declivity 10°

Description:

Ao	00-5 cm	dark reddish brown (5YR 3/2) sandy Humus = Moder
A1	5-10 cm	grey yellowish brown (10YR 4.5/4) sandy clay
C	> 10 cm	bedrock

These shallow soils have generally a good drainage and during dry spells they even may get quite dry as water retention is low. The vegetation cover is sparse to absent on several places.

1.3 Colluvium soils

This kind of soils occurs under subalpine forest or shrub-rich vegetation on old fixed screes, limestone rock fans or morainic till with medium drainage and strong declivity. These colluvium soils have a strong content of more or less decomposed organic matter and high proportion of silt or clay. Most material has been transported downhill or laterally. Eight plots have been classified within this category: N° 22, 30, 32, 36, 39, 42, 78, and 81.

The upper humus horizon is generally covered by a thick moss carpet up to 80 cm high. The very acid humus is of Mor type. The humus horizon lays on a clay layer of variable thickness with strong silt proportions. The generally high C/N ratio (> 15) indicates little biological activity with tendency to podzolisation. In this cool climate biological activity is nearly reduced to acidiphillous fungi; no earthworms could be observed!

On the other hand the C/N ratio often increases from top to bottom which is another indication for podzolisation. But we must take in consideration the fact that the subalpine forests and shrubbery are dominated by the *Ericaceae Rhododendron spp.* and *Vaccinium spp.*, whose tissues have already a very high C/N ratio. Thus the high ratio in the soil is at least partly due to the litter of the vegetation cover itself. Finally in all plots we could see a slight tendency to hydromorphy.

Plot N° 22 (20/08/1983): subalpine rain forest

Site characteristics: Somalak valley, 3650 m, declivity 30°

Description:

Ao	00-15 cm	dark reddish brown (5YR 3/2) Humus = Mor
A1	15-30 cm	black brown/brownish grey (7.5YR 3.5/2) sandy loam, big rock boulders included in the clay matrix

Plot N°30 (23/08/1983):subalpine rain forest

Site characteristics: Somalak valley, 3680 m, declivity 50°

Description:

Ao	00-70 cm	black reddish brown (2.5YR 2.5/2) Humus = Mor

Plot N° 32 (23/08/1983): subalpine open woodland

Site characteristics: Somalak valley, 3740 m, declivity 45°

Description:

Ao	00-50 cm	black reddish brown (2.5YR 2.5/2) Humus = Mor
A1	> 50 cm	black brown (10YR 2/2) sandy clay, rock boulders included in the matrix

Plot N° 36 (24/08/1983): subalpine rain forest

Site characteristics: huge valley east of Somalak valley, 3400 m, declivity 45°, good drainage

Description:

Aoo	00-20 cm	black reddish brown (2.5YR 2.5/2) Humus = Mor
Ao	20-40 cm	grey black/black (2.5YR2.5/1) Humus = Mor
A1	> 40 cm	black brown (7.5YR 3.5/2) silty, sandy clay, rock boulders incorporated

Plot N° 39 (25/08/1983): upper montane transition forest

Site characteristics: Baliem-Wamena river valley, 3150 m, declivity 5°

Description:

Ao	00-40 cm	black reddish brown (2.5YR 2.5/2) Humus = Mor
A1	> 40 cm	sandy loam

Plot N° 42 (25/08/1983): treefern shrubland

Site characteristics: Baliem-Wamena river valley, 3000 m, declivity 35°

Description:

Aoo	00-40 cm	Sphagnum moss carpet
AoA1	40-80 cm	grey yellowish brown (10YR 4.5/4) silty clay

Plot N° 78 (17/08/1984): subalpine rain forest

Site characteristics: huge valley east of Somalak valley, 3460 m, declivity 35°

Description:

Ao	00-30 cm	dark reddish brown (5YR 2.5/2)
		Humus = Mor
A1	> 30 cm	dark olive grey (5YR 3.5/2) heavy silty clay

Plot N° 81 (18/08/1984): subalpine heath

Site characteristics: huge valley east of Somalak valley, 3460 m, declivity 35°

Description:

AoA1	00-10 cm	black brown (10YR 3/1.5) silty humic clay
A2	10-40 cm	black brown (10YR 3.5/2) silty clay, watertable at -40 cm

A particular soil (Plot N°79) has been encountered in the huge valley east of Somalak valley, at 3450 m, on a flat terrace some 20 m away from plot N°78. This soil is totally waterlogged and bears wet sedgeland. Immediately under the soil surface, we may see a yellow brownish grey (10YR 4/2) very heavy silty clay without any humus layer. This seems to be alluvial material from the higher situated plot N°78 that has been laterally leached downvalley.

2. Differentiated soils

Mineral and humus soils, as discussed in detail by Haantjens et al. (1967), Bleeker (1980) and Reynders (1959) are the most common mature soil types on Mt Trikora. Using the classification of Haantjens et al. (1967), they may mostly be considered as climamorphic or hydro-lithomorphic soils.

2.1 Podzolic soils

On the relatively flat areas of the valley floors, tussock grassland develops on alpine podzolic soils. Normally podzols are known from acid rocks (cf. Reynders, 1964), but although we could not find a typical podzol, clear podzolisation is taking place on Mt Trikora, especially on the more quartzitic limestones. The leaching of the uppermost layers is strong, thus resulting in a more or less bleached subsurface horizon. Lower down we find an accumulation horizon of organic matter, variable in thickness. Plot N°5 (plate 9) is a good example of such a podzol. The underlying layer is impervious clay and the watertable is close to the surface.

Podzolic soil

Podzolic gley soil

Alpine humus soil

Plot N° 5 (16/08/1983): subalpine short grass bog

Site characteristics: Somalak valley, 3640 m, waterlogged soil

Description:

AoA1	00-10 cm	brown (7.5YR 4.5/4) sandy humus
A2	10-20 cm	bleached horizon, greyish sand
Bh	20-40 cm	accumulation of organic matter, black brown (7.5YR 3/2) light sandy clay
Bt	> 40 cm	blueish-grey silty clay

2.2 Podzolic gley soils

In the high valleys on Mt Trikora, the watertable is everywhere very near to the soil surface thus creating conditions for the formation of hydromorphic soils. The field work has often been disturbed by such a high watertable.

On the slightly undulated or sloping terrain the moving watertable creates gley horizons at various depths. This soil type has a wide distribution on Mt Trikora, with a discontinous grassland or boggy vegetation cover. Four plots correspond to this soil type: N°12, 17, 33 (plate 9) and 84. In general we may say that this soil type is a very silty clay, showing some leached and gleyed horizons with rust coloured mottles.

Plot N° 12 (17/08/1983): *Gleichenia vulcanica* subalpine bog

Site characteristics: Somalak valley, slightly undulated terrain, 3650 m

Description:

AoA1	00-15 cm	brown/grey-brown (7.5YR 4.5/4) sandy clay
Go	> 15 cm	dark grey (2.5YR 4.5/0) sandy clay, ocre to rust coloured mottles, gravel incorporated

Plot N° 17 (18/08/1983): *Astelia alpina* subalpine bog

Site characteristics: Somalak valley, 3640 m, slightly sloping terrain

Description:

AoA1	00-10 cm	dark brown (7.5YR 3.5/3), Humus = Moder
Go	10-30 cm	grey (2.5YR 5/0) silty heavy clay horizon, ocre to rust coloured mottles, with pockets of blackish brown (5YR 2.5/1) humic sandy loam, also gravel incorporations in the clay matrix
C	> 30 cm	sandy bedrock

Plot N° 33 (plate 9) (23/08/1983): subalpine short grassland

Site characteristics: Somalak valley, slightly sloping terrain, 3790 m

Description:

AoA1	00-5 cm	grey brown/brown (7.5YR 4.5/4) sandy loam
Go	5-30 cm	clay with ocre to rust coloured mottles and blue-green vertical trails
Gr	> 30 cm	dark grey (7.5YR 3.5/0) sandy loam, gravel incorporated

Plot N° 84 (18/08/84): *Gleichenia vulcanica* subalpine bog

Site characteristics: huge valley east of Mt Trikora, 3430 m declivity 20°

Description:

AoA1	00-15 cm	dark brown (10YR 2.5/2) humic loam
Gr	15-35 cm	dark grey (7.5YR 3.5/0) sandy clay, gravel incorporated
C	> 35 cm	bedrock

2.3 Alpine humus soils

The huge valleys north of the summit have been eroded by Pleistone glaciation, forming flat areas or depressions where watertables are high during a considerable part of the year. Boggy soils with highly organic to peaty horizons are largely found under tussock grassland.

The wet and cool climate promotes an accumulation of organic material, mostly very little decomposed! These alpine humus soils or peat soils are completely waterlogged and therefore the lower horizons could not be examined. The accumulation of organic material is causing a certain uplift of the soil surface thus enabling less hydrophile plants to develop.

Real *Sphagnum* peats have rarely been observed. *Sphagnum* mats occured mostly as soil cover in subalpine forest. Plots N° 13 (plate 9), 37 and 86 situated between 3000 and 3650 m, are characterised by an acid, dark reddish brown (7.5YR 3/3) or blackish brown (5YR 2.5/1) friable peaty surface horizon.

The humus soil often show evident sign of podzolisation as we may see in the plots N° 7, 11 and 14. These plots are inbetween a real alpine humus soil and a podzolic soil. Very acid upper horizons are followed by a bleached horizon and overlying a slight accumulation of organic matter. All over the profile we find rough unrotten fibrous plant remnants.

Plot N° 7 (16/08/1983): subalpine bog heath

Site characteristics: Somalak valley, 3640 m, flat terrain

Description:

Aoo	00-15 cm	dark reddish brown (5YR 3/2) Humus = Mor (pH=3.4)
Ao	15-25 cm	black brown (10YR 2/1) Humus = Mor, water table at -25 cm

Plot N° 11 (17/08/1983): *Astelia alpina* subalpine bog

Site characteristics: Somalak valley, 3650 m, waterlogged soil, flat terrain

Description:

AoA1	00-15 cm	dark brown/brown (7.5YR 3.5/4) heavy humic clay
A2	15-25 cm	black brown (7.5YR 3/2) silty humic clay

Plot N° 14 (18/08/1983): subalpine bog heath

Site characteristics: Somalak valley, 3630 m, flat terrain

Description:

AoA1	00-15 cm	grey brown / grey orange (7.5YR 5.5/4) sandy loam

A2	15-25 cm	black brown (10YR 2/2) sandy humic loam with accumulation of organic matter

Finally we analysed four plots (N°78, 79, 81, 86) to get an indication of the assimilable nutrients present (table 2).

Table 2: assimilable nutrients from the plots N°78, 79, 81, 84 and 86.

Plot n°	P_2O_5 ass.mg%	K_2O ass.mg%	MgO ass.mg%
78	4.3	9.0	6.1
79	0.2	6.1	11
81	2.6	7.9	5.2
	4.3	5.6	>20
84	0.2	6.9	>20
	1.1	3.6	5.2
86	3.9	14.1	2.6

The analysis, although very concise, shows that the high altitude soils on Mt Trikora are relatively poor in plant nutrients, especially in Phosporus.

III. The Climate

1. General climate

From the very hot and humid lowlands to the snow-capped mountains, New Guinea presents a huge variety of climatic conditions. The climate of the island in general is determined by the trade winds (Fontanel & Chantefort, 1978). In fact New Guinea is in a zone where airstreams from the northern and southern hemisphere converge and rise.

During boreal winter New Guinea is under influence of north-west monsoons, giving a maximum rainfall to the lowlands and hills north of the main range. The situation is inversed from June to September where south-east/

north-west winds from Australia are charging humidity over the Arafura sea and thus take rain to the southern lowlands.

Examining the rainfall map for Irian Jaya (fig. 5), we see that only the southernmost parts are confronted to a drier period. This may be explained by the narrowness of Torres Strait, i.e. there is fairly no possibility to supply humidity to the air masses. Getting north, a maximum of rainfall (6000-7000 mm) is reached on the very steep south slopes of the main range due to a forced ascent of the humid air masses from the southern lowlands. The rainfall increases with altitude up to a certain point and then decreases with higher

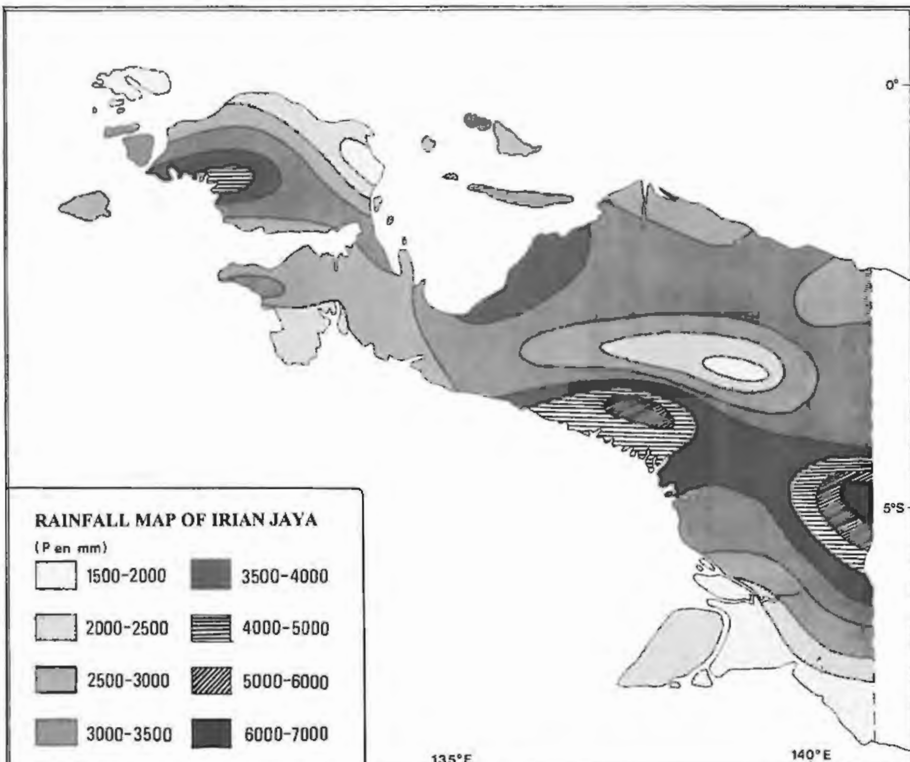


Fig. 5: Rainfall map of Irian Jaya (West New Guinea)
(after: meterological note N°9, rainfall atlas of Indonesia Vol.2 , 1911-1940, Dept. Comm. Met. & Geoph. Inst., Jakarta 1974)

elevations. Thus the summit areas get less rain than the mid-mountain zones. The huge intramontane plains like the Baliem valley get also far less rain. This is due to modifications of the general rainfall pattern by the complex topography. The northern lowlands are quite well watered (3000 - 4000 mm) with only the northern part of the Vogelkop peninsula being again drier.

As for most mountain areas in New Guinea, long-term climatological survey is also lacking for the the higher parts of Mt Trikora. The nearest meteorological survey station is at Wamena in the Baliem Valley. Records from this station are shown in detail in appendix I.

Wamena, situated at 1550 m altitude, gets an annual mean of 1754 mm rainfall, which is very little compared to the rest of the island. This may be explained by the rather sheltered position of the Baliem valley, protected to the north and south by mountains more than 3000 m high. Thus from June till September, Wamena experiences a relatively dry period (fig.: 6), with a

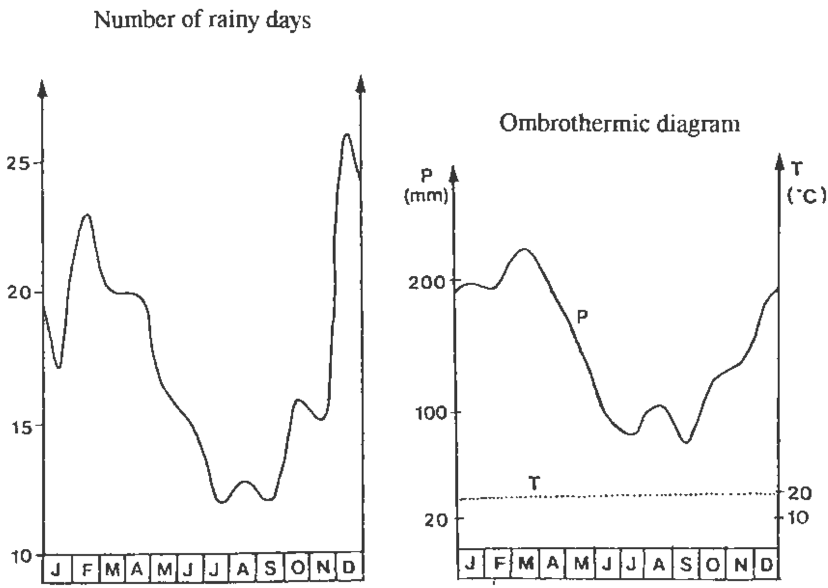


Fig. 6: Climatic diagrams for Wamena (Baliem Valley, Irian Jaya)

minimum of 17 mm rainfall for July 1982. (November 1982 being an exception with 1 mm rainfall only). From December to March, the Baliem knows a wet season culminating in March (224 mm).

An absolute maximum rainfall of 402 mm has been measured in january 1980 (17 rainy days !). Furthermore we count an annual mean of 195 rainy days for this huge valley. Mean annual temperature is 19.6°C with maxima between 25 and 26°C and minima of 13-15°C. Nearly inexistant seasonal fluctuations in air temperature remind us that we are in equatorial climate regime (Troll, 1959).

In the Baliem valley strong winds are blowing nearly every day upvalley from the south-east. These winds have a considerable dessication effect and occur mostly in the aftenoon, reaching a maximum speed of 46-56 km/h with mean wind speeds of 28-37 km/h! Nevertheless the climate of this huge valley is in general very mild, providing ideal conditions for the growth of the sweet potatoe, main food crop for the Dani papuans.

2. Meteorological characteristics of Mt Trikora

Apart general air circulation, the climate of Mt Trikora depends on local orographic effects and of course on elevation. As no meteorological survey station exists at higher altitudes the records available are poor and incomplete. Only short-term surveys have been done, mostly by Brass (1942) and former explorers or by myself during my field work.

2.1 Temperature

Air temperature on Mt Trikora shows typical equatorial high mountain patterns, i.e. decreasing T° with increasing altitude and little seasonal variations. Several authors have tried an estimation on the lapse rates of mean temperature for New Guinea. The following rates show significant regional variations:

- -0,53°C/100m for New Guinea (Smith, 1974)
- -0,60°C/100m for Mt Wilhelm (Mc Vean, 1974)
- -0,67°C/100m for the snow-capped Mt Jaya (Allison & Bennett, 1976)

Trying to estimate the mean annual temperature at a certain altitude, Braak (1931) and Reynders (1959) used slightly different formulas. Following Reynders' formula (T= 27,5 - 0,6 x height in hectometers), the freezing level (isotherm 0°C) is at 4583 m for Mt Trikora. Nevertheless, although reaching 4725 m, this mountain is not actually covered by eternal snow. Looking at the air temperatures actually measured in the field at comparable altitudes (Table 3), we have to consider that long-term survey exists only for Mt Wilhelm. The values for Mt Trikora and Mt Jaya are only indications.

Table 3: Temperature indications for Mt Wilhelm (after Mc Vean, 1974), Mt Jaya (after Allison et al., 1976) and Mt Trikora (field mesurements by the author in 1983 &1984)

	Mt Jaya		Mt Trikora	Mt Wilhelm	
Altitude	3600 m	4250 m	3630 m	3450 m	> 4000 m
Absolute min. T°	-	0.1	0	-0.8	-3.2
Mean maximum T°	-	6.8	14.8	11.4	4.8
Mean minimum T°	-	1.5	3.3	3.9	-0.7
Mean T°	8.1	3.1-4.9	9.7	7.6	2.1

The data for Mt Trikora have been obtained in the Somalak valley at 3630 m altitude (august 1983 and 1984). The lowest air temperature record was 0°C and the highest 22°C. During his visit to Mt Trikora, Brass (september 1938) recorded a mean air temperature of 6,8°C at 3560 m and of 9,5°C at 3225 m near lake Habbema.

These temperature records do of course not give reliable information on life conditions at that altitude. We get better indications if we consider the daily range of air temperature or if we look at the absolute minima, which are a limiting factor to plant growth. From our records we may suggest that the mean daily range of air temperature on Mt Trikora is about 10-12°C.

Measurements by Hniatuk et al. (1976) made on Mt Wilhelm at 3480 m, show that this range between day and night is higher during the 'dry season' (june-september) than during the 'wet season' (december-march). This of course may be explained by the cloud cover during the night, cloud cover reducing considerably the heat loss.

Studies made elsewhere in the world show similar ranges for equatorial high mountains and let Hedberg (1964) advance the famous statement « Winter every night and summer every day ». This is well conceivable if we consider the frequent ground frost after cloudless nights; on Mt Trikora even down to 3400 m. For Mt Wilhelm, at 3480 m, Mc Vean (1974) recorded 126 days a year of such ground frosts !

If we look at temperature ranges at ground level, even higher ranges occur. Barry (1978) reports diurnal differences in soil temperature of 35 C at -0,5 cm in a soil without vegetation cover, during a rainless day with an air temperature of 14°C ! Although vegetation cover may reduce this range considerably , we easily understand that such extreme temperature ranges make life difficult at these altitudes.

2.2 Rainfall

Rainy days are something very normal in the tropics, but cold and rainy days are only to be experienced in the high altitude parts of equatorial mountains. But let us tell what a typical day on Mt Trikora looks like. We may say that at dawn and on sunset generally the weather is fine and that in between i.e. from 9 a.m. till 5 p.m. the sky is covered with thick clouds or mist. At least once a day more or less heavy, longlasting rain taking turns with snow or hail makes any field work difficult.

During my journeys to Mt Trikora, I experienced only one day out of 39 spent at high altitude, completely free of clouds! Seven days have been rainless, the sky being nevertheless cloudy. Very often the clouds where very low thus giving no far sight. Combined with rain this may be very depressing.

During August 1984 the rainfall measured for 13 consecutive days totalled 139 mm in Somalak valley (3630 m). On August 5th, a maximum of 34.4 mm in 24 hours has been measured. Brass (1942) reports the following rainfall quantities at lake Habbema (3225 m) during his journey to Mt Trikora.

September 1938 (21 days) : 244 mm
October 1938 (21 days) : 258 mm

These indications confirm the impression of a general high rainfall in the summit area of Mt Trikora. For Mt Jaya, Allison & Bennett (1976) have estimated a mean of 10 mm/day at an altitude of 4250 m, with a maximum of 48.4 mm/24 h measured on march 25th, 1972.

PLATE 10

Mt Jaya

Mt Jaya seen from Mt Trikora on a clear morning, august 21st, 1983

Papuas travelling in the mist, Mt Trikora Pass, ± 3750 m

Lacking long-term measurements, these authors estimate a mean annual rainfall of 3020 mm at an altitude of 4400 m on Mt Jaya. Furthermore, between January 1st. and March 6th. 1972 three days only had been without rain.

For Mt Wilhelm, McVean (1974) advanced the following mean rainfall data:
Rainfall at 3480 m: 2722 mm
Rainfall on the summit ridge: 3100 mm
number of rainy days: 262 / year
cloudless days: 12 / year
Considering all of New Guinea, Allison & Bennett (1976) supposed that from east to west the high mountain climate in New Guinea gets more and more humid, Mt Jaya getting much more rain than Mt Wilhelm. The seasonal fluctuations are less important on Mt Jaya. This statement may be explained by the geographical position of both mountains. The eastern ones being much closer to the Australian continent and thus the air masses reaching the mountains are less charged with humidity. From Mt Jaya the warm Arafura sea lies only about 80 km south, providing high moisture to the air.

3. Eternal snow on Mt Trikora

Early morning sightings of snow on top of the summit or even down to 3800m occured regularly on Mt Trikora, but a permanent ice cap, firn etc. is not present anymore! Three summits are actually covered by eternal snow, all three in Irian Jaya. From west to east these are Mt Idenburg (4680 m), Mt Jaya (4884 m) and Mt Mandala (Mt Juliana, 4640 m), with a total ice surface of about 10 square km (Barry 1980). During the dutch expedition to Mt Mandala in 1959, Verstappen (1959) estimated the glacier extent on this summit to be 0.29 square km with a thickness not exceeding 50 m. This author indicates a regression of the ice sheet between 1937 and 1959 of about 15 %.

A detailed study of the ice areas on Mt Jaya by Allison & Peterson (1976) has shown a regression of 45 m of the glaciers between 1936 and 1973. A similar if not even heavier regression has to be reported for Mt Trikora. A photograph taken by Hubrecht in 1913 shows two areas covered by ice (plate 11), whereas on the U.S.A.F. areal photograph from 1942, only one single ice sheet remains. Very poor reminders indeed of the area covered by ice during the maximum glaciation in the Pleistocene; a total of 5000-6000 km2 in the

Eternal snow on Mt Trikora in 1913 (photo: Hubrecht, Archives Rijksherbarium, Leiden)

Eternal snow on Mt Trikora in 1942 (U.S.A.F. oblique aeral photograph) central Mountains of Irian Jaya alone (Verstappen, 1959)! The reasons for this regression of the glaciers are not well known. After Allison & Bennett (1976) several factors are involved. A general warming up of the atmosphere with a decreasing rainfall and also decreasing albedo of the ice may contribute to this increased ablation. This destruction is hastened by the small extent of the ice masses that remain, making them very sensitive to even small changes of the regional climate.

4. Climate and plant growth

The climate in the New Guinea highlands has been compared by Hnatiuk et al.(1974) to that of the southern oceanic islands, i.e. cool, temperate and everwet with nearly no seasonal fluctuations. In a sense these conditions may also be found on the equatorial mountains of Africa or even South America. Hedberg (1964) showed in his study on afro-alpine plant ecology that despite of high rainfall, the plants show pronounced xeromorphic characters, i.e. reduced leaf surface, pubescent leaves, thick cuticle, curved leaf margins and reduced growth.

These are adaptations for resisting increased water loss by tranpiration, although the plants are rooting in waterlogged soils. Kramer (1956) explained this difficulty that roots have to absorb water by the following fact: at 0°C the viscosity of water is twice as high as it is at 25°C, reducing by 50% water transportation through the cell membrane. The result of these observations is that for a soil temperature of 5°C the water transportation through the roots is reduced by 25% compared to a temperature of 25°C.

On the other hand, transpiration is enhanced by the low atmospheric pressure (620-625 mb at 4250 m on Mt Jaya, Allison & Bennett, 1976), intense radiation and a strong increase in air temperature during daytime. Locally strong winds worsen the situation. All these factors may explain the xeromorphic tendency of most of the high altitude plants on Mt Trikora. Beside these characters, the low air temperature during night and the high irradiation, at least on cloudless days, have an inhibative effect on internode elongation leading to the typical rosette, hemi-rosette or cushion lifeforms of many alpine plants on Mt Trikora.

CHAPTER III: The vegetation of Mt Trikora

I. Survey methods

Before starting the description of the vegetation units from the upper parts of Mt Trikora, it is necessary to comment on the survey methods used to compile the following data. Right from the beginning of my work, it was clear that I could spend only a relatively short time in the field, and thus a reliable and rapid method had to be found.

From former works in montane New Guinea (Wade & Mc.Vean 1969; Hope 1976), it appeared that the vegetation could be examined properly by setting a number of plots non randomly in areas with apparently differing vegetation. Although this is a rather subjective way of proceeding, it seems that the results could be acceptable, i.e. not differring greatly from those obtained by a random distribution of the plots all over the area (Hope 1976).

After having gained an overall view of the vegetation, 86 plots have been studied, allowing to distinguish 26 different plant communities. The relatively small number of plots can of course not be used to differentiate vegetation associations, but a relatively detailed picture of the vegetation of this huge area could nevertheless be obtained. The term 'plant communities' has therefore be used to distinguish the vegetation units.

The entirety of the plots is situated north of the summit of Mt Trikora, mostly in the Somalak valley, where a good rock shelter served as a working base (cf.sketch map), in the first valley east of Somalak valley, on the terraces west of 'Trikora Pass', in the second valley west of Somalak valley, and in the huge Baliem-Wamena river watershed basin.

The sample plot sizes have been chosen as follows: 20x20 m in the subalpine forest, 3x3 m in grasslands or heaths and 2x2 m in herbfields, bogs, fens, and tundra. The 'minimal area' for plot sizes could not be determined because of a lack of time. For the vegetation studies I used the combined cover and abundance 11 point scale of Domin-Krajina (Krajina, 1933) slightly modified by Wade & Mc.Vean (1969) and by myself.

Rate:	**Magnitude** afterDomin-Krajina (1933) modified by Wade&McVean (1969)		**Mean cover degree** (*)
+	solitary with small cover		1 %
1	rare with small cover		2 %
2	very scattered with small cover		3 %
3	scattered with small cover		4 %
4	frequent with cover	5-10 %	7.5 %
5	"	10-20 %	15 %
6	"	20-33 %	27 %
7	"	33-50 %	40 %
8	"	50-75 %	63 %
9	cover at least 75 % but not complete		88 %
10	cover 100 %		100 %

(* arbitrarily determined for the rates + to 3, in order to be able to calculate the life form spectra including the cover-abundance scale)

The great number of subdivisions of this scale was the reason of a number of hesitations in the allocation of a value to the species. Reducing the number of possible choices, the Braun-Blanquet scale would have had the advantage of a greater objectivity in characterizing the plant communities. Although a conversion of the Domin-Krajina scale to the Braun-Blanquet scale would have been possible, I chose the first one in order to facilitate a comparison of my plots with those established by Wade & Mc.Vean(1969) on Mt Wilhelm, respectively those by Hope (1976) on Mt Jaya.

After having located a homogenous vegetation unit, a sample plot was staked out and the general characters of the station described. Informations about altitude, declivity, exposition, drainage and other edaphic factors were noted down. For several plots a closer analysis of the first 50 cm of soil was undertaken, and soil samples were taken for a partial chemical analysis .

All the species present in a plot were listed, followed by an estimate of the combined cover-abundance rate for each of them. The fact that the flora of this area is not well known, decided me to make collections of plants that could not be identified properly in the field. This showed to be absolutely necessary for the taxonomically difficult groups as the *Poaceae, Cyperaceae, Ericaceae* etc.. And yet misidentifications surely occured and I want to apologize to the reader or later prospector for such a misfortune.

In many plots the mosses, liverworts and lichens took a large part of the vegetation cover, and a closer look at them should have been necessary. But as the different species could not be recognized with certainty, as they mostly were mixed, a correct estimate for combined cover and abundance in situ was impossible. As an alternative, I chose to attribute one single value for all the groups present.

To complete the study of vegetation structure, life forms and life form spectra analysis have been added to the plots in order to help dissociating the different communities and showing the response of the different species to environmental factors. This life form analysis has been done using Raunkiaer's classification as modified by Ellenberg and Mueller-Dombois 1967b (in Mueller-Dombois & Ellenberg 1974). From this key the following groups have been retained for the study of plant life forms of Mt Trikora:

MesPscap	Large trees = Mesophanerophytes 5-50 m
MiPscap	Small trees = Microphanerophytes 2-5 m
MiPros	Small trees = Rosulate microphanerophytes 2-5 m
MiPcaesp	Tall shrubs = Microphanerophytes 2-5 m
NPcaesp	Normal-sized shrubs = Nanophanerophytes <2 m
Chfrut	Woody dwarf shrubs = Frutescent chamaephytes
Chfrutrept	Reptant woody dwarf shrubs
Chfrutpulv	Pulvinate woody dwarf shrubs (cushion form)
Chsuff	Semi-woody dwarf shrubs = Suffrutescent cham.
Chherb	Herbaceous chamaephytes
gChherbpulv	Globose pulvinate herbaceous chamaephytes
fChherbpulv	Flat pulvinate herbaceous chamaephytes
Hcaesp	Caespitose hemicryptophytes
hydHcaesp	Aquatic hemicryptophytes (hydrophyte =hyd)
Hrept	Reptant hemicryptophytes (creeping or matted)
Hros	Rosette scapose hemicryptophytes
Hsem	Semi-rosette scapose hemicryptophytes
Grhiz	Rhizome-geophytes
Tscap	Annuals = scapose therophytes
PLfrut	Woody climbers = frut. phanerophytic lianas
PLsuff	Semi-woody climbers = suffruticose ph.lianas
PLherb	Herbaceous climbers

ChEfrut	Woody or suffruticose epiphytes
ChEherb	Herbaceous epiphytes
ChEsucc	Succulent epiphytes
BrChpulv	Cushion-forming mosses (= pulvinate bryo.)
BrChsph	Hummock forming mosses (= sphagnoid bryo.)
PhycH	Phyco-hemicryptophytes (Adnate algae)

For all species in a plot, the life form has been determined and the importance of the different life form classes shown in a life form spectrum enabled a comparison of the different plots. These life form spectra have been assembeled in two ways. Calculated after the floristic composition alone (number of species/life form), they may illustrate the diversity of plant communities, but do not inform about the structure of the unit. Thus a life form may come up with a very low percentage but cover nearly 50 % of the surface (e.g. *Gleichenia vulcanica* bog).

In order to get a better illustration of the real importance of a certain life form, the spectrum has also been calculated using the cover and abundance ratings. This of course needed the conversion of the rating symbols of the Domin-Krajina scale into mean cover degrees (in percentage). For a better comparison, both types of spectra have been shown in the diagrams.

Finally the results of the vegetation survey are depicted in phytosociological tables which are seperately compared and discussed. Furthermore, a preliminary checklist of the flora of Mt Trikora from above 3000 m, including the author`s collections and those of Brass and Brass & Meyer Drees 1939 is given in appendix III. A list of plants collected by the author below 3000 m and from the Baliem valley is also given in appendix II.

II. Subalpine vegetation

1. The forests

Following the Mt Trikora trail from Wamena, the visitor leaves the closed forest of the upper montane zone to enter a huge east-west orientated basin, the so-called 'Baliem-Wamena river' watershed basin. It is situated between 3000 and 3200 m altitude. The southern border of this basin is formed by terminal moraines covered with a rather peculiar type of forest.

1.1 *Libocedrus* forest - Upper Montane Transition Forest

It is in this forest type that the plot N°39 (Appendix IV:Table 1) has been established at 3150 m altitude.The forest is dominated by the 10-15 m high *Libocedrus papuana*, forming a relatively open canopy enabling the developement of a dense shrub and herb layer. Besides *Libocedrus*, two other conifers are present although less frequent. *Dacrycarpus compactus* forms large trees 15-20 m high and 50 cm in diameter, whereas *Phyllocladus hypophyllus* is only present as an undergrowth shrub.

As a typical emergent, we find the *Araliacea Schefflera altigena* with its showy red inflorescences and many branched stems. The canopy is underlain by a well developed shrublayer 1-5 m high formed by *Phyllocladus hypophyllus, Drimys piperita, Rapanea cacuminum, Prunus costata, Pittosporum pullifolium, Coprosma brassii, Xanthomyrtus compacta, Rhododendron brassii, Rh.gaultheriifolium, Rh.versteegii, Styphelia suaveolens* and *Trochocarpa nubicola.*

Brass (1941) indicates the presence of *Vaccinium dominans* as a common shrub in an analogous forest near lake Habbema, north of the present plot. Nevertheless, this species was not present neither in plot N°39 nor in the surrounding forest. Furthermore, the thick moss carpets on the branches and treetrunks, typical for the upper montane forest, are nearly absent and the number of epiphytes is relatively low.

Within the latter group of plants we may mention the orchids *Phreatia sp.*(619),*Dendrobium spp.*, *Platanthera elliptica* and the ferns *Hymenophyllum* *rubellum, Hymenophyllum sp.*(582), *Humata pusilla, Selliguea plantaginea* and *Grammitis fasciata*. Very peculiar are the many myrmecophytes *Myrmecodia cf.lamii.* These ant-plants with succulent tuberlike stems of 10-40 cm in diameter, and ±1m long tentaculous branches, grow either fixed to the treetrunks or on the ground. On Mt Trikora, they were closely linked to the present type of forest, occuring only between 3000 - 3400 m. Very rare specimens have been found higher up in the subalpine forest.

Few lianas could be observed. Apart from *Alyxia cacuminum* and the creeping *Rubus lorentzianus*, *Tecomanthe volubilis* is most showy with its bright, red flowers. The herb layer is well developed. Huge cushions of mosses cover more than 75% of the ground, and most other plants grow in or on these cushions, more or less as epiphytes. Within this herb layer the tussock plants are well represented with *Gahnia javanica* and *Machaerina teretifolia*. The caespitose hemicryptophyte *Agrostis rigidula* var. *remota* are also frequent.

The type of forest described above has also been observed elsewhere in New Guinea and has often been considered as part of the forest of the subalpine zone. (Paijmans 1975, Wade & Mcvean 1969, Hope 1976). On Mt Wilhelm, Wade & McVean (1969) described a 'Lower Subalpine Forest' dominated by *Dacrycarpus compactus* occurring as high up as 3500-3600 m.

Nevertheless, *Libocedrus* and *Phyllocladus* do not grow above 3000 m on Mt Wilhelm, and *Harmsiopanax harmsii (Araliaceae)* present on Mt Wilhelm, has not been recorded on Mt Trikora neither on Mt Jaya! Hope (1976) recognized a *Dacrycarpus compactus-Trochocarpa nubicola* community on Mt.Jaya and onsidered it also as belonging to a 'Lower Subalpine Forest'.

However, Grubb & Stevens (1985) found that these types of forests share about 55% of their flora with the 'Upper Montane Rain Forest', 40% with the 'Subalpine Rain Forest' and 12% consists of exclusive species. They use the term 'Upper Montane Transition Forest', an expression adopted also by Hope in the Alpine Flora of New Guinea (P. van Royen, 1980, Vol.1).

On Mt Trikora and particularly on the north-eastern border of the 'Baliem-Wamena river' watershed basin, the forest described in plot N°39 was observed to be contiguous to, and sharing a number of species with a *Nothofagus* dominated forest that reaches up to 3000 m. To its upper limit (3400 m), the *Libocedrus* forest passes without any interruption into the lower subalpine rain forest with which it has also a number of species in common.

Myrmecodia lamii Merr. & Perry as an epiphytic shrub on *Libocedrus papuana* (F.v.Muell.) Li, alt. ±3250 m

Stem section of *Myrmecodia lamii* with ants

Branch with leaves and flowers of *Myrmecodia lamii*

We therefore agree with Grubb & Stevens to call this type of forest a transition forest between the 'Upper Montane Rain Forest' and the 'Subalpine Rain Forest'. It seems that *Dacrycarpus compactus* finds its upper limits at 3400 m on Mt Trikora, as it has not been found higher up, although this species reaches up to 3800-3900 m both on Mt Wilhelm and Mt Jaya.

1.2 Subalpine Rain Forest

At about 3400 m, the *Libocedrus* dominated transition forest gives place to a dense evergreen scrub 3-5 m high. This vegetation community only developes on slopes with well drained soils between 3400 and 3750 m.

Four plots have been analyzed (Appendix IV: Table 1), i.e. in the hottom of Somalak valley at 3650 m (N°22), above the Somalak shelter at 3680 m (N°30), in the huge valley west of Somalak valley at 3460 m (N°78) and on the crest of the southern border of the watershed basin at 3400 m (N°36).

These tall shrublands are caracterized by a high density of stems, as many species are multistemmed. The study of the life form spectrum clearly shows this dominance of the caespitose microphanerophytes (fig.7). The crowns are entangled thus forming a dense, closed canopy with a rather poor undergrowth, except the dense moss cushions on the trunks, branches and the forest floor. The study of the leaf sizes (fig.8) shows tbat in this type of vegetation

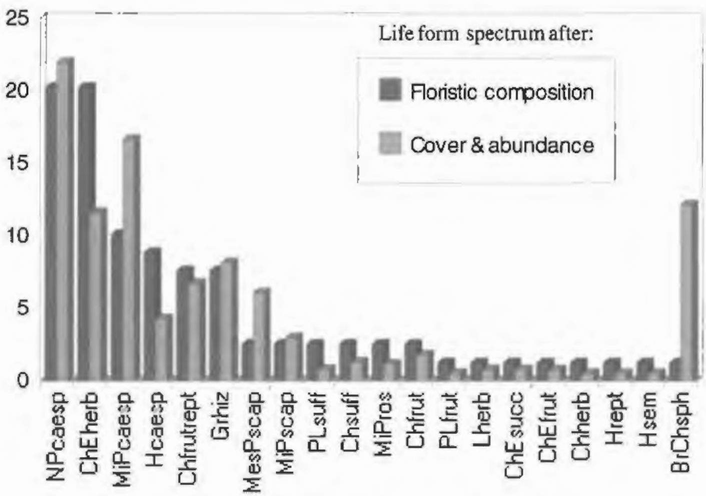


Fig. 7: Life form spectrum - Subalpine Rain Forest

Subalpine Rain Forest at 3700 m altitude

Subalpine Rain Forest undergrowth

Vaccinium dominans Sleumer

Schefflera altigena Frodin

unit, most woody species have sclerophyllous leaves with strongly reduced leaf surface. From 35 species analyzed, 31 have simple, coriaceous leaves with often revolute margins or possess a more or less dense indument on the

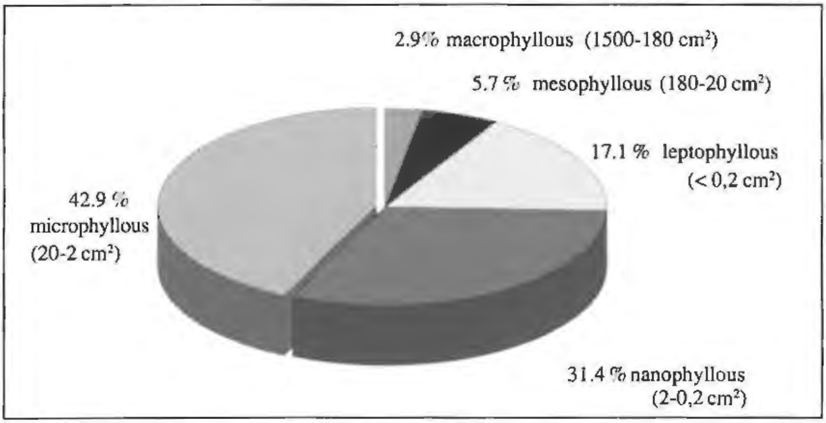


Fig. 8: Distribution of leaf sizes in Subalpine Rain Forest

lower side of the leaf. Only 4 species, including the tree ferns, have compound leaves. The very low variability in leaf forms and the xeromorphic aspect of the leaves express a clear adaptation to severe climatic conditions, e.g. high transpiration due to intense radiation, low atmosphere pressure, and a rapid increase in air temperature during daytime. During the night and part of the day, low temperatures restrain the absorption of water by the roots and also strongly reduce the transport of water inside of the stems (cf. chapter II).

This altimontane scrublike forest has a distinct floristic make-up. Only two species, *Schefflera altigena* and *Saurauia alpicola*, clearly emerge from the canopy with heights between 7 and 8 m. The major part of the forest is formed by *Vaccinium dominans* which, as its name seems to indicate, dominates in the canopy, and by *Rhododendron correoides, Rh.gaultheriifolium, Sericolea calophylla, Rapanea cacuminum, Olearia velutina, Drimys piperita, Coprosma brassii* and *Xanthomyrtus compacta. Prunus costata* is one of the rare single-stemmed species with more than 10 cm in diameter. In places with a more open canopy, the shrub and herb layers are well developed with *Styphelia suaveolens, Trochocarpa nubicola* and some grassland species as *Agrostis rigidula* var. *remota, Oreobolus* and *Gahnia. Rubus lorentzianus, Alyxia cacuminum* and *Lycopodium clavatum* being the only lianas encoun-

Rhododendron correoides J.J.S.

Dendrobium dekockii J.J.Sm.

tered. Epiphytes are fairly common. One frutescent species, *Cladomyza microphylla*, finds its place between the many orchids like *Glomera sp. Octarrhena sp.*, the very beautiful orange coloured *Dendrobium dekockii* and the ferns *Hymenophyllum foersteri, Hymenophyllum rubellum* and *Selliguea spp.*, to cite only the most common ones.

As mentioned above, the closed canopy enables the development of dense moss cushions covering like a carpet not only the branches but also the stems. On the ground, the tangle of roots, dead branches and rockcrevices covered by up to one meter high moss hummocks make it difficult to distinguish the different individual plants and causes big problems to the visitor to move around. Apart from the mosses , the herb layer is formed by scattered ferns like *Plagiogyria tuberculata* var. *decrescens, Blechnum revolutum, Asplenium sp.*, some *Poaceae, Cyperaceae* and dicotyledonous herbs.

On many places, these scrublike forests are intermingled with small patches of grassland thus having a rather loose, scattered appearance. One plot (N°32), situated at the western border of Somalak valley at 3740 m, illustrates well this type of vegetation. Analysing the life forms, we see that herbaceous chamaephytes are quite common in this vegetation unit, which thus resembles more a 'shrubrich grassland' or 'woodland' than a forest.

The *Poaceae Deschampsia klossii, Agrostis rigidula* var. *remota, Danthonia oreoboloides*, the *Cyperaceae Gahnia javanica, Carex sp, Oreobolus pumilo* and the *Liliaceae Astelia alpina* occupy a large area in this vegetation unit. The shrub species being the same as in the subalpine forest proper, it is probable that under undisturbed conditions, i.e. low fire frequency, this open woodland will be invaded from these nuclei of woody plants to form a closed shrubland leading ultimately to the 'Subalpine Rain Forest' as described above.

2. The Shrublands

2.1 *Cyathea tomentosissima* - Treefern Shrubland

This type of shrublands, caracterized by the 2-5 m high *Cyathea tomentosissima*, can be frequently observed between 3000 and 3500 m. This community developes best on gentle slopes or flat areas, with medium drainage, or in areas frequently disturbed by fire. This vegetation community usually consists of a more or less dense stand of treeferns, set in tussock grassland with several smaller shrubs. Wade & McVean (1969) and Hope

Baliem-Wamena river watershed basin. In the foreground *Cyathea* shrub-land; far left : Upper montane transition forest, alt. ±3100 m

Cyathea muelleri Back.(center) and *Cyathea tomentosissima* Copel. (left and right)

(1976) included this type of vegetation into the 'shrub-rich grasslands', whereas Paijmans & Löffler (1972) redefined it as a savanna.

I agree with Hope (in P.van Royen 1980,vol.I) who says : «...the formation is best treated as a shrubland ...some areas support a quite dense growth of treeferns with many understorey shrubs and rather sparse grass cover, so that the formation cannot be generally included in grasslands». The expression 'Treefern Shrubland' seems therefore the most appropriate, although the part taken by grassland may be considerable, at least in areas frequently disturbed by fires. On Mt Trikora, this formation covers huge areas, mostly in the watershed basin of the 'Baliem-Wamena river'. Three plot's (N°40; 41; 42; appendix IV: table 2) have been studied in this valley between 3000 and 3050m altitude and one plot (N°85) at 3420 m in a valley east of Somalak.

In the rather closed treefern shrublands, many shrubs that occur also in the 'Subalpine Rain Forest' or in heath formations could be found such as *Olearia velutina, Drimys piperita* entity '*reducta*', *Symplocos cochinchinensis* var.*orbicularis, Coprosma brassii, Tetractomia tetrandum, Vaccinium debilescens, Rhododendron versteegii, Decaspermum nivale, Xanthomyrtus compacta* as erect shrubs and *Hypericum macgregorii.*

The herblayer includes mostly herbs from the typical grassland communities e.g. *Deschampsia klossii, Anthoxantum horsfieldii* var. *angustum, Anthoxantum redolens* var. *longifolium, Cortaderia archboldii, Dichelachne rara* var. *rara and Agrostis rigidula* var. *remota.* On bad drained surfaces, some *Cyperaceae* like *Carex filicina, Carex gaudichaudiana* and *Gahnia javanica* are also present, accompanied by *Astelia alpina* cushions. Diverse dicotyledonous herbs complete the picture.

The treefern shrublands are bordered by grasslands, diverse bog communities, or they form a transition between the grasslands and the 'Subalpine Rain Forest' as we may see in plot N°42. The number of epiphytic mosses increases considerably, and the herbs are practically absent. In addition to the moss carpets on the shrubs, the floor is covered more than 75% by big moss hummocks, where *Sphagnum spp.* play an important part. Wade & McVean (1969) defined a vegetation association called 'forest edge community' making the transition between the grasslands and the forest, and differing from the treefern shrublands. The vegetation cover observed in plot N°42 has some differences with the typical treefern shrublands, *e.g. Coprosma habbemensis*, frequent as an undergrowth shrub in the 'Upper Montane Rain Forest'. The abundance of *Gleichenia bolanica* shows that this unit developes on an area where forest has been destroyed a few years ago. Only the prolific growth of treeferns decided me to include this vegetation type into the treefern shrublands, although it might be considered as a highly evolved unit, transitional to the 'Subalpine Rain Forest'.

Another interesting observation could be made on the valley floors, where *Cyathea tomentosissima* grows like a gallery at the left and right of small rivulets. As these small rivulets erode 1-2 m deep channels, the drainage on their edges is distinctly better than elsewhere on the valley floor. It seems that *Cyathea* is quite sensible to soil humidity and its distribution is more determined by this factor and the effect of fire than by cold air drainage in the valleys. On Mt Trikora, *Cyathea tomentosissima* has its upper growth limit at 3700 m, and close to this limit we may find a few scattered clumps of *Cyathea* shrublands were *Cyathea muelleri* occurs next to *Cyathea tomentosissima*. Some rare *Cyathea muelleri* could also be observed in subalpine rain forest although not present in our plot's. *Cyathea tomentosissima* is always absent from the 'Subalpine Rain Forests' as well as from 'Upper Montane Rain Forest'.

The treefern shrublands might therefore be considered as a natural vegetation formation, although at least on Mt Trikora, its extension is largely favoured by fire disturbance. Hope (1976) showed that treefern shrublands had a wide distribution above the forest limits during the last glaciations and therefore argues in favour of an «expansion from 'natural' stands» (Hope, in P.van Royen, 1980).

2.2 Treeline Shrublands

The upper limit of the closed scrub is on Mt Trikora at about 3750 m. Higher up, till 3850 m, only a few rare 'Subalpine Rain Forest' species like *Rapanea sp.* and *Drimys piperita* manage to survive. On the northern slopes of Mt Trikora, *Coprosma novoguineensis* forms dispersed open shrublands between 3900 and 4000 m on sandstones or marly limestones indicating a rather low treeline on this mountain.

Two plots have been studied, one at 3950 m (N°29, appendix IV: table 2) and the other at 3940 m (N°60), both on rather steep slopes below and north of the 'False Peak'. The total ground cover is 100% and the number of species is still high (32 resp. 23 species). *Coprosma novoguineensis* subsists as 1-2 m high more or less scrambling shrubs, often covered by mosses and lichens. Some other shrubs are present but do not exceed 50 cm in height. Apart from *Styphelia suaveolens*, we may observe *Rhododendron pusillum, Gaultheria* *mundula, Tetramolopium klossii, Tetramolopium prostratum* and *Parahebe ciliata*. In the ground layer *Trochocarpa dekockii, Vaccinium oranjense* and *Drapetes ericoides* grow as tiny creeping shrubs together with tufts of *Deschampsia klossii, Festuca parvipaleata, Deyeuxia stenophylla* var. *chaseana* and the cushions of *Rhododendron saxifragoides, Astelia alpina, Lepidium minutiflorum , Danthonia oreoboloides* and mosses (especially in plot N°60). Some typical high altitude species like *Epilobium detznerianum* and *Geranium monticola* are here at their lower limit.

On Mt Jaya, Hope (1976) described similar treeline shrublands but forming a dense scrub extending up to 4100m. The same observations have been made by Mitton (in Hope 1976) and Brongersma & Venema (1962) from Mt Mandala between 3900 and 4200 m. It seems that the treeline shrublands are better developed on limestone than on the sandstones and marly limestones of Mt Trikora.

The influence of man as a limiting factor has to be excluded at such high altitudes on Mt Trikora, as the hunting grounds are situated well below in the huge grasslands or forested areas. Hope (in P.van Royen 1980 and pers.comm.) advances nutritional reasons for such a low treeline scrub, or maybe a better drainage on limestone. This last reason seems very doubtful and only a serious chemical soil analysis could confirm or reject the first one.

2.3 Subalpine Heaths

In many grasslands, the smaller shrubs are quite common, and thus the definition of a distinct heath community is difficult. After Hope (in P.van Royen, 1980), the typical subalpine heaths are relatively rare in New Guinea and have been described only from Mt Albert-Edward in Papua New Guinea (Hope 1975). In the alpine zone, such heath communities are known to occur on nearly all higher peaks. Nevertheless, for Mt Trikora, several plot's studied between 3450 and 3790 m altitude differ enough from the surrounding vegetation to be considered as two distinct heath formations.

2.3.1 *Coprosma brassii - Styphelia suaveolens* Heath.

Four plots (N°71, 75, 81, 82, appendix IV: table 3) have been attributed to this type of heath which often developes on the edge of subalpine forest. This heath community is close to the '*Coprosma-Gaultheria* heath' described by Hope

Subalpine heath

Treeline shrubland, with *Coprosma novohuineensis* Merr.& Perry

Coprosma novoguineensis Merr.& Perry, female flowers (in P.van Royen 1980) from Mt Albert Edward, except that *Gaultheria mundula* does not occur in the heaths on Mt Trikora. Plot N°75 may be considered the most typical of this heath type on Mt Trikora.

Characteristically, there is a thick moss layer on the ground, from which emerge several crooked shrubs, 50-100 cm high, like *Coprosma brassii* and *Rhododendron correoides*, the smaller *Styphelia suaveolens* and *Rhododendron versteegii*. Some creeping shrubs as *Trochocarpa dekockii, Vaccinium coelorum, Vaccinium* cf. *sororium, Vaccinium oranjense* and *Eurya brassii* (reptant form!) are well represented. *Poa lamii, Deschampsia klossii* and *Agrostis rigidula* var. *remota* being in competition with *Gahnia javanica, Astelia alpina* and *Oreobolus pumilio* for the free room between the shrubs and mosses.

2.3.2 Dwarf Shrub Heath on Shallow Soils.

This vegetation type developes on flat rocky areas, where soil formation is still going on, i.e. on shallow soils 10-20 cm deep overlying hard bedrock in the subalpine zone. On Mt Trikora, such shallow soils may be found on gently sloping rock surfaces, where soil erosion is nearly as fast as soil formation.

Several plots have been staked out on sandstones or marly limestones either in the Somalak valley at 3630 m (N°20, appendix IV: plate 3) looking east just in front of the Somalak rock shelter, above this same rock shelter at 3690 m (N°31), or on the terraces immediately beyond 'Trikora Pass' at 3790 m (N°52 and 53).

This heath community harbours dwarf shrubs, 20-30 cm high, like *Tetramolopium klossii* f. *klossii, Styphelia suaveolens, Rhododendron gaultheriifolium* var. *expositum* and *Drapetes ericoides*. Some reptant *Trochocarpa dekockii*, cushion forming herbs like *Danthonia oreoboloides, Oreobolus pumilio, Potentilla brassii* and rosettes of *Plantago depauperata* are well represented. Sparse tufts of *Agrostis rigidula* var. *remota* do also occur.

The structure of this vegetation community is well shown by the life form spectrum (fig.9).

Rhododendron versteegii J.J.S.

Rhododendron saxifragoides J.J.S.

Rhododendron pusillum J.J.S.

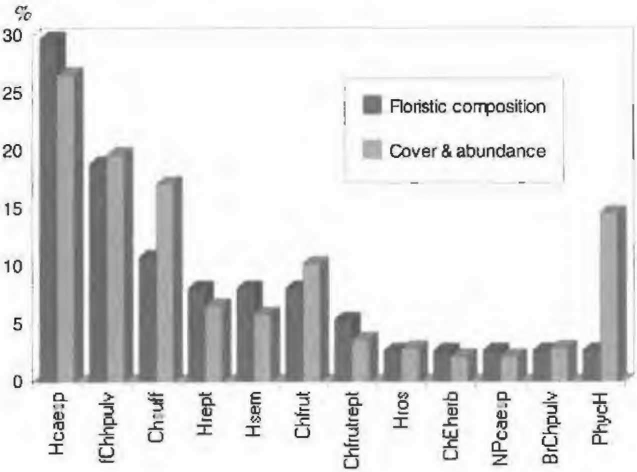


Fig.9: Life form spectrum - Subalpine Dwarf Shrub Heath on shallow soils

It reveals that the caespitose hemicryptophytes share the available space with the cushion forming species and the dwarf shrubs. On places where soil does not exist or where it is very poorly developed, the blue algae *Stigonema panniforme* (phyco-hemicryptophytes) form a blackish slippery carpet with a considerable extent. *Drapetes ericoides* is here shown to be an erect shrub although it occurs very often in a tiny reptant form!

3. The Subalpine Grasslands

Huge grasslands are a typical feature of the New Guinea highlands, thus nearly all the botanists visiting the highlands at least mentioned them. Coming from the coastal plains, the first expeditions have been quite disappointed when they saw these dull ochre grasslands with only scattered brigh-coloured shrubs. Indeed, the highland grasslands of New Guinea are not comparable to the bright green meadows from the european Alps with their mosaic of brightly coloured flowering plants. The New Guinea grasslands resemble far more to the grasslands known from the southern oceanic islands, e.g. New Zealand or Tasmania.

On Mt Trikora, the grasslands cover a considerable range in the subalpine as well as in the alpine zone. This extension may indeed be linked to the frequent burning by hunting parties, who regularly cross the highlands. Typically tussock grasslands, they are caracterized by grasses whose young shoots are well hidden in a thick tussock of dead leaves which form a protecting 'tunic' around the young shoots. Rauh (1988) considered these tussocks as herbaceous chamaephytes i.e. perennial evergreen grasses with a remnant shoot system that remains green at least 25 cm above the ground surface.

These perennial plants are well adapted to the extreme conditions of these high altitudes, the persisting litter of the leaves creating a protecting layer for the young shoots. These are forming in regular intervals on the outer part of the tussock (Rauh, 1988). The older, central parts frequently die away and leave a ring-like structure.

In his work on afro-alpine plant ecology, O.Hedberg (1964) measured a difference in temperature of 7.5°C between the inside and the outside of the tussocks. This shows that such a structure creates a favorable micro-climate inside the tussocks. Furthermore, during dry spells, the tussocks are capable to keep humidity much longer. A final advantage of this growth form is the resistance to fire. Although the external dry leaves burn easily, the inner parts stay alive and may regrow rapidly.

Three different grassland communities, mostly determined by soil characteristics, have been recognized in the subalpine zone of Mt Trikora.

3.1 *Deschampsia klossii* - Subalpine Tussock Grassland

This community has by far the greatest extent on Mt Trikora between 3000 and 4000 m. Six plots (N°74, 10, 18, 23, 55, 34, appendix IV: table 4), mainly in the bottom of the valleys and less often on gently sloped terrain, have been studied in the Somalak valley, beyond the 'Trikora Pass' and in a huge U-shaped valley east of Somalak. They all show that this kind of vegetation cover is poor in plant species, e.g. varying from 10-21. Plot N°74 may be considered as a transition between the *Coprosma* heath and the grasslands.

The soil under this grassland is a typical alpine humus soil with a thick dark coloured upper horizon of little decomposed organic matter. Very often it is poorly drained or waterlogged, with a groundwater level at some 50 cm depth. As the life form analysis reveals, this type of grassland is largely dominated by the chamaephytic grasses, *Deschampsia klossii* forming large tussocks 30-40 cm in diameter and 50-100 cm high. *Agrostis rigidula* var. *remota, Anthoxanthum spp., Deyeuxia stenophylla chaseana* and *Festuca jansenii* are the accompanying caespitose *Poaceae.*

As Diehls (1934) stated already for the paramo tussocks of the south-american Andes, these tussocks often do not form a completely closed vegetation cover, but they leave some free space which is available for a ground layer. On Mt Trikora, a very poor ground layer develops with a flora restricted to bryophytes, lichens such as *Thamnolia vermicularis* and a few flowering plants like *Potentilla brassii, Pilea johniana, Ranunculus spp., Oreomyrrhis pumila* and the rosettes of *Plantago depauperata.*

On better drained spots, some shrubs like *Styphelia suaveolens, Vaccinium spp.* and *Rhododendron saxifragoides* emerge from the grassland although continual firing and/or waterlogging often inhibits any significant shrub formation. It seemed fairly evident to me that the tolerance for waterlogging assures the success of *Deschampsia* in swampy sites, even if one may observe that, as the tussocks grow permanently higher, the roots are in slightly better drainage conditions.

3.2 *Gahnia javanica* - Tussock Sedgeland

On slightly sloping ground more to the edge of the valleys, from 3000 to 3700 m, occurs a typical community dominated by the dense blackish tussocks of *Gahnia javanica.* These strong tussocks 50 cm in diameter and 80-100 cm high are nevertheless not growing as close together as the *Deschampsia* tussocks.

A typical plot (N°66, appendix IV: table 4) has been staked out in the second valley west of Somalak valley at 3650 m altitude. In the gaps between the *Gahnia javanica* tussocks grow various shrubs like *Tetramolopium klossii,* other sedges as *Carpha alpina, Oreobolus pumilio* or the grasses *Agrostis rigidula* var. *remota* and *Danthonia oreoboloides.* The total cover of the vegetation is not exceeding 70% in this plot, thus leaving free space where bare soil or necrotic lichens may be found.

Two plots (N°37 and 38, appendix IV: table 4) located at 3100 m in the 'Baliem-Wamena river' watershed basin differ slightly from the plot N°66. A soil analysis of plot N°37 shows a surface horizon of dark red peat (cf. chapter II) constantly humid, overlying black peat with a groundwaterlevel at 15 cm below surface. Apart from the *Gahnia javanica* tussocks, *Scirpus subcapitatum* is well represented indicating a bad drainage. The shrubs *Tetramolopium klossii, Styphelia suaveolens, Rhododendron versteegii, Drimys piperita,* and *Rhododendron gaultheriifolium* confer an aspect of shrubrich savanna to this tussock community and indicate that this plot has at least not recently been disturbed by fire.

The ground layer is composed by a moss layer alternating with tiny dicotyledonous herbs like *Drosera peltata,* indicating a high acidity of the underlaying humus soil, *Gentiana enttingshausenii, Lactuca laevigata* var. *pusilla* or *Potentilla foerst.*var.*foersteriana*. Interesting is also the presence of the matforming creeping shrubs *Trochocarpa dekockii* and *Xanthomyrtus compacta* (reptant form!).

This vegetation formation occurs on nearly all the high mountains of New Guinea and has been described by Hope (in P.van Royen 1980) as '*Gahnia javanica - Plagiogyria papuana* Tussock Sedgeland' from Mt Scorpion in Papua New Guinea. *Plagiogyria* is playing an important part of a unit which seems rather variable. On Mt Wilhelm *Gahnia javanica* is absent, and on Mt Trikora *Plagiogyria glauca* has not been reported from such sedgelands.

3.3 Subalpine Short Grassland

In the Alpine Flora of New Guinea (P.van Royen, 1980) Hope mentioned a community of dense tufted species called '*Poa erectifolia - Styphelia suaveolens* Short Grassland'. On the northern slopes of Mt Trikora, a very extensive and structurally similar vegetation unit occurs, although floristically different. *Poa erectifolia* is absent and replaced by the dwarf sedge *Carpha alpina*. This *Cyperacea* is by far the most showy plant of this unit, which may nervertheless be considered a short grassland as the grasses *Agrostis rigidula* var. *remota, Danthonia oreoboloides* and *Deyeuxia spp.* are quite common.

The soil under the vegetation unit is a typical gley-soil, 60-80 cm deep with a constantly fluctuating groundwater level (cf. chapter II.). The vegetation cover is discontinuous, with a mean cover of 75%. Five plots have been studied in this community (N°6, 15, 33, 61, 76; appendix IV: table 4), all situated on moderately sloped terrain on the edge of the glacier valleys, where this vegetation type is most common, and on the terraces of the glacial cirque north of the summit, in Somalak valley. The altitudinal range of this community is 3400 - 3800 m.

Besides *Styphelia suaveolens* and *Tetramolopium klossii*, the only shrubs well represented, we see the importance of the pulvinate herbaceous chamaephytes (fig.10) who cover 17% of the surface.

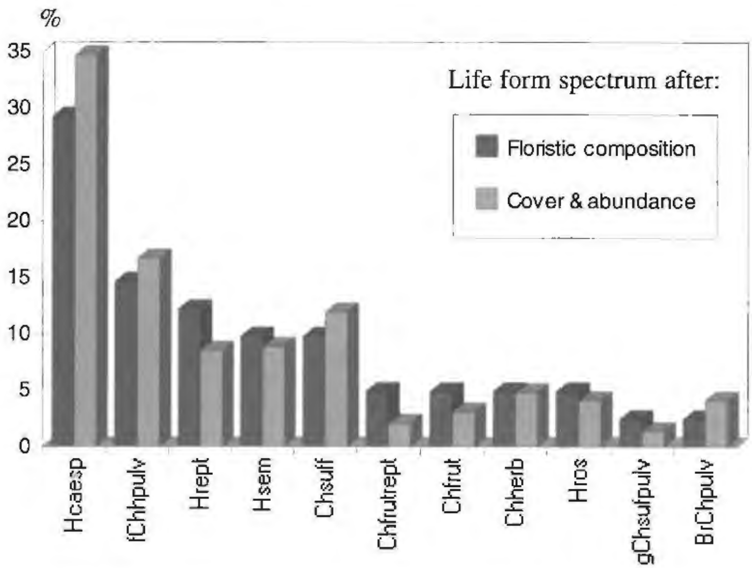


Fig. 10: Life form spectrum - Subalpine Short Grassland

Danthonia oreoboloides, Oreobolus pumilio, Centrolepis philippinensis and *Potentilla foersteriana* var.*brassii* develop well together with the creeping *Gonocarpus micranthus, Lycopodium carolinianum,* the rosette or semi-rosette forming *Plantago depauperata, Abrotanella papuana, Lactuca laevigata* var. *pusilla* or *Pilea johniana.* The *Poaceae Agrostis rigidula* var. *remota, Festuca crispato-pilosa* and *Deyeuxia pusilla* are present but have only a very low cover and abundance ratio.

4. The Mires

Mt Trikora, as all the high mountains of New Guinea, has a cold and wet climate, so that it is not astonisbing to find large areas covered by mire communities. Bogs and fens are a constant obstacle to the visitor who is not only getting soaked in the rain, but is also walking permanently in wet shoes on boggy waterlogged terrain. Five bog communities and two fen formations have been recognized in the subalpine zone of Mt Trikora.

4.1 Subalpine Bog Heath

In the valley bottoms, where the groundwater level is quite near to the surface, scattered patches of a bog heath community compete with *Deschampsia klossii* grassland. Three plots have been studied in the Somalak valley between 3630 and 3650 m (N° 7, 14 and 16; appendix IV: table 3). The subsequent soil is a somewhat uncommon peat in so far as slight podzolisation occurs, indicating that the groundwater level is fluctuating. This is quite different from the adjacent *Deschampsia tussock* grassland or the hard cushion bog where waterlogging is permanent (cf.chapter II).

This bog community consists of an open sward of low (20-30 cm) *Poa lamii* tussocks with scattered shrubs, e.g. *Styphelia suaveolens, Tetramolopium klossii* and the creeping *Trochocarpa dekockii* and *Vaccinium decumbens.* Some large *Rhododendron saxifragoides* cushions with their nice red flowers

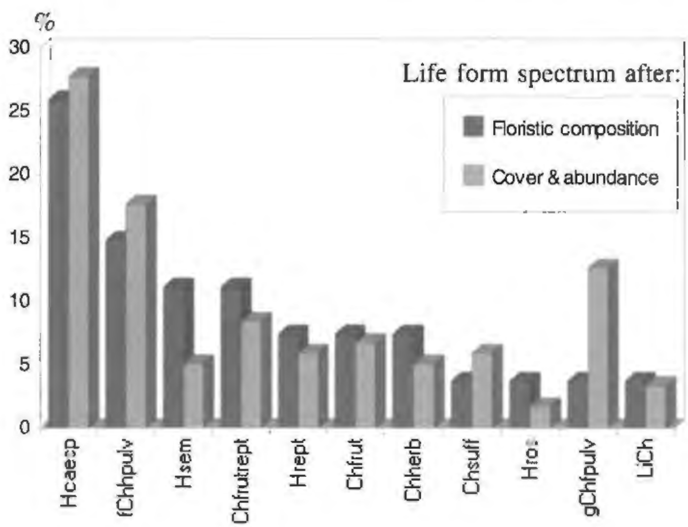


Fig. 11: Life form spectrum - Subalpine Bog Heath

cut the monotony of the ochre coloured grasslands. *Poa lamii* is the dominating grass in a community with 70-75% total cover. *Gahnia javanica* and the cushion forming *Astelia alpina, Oreobolus pumilio* and *Centrolepis philippinensis* grow between resp. below the grass tufts. Open places are colonized by the whitish lichen *Thamnolia vermicularia*; mosses are completely absent from this unit.

Structurally speaking this vegetation formation could have been ranged with the grasslands, *Poa lamii* covering around 50% of the surface. This could have been confirmed by the life form spectrum when calculated only after the floristic composition of the plots. But, when calculating it including the cover and abundance ratios, the importance of the shrubs and of the either flat or globose cushion forming pulvinate species, becomes obvious (fig. 11). This has been the reason why I consider this vegetation type as a boggy heath. Hope (1976) distinguished a nearly identical vegetation community from Mt Jaya, with *Vaccinium amblyandrum* forming dense mats between the *Poa lamii* tufts. This unit has later on been renamed as *Vaccinium-Xanthomyrtus* bog heath by the same author (Hope in P.van Royen, 1980). Whatever the differentiating shrub species might be, it is clear that the shrubs have a significant structural role in this subalpine mire community.

4.2 Hard Cushion Bog

This type of vegetation develops essentially where the groundwater level is very near to the surface, or in permanently flooded areas. This is the case in the valley bottoms on horizontal terrain, where three plots have been studied in the Somalak valley (N°8 and 9; appendix IV: table 5) and in the big U-shaped valley east of Somalak (N°83).

In this community the cushionforming species build a hard mat, 10 cm and more thick. It is possible to walk on them without breaking through! The form of the cushions is varying, either very flat or globose. The main species occuring in this vegetation unit are *Centrolepis philippinensis, Oreobolus pumilio, Eriocaulon alpinum* and *Eriocaulon pulvinatum.* This last species even colonizes open water surfaces as it can grow even if submerged.

On top of these hard cushions grow plants that are not as hygrophilous, e.g. *Astelia alpina, Danthonia oreoboloides, Deyeuxia brassii, Agrostis rigidula* var.*remota, Potentilla brassii, Plantago depauperata* and several mosses. In the course of time, more and more grasses grow on the cushions, as by accumulation of organic matter the ground thickens and 'rises' well over the

Hard cushion bog

Hard cushion bog, *Eriocaulon pulvinatum* van Royen growing into the water

Hard cushion species on Mt Trikora trail at 3650 m

Trachymene pulviliforma Buw. flat cushion groundwater level. The hard cushion bog species die away and some shrubs may root. Thus this vegetation unit evolves into a bog heath or into *Deschampsia tussock* grassland.

The sub-alpine zone of Mt Trikora is at many places crossed by the footpaths of papuans travelling from one valley to another or of hunting parties crossing the area for controlling their traps, or in search of small game. These paths, as shown on plate 19, are often easily recognizable from the surrounding vegetation, as they are formed by a particular hard cushion vegetation that easily supports the weight of a person. Next to *Oreobolus pumilio, Centrolepis philippininensis, Eriocaulon spp.* and *Danthonia oreoboloides*, we find the small, slightly rounded, light green cushions of *Trachymene pulviliforma*, a species that has not been found elsewere in hard cushion bog. It seems that only the effect of periodical trampling enhances this type of vegetation. It is found mostly in valley bottoms, showing the way through the *Deschampsia tussock* grassland.

4.3 *Astelia alpina* - Subalpine Bog

The caracteristic feature of this community is a dense mat (fig.12), formed by the 30 cm high *Astelia alpina* cushions. On Mt Trikora, it grows either on peat soils, clay loams or silty clays, with fluctuating groundwater level. Eight plots have been studied (N°11, 13, 17, 35, 56, 69, 77, 86; appendix IV: table5) and they show that this formation may be very variable. The plot's N°17, 35 and 86 may be considered the most typical ones. Apart from *Astelia alpin*a, caespitose or tussock grasses are well represented like *Deschampsia klossii, Agrostis rigidula* var. *remota, Festuca crispato-pilosa, Danthonia oreoboloides* and *Deyeuxia brassii.*

In the plots N°13 and 69, *Scirpus subcapitatum* is mixed with *Astelia alpina* and covers a considerable surface despite its tapered growth form. Several other herbs as *Carpha alpina, Oreobolus pumilio, Potentilla brassii, Potentilla foersteriana, Potentilla hooglandii, Plantago aundensis, Pilea johniana* and several mosses may be of some importance between the big hummock forming *Astelia* cushions .

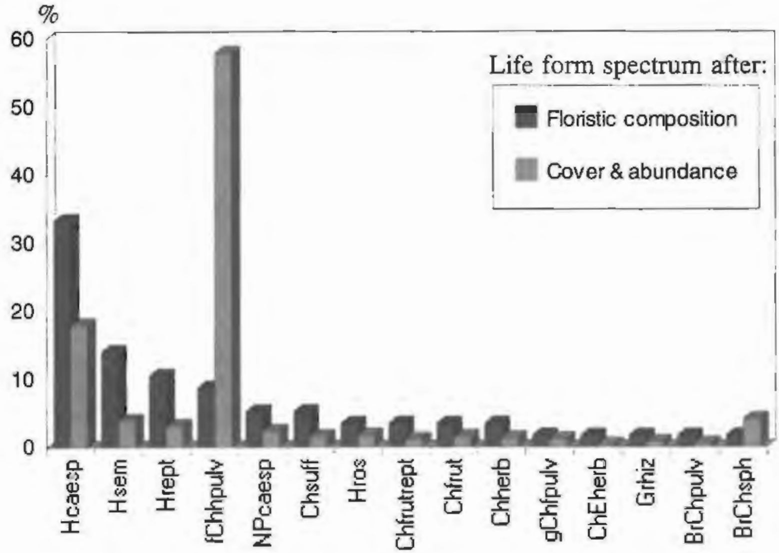


Fig. 12: Life form spectrum - *Astelia alpina* Subalpine Bog

4.4 *Gleichenia vulcanica* Bog

On various places, the fern *Gleichenia vulcanica* forms a dense nearly monospecific vegetation cover. As *Astelia* Bog or the Short Grasslands, this vegetation unit prefers localities of better drainage. We find it mostly in areas with low pendage or on undulating terrain. The soil analysis of plot N°12, typical for this kind of vegetation unit, shows a gley soil with varying ground water level (cf.chapter II).

Gleichenia, a fern proliferating by rhizomes, is very resistant to fire and thus developes well in burnt areas. On Mt Trikora, it is frequent in the watershed basin of Baliem-Wamena river. The typical greyish apparence of this formation is due to the dead fronds of *Gleichenia* which remain in place and thus may easily burn during a dry spell.

The analysis of four plot's (N°12, 67, 68, 84; appendix IV: table 5) show the dominance of *Gleichenia* (fig.13) leaving little space to *Carpha alpina, Astelia alpina,* the small cushions of *Centrolepis philippinensis, Oreobolus pumilio, Danthonia oreoboloides,* the creeping *Pilea johniana,* some tus-

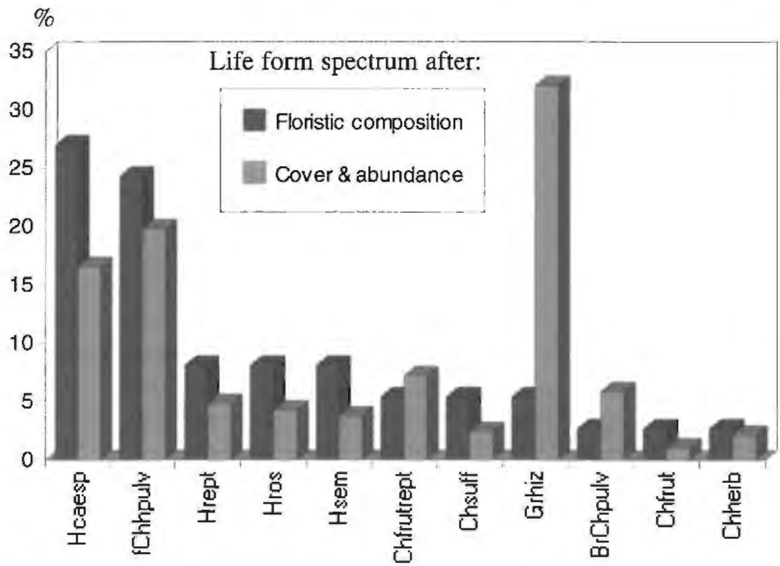


Fig. 13: Life form spectrum - *Gleichenia vulcanica* Bog

socks of *Gahnia javanica* and moss cushions. This community has been reported from nearly all explored areas of New Guinea (Hope in v.Royen, 1980). Although frequent on Mt Trikora it is of small extent, mostly between 3000 and 3700 m.

4.5 Subalpine Short Grass Bog

This mire community is caracterized by a heterogenous structure with partly open water surfaces, in this regard resembling to an open fen. Studying the plot's (N°5, 70, 72; appendix IV: table 6), all between 3480 and 3640 m and situated on flat areas in the valley bottoms north of Mt Trikora, we have to point out the abundance of the small pulvinate herbs forming a dense carpet or tufts, alternating with free water (fig.14).

Depending on the degree of waterlogging, this unit evolves or into a hard cushion bog, into bog heath, or into *Deschampsia* Tussock Grassland. Some small shrubs like *Styphelia suaveolens, Tetramolopium klossii,* or the creeping *Vaccinium coelorum* and *Xanthomyrtus compacta* are dispersed on the cushions of *Oreobolus pumilio, Centrolepis philippinensis, Astelia* *alpina, Potentilla brassii* and *Danthonia oreoboloides.* A few grasses e.g. *Agrostis rigidula* var. *remota, Deschampsia klossii* and *Deyeuxia brassii*

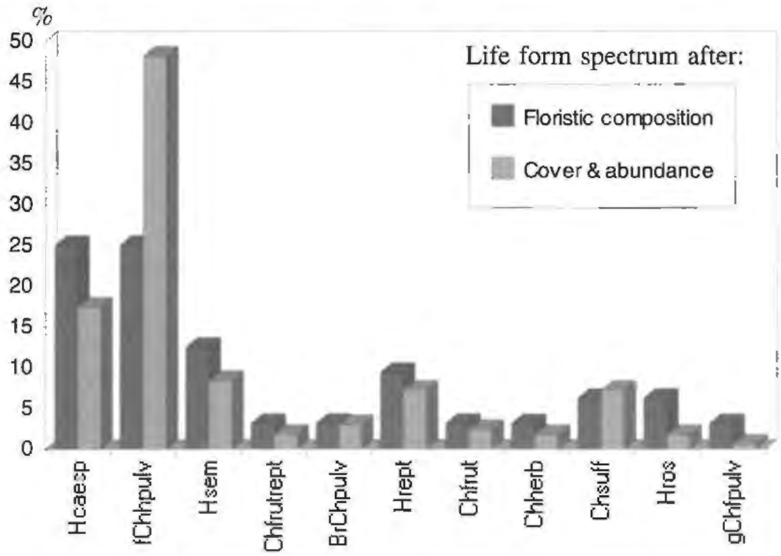


Fig. 14: Life form spectrum - Subalpine Short Grass Bog

may be present. Frequent are also the rosette or semi-rosette scapose hemicryptophytes as *Plantago depauperata, Lactuca laevigata* var. *pusilla, Abrotanella papuana, Ranunculus angustipetalus, Gentiana sp.* and the showy red stems of the creeping *Gonocarpus micranthus.*

4.6 Open Wet Sedgelands

On Mt Trikora, the fen communities are very sparse and subordinate to the bog communities.

4.6.1 *Carpha alpina* Fen

As on many other New Guinea mountains, e.g. Mt Jaya (Hope,1976) or Mt Wilhelm (Wade & McVean, 1969), we may find on Mt Trikora a *Carpha alpina* dominated fen in inundated places, on the glacier terraces west of 'Trikora Pass' (plot N° 54; appendix IV: table 6). In this unit, only fifteen species could be observed, which shows well the predominace of the tufts of

Carpha alpina (fig.15), which form a rather closed sward, ocher in colour.

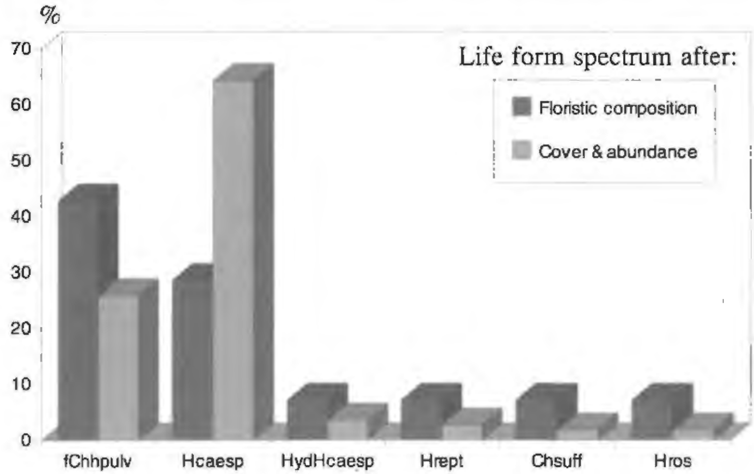


Fig. 15: Life form spectrum - *Carpah alpina* Fen

This community, although present, is of a very small extension on Mt Trikora between 3600 and 3750m. Only the pulvinate herbaceous chamaephytes like *Centrolepis philippinensis, Gaimardia setacea, Oreobolus pumilio* and *Potentilla brassii* are well represented.

4.6.2 *Carex spp.* open fen and related vegetation

Three plots (N°19, 73 and 79; appendix IV: table 6) all located in the glacier valleys north of the summit, illustrate well this -at least floristically- very heterogenous community. The soil is completely flooded and thus very muddy.

Carex cf.celebica, Carex bilateralis and *Carex gaudichaudiana* typify this vegetation unit. Apart from the *Cyperaceae* cited, we could locally observe a number of *Poaceae* as is shown mostly in plot N°79: *Festuca crispato-pilosa, Festuca jansenii, Agrostis avenacea* and *Anthoxantum horsfieldii* var. *angustum*. Some associated, more subordinate herbs like *Oreobolus pumilio, Plantago aundensis, Ranunculus amerophylloides* and *Triplostegia glandulifera* have a sparse distribution in this community. In completely flooded areas, *Scirpus fluitans* may dominate, although this fen type is very scattered.

This very variable vegetation type can at best be compared to what Hope (1976) described as '*Carex gaudichaudiana* fen' on Mt Jaya.

On Mt. Wilhelm, Wade & McVean (1969) recognized three open fen communities, all open wet sedgelands with poor species diversity. The *Carex spp.* fen on Mt Trikora differs in some detail from these by the more dense growth of the sedges, and a relative abundance of the *Poaceae*. Small depressions with shallow water are occupied by the depauperate sedges *Scirpus fluitans* and/or *Schoenus maschalinus*, a unit that evolves into hard cushion bog.

In the big U-shaped glacier valley east of Somalak, a peculiar vegetation unit was present on a steeply sloping (40° declivity) small landslide where water was seeping from the ground at 3470 m (Relevé N°80; appendix IV: table). Here *Equisetum ramosissimum* is forming a dense stand , covering about 50% of the surface. *Coprosma archboldiana*, a matforming creeping *Rubiacea*, and moss hummocks are well represented among some scarce sedges like *Schoenus maschalinus*, *Carex brachyathera*, the shrubs *Tetramolopium klossii*, *Vaccinium coelorum* and the small herbs *Triplostegia glandulifera* and *Epilobium sp.*

Finally, we may mention that Brass (1942) described an important population of *Isoetes habbemensis* on the banks of lake Habbema, 15 km north of the summit of Mt Trikora. Unfortunately we could not have a closer look at this area.

5. The Open Rocky Slope Communities

On bare rocky surfaces and on marly limestone or sandstone cliffs, where soil formation is little advanced, particular vegetation units occur. Several of such pioneer communities have been recognized and they have been grouped here for conveniance.

5.1 *Gleichenia bolanica* Shrublands

In the Somalak glacier valley, steep slopes or cliffs are quite common and on some places are colonized by *a Gleichenia bolanica* fern community. Plot N°21 (appendix IV: table 7) has been set in such a community of about 100 square meters on a steep rocky slope near the Somalak rock shelter at 3640 m. *Gleichenia bolanica* is the dominant species, forming a densely interlaced, one meter high, scrub.

Only *Coprosma novoguineensis* is overtopping the ferns and some creeping *Xanthomyrtus compacta, Vaccinium decumbens, Trochocarpa dekockii* and

Eurya brassii are covering the soil. In the herb layer another fern, *Gleichenia vulcanica* and *Astelia alpina* cushions cover a small surface. An interesting observation is the growth of *Mediocalcar sp.* on the ridge of the rocky cliff, an orchid genus normally growing as epiphyte in the upper montane forest.

This type of shrubland has not been mentioned from Mt Jaya (Hope,1976). It could have been considered as a transition shrubland analogous to that of Plot N°42 (Treefern Shrubland), where nearly the same frequency of*Gleichenia bolanica* has been noted, but that unit is structurally quite different. We agree with the definition by Wade & McVean (1969) who described a proper association of '*Gleichenia bolanica - Haloragis microphylla*' on Mt Wilhelm, that is practically identical to the unit observed on Mt Trikora and occurs on a similar terrain.

5.2 *Stigonema panniforme* - Algal Community

On most glacial terraces or rock flats, the rock surfaces are rapidly colonized by a blackish slippery carpet of the Cyanophyta *Stigonema panniforme*. Plot N°51 (appendix IV: table 7)) is characteristic of such a primary colonizing unit, with 13 species covering in all 60% of the rock surface.

The algal layer is little by little grown over by the cushion forming herbs *Danthonia oreoboloides, Oreobolus pumilio* and later on the creeping shrubs of *Trochocarpa dekockii* or the prostrate *Tetramolopium klossii f.klossii* and *Rhododendron gaultheriifolium* var. *expositum*. On some places the orange coloured terrestrial orchid *Octarrhena sp.* is growing gregariously on the algal carpet. This pioneer vegetation is evolving slowly into a dwarf shrub heath (cf.plot N°52 and 53), which normally grows in bordering areas on better soil conditions.

5.3 Rocky Overhang Communities

On the heavily windswept cliffs of the glacial terraces, natural overhang areas have a wide range in the subalpine zone on Mt Trikora. Erosion pockets give shelter to a number of species also found in other communities with a heterogenous structure and floristic composition. On such a cliff at 3780 m, twenty-four species of flowering plants have been collected. Mosses and lichens cover the bare soil or rock. Various small herbs like the cushion forming Centrolepis philippinensis, Oreobolus pumilio, the creeping *Pilea* johniana or the tiny *Euphrasia versteegii, Keysseria pinguiculiformis f.nana*, *Potentilla foersteriana, Lactuca laevigata var. pusilla, Gentiana* cf. *ettingshausenii, Trachymene novoguineensis* and *Plantago depauperata* colonize these austere biotopes.

Some small shrubs like *Drimys piperita, Coprosma novoguineensis, Vaccinium coelorum, Rhododendron versteegii, Tetramolopium klossii* and *Drapetes ericoides,* crooked by the effect of strong winds, just survive.

III. Alpine vegetation

Under this heading are treated all the vegetation communities which develope best above the treeline, although they might be present at lower altitudes. The limit between the subalpine and alpine zone is thus variable; we fixed it on Mt Trikora between 3850 and 4050 m.

In the alpine zone of Mt Trikora, we distinguish two types of bedrock. To the north of the summit a series of sandstones and marly limestones constitute the 'False Peak' (alt. 4100 m). The summit itself is limestone material (cf. chapter II). Between the two peaks, an east-west orientated valley, the so called 'Hanging Valley', has been cut in soft marles or marly sandstones.

1. Alpine Dwarf Shrub Heath

In contrast with the dwarf shrub heath of the subalpine zone developing on very shallow soils, it seems that at high altitudes dwarf shrub heath occurs on deeper soils, showing that here the prostrate aspect is more due to climatic than to soil conditions. We observed nevertheless that edaphic conditions may influence the floristic composition of such dwarf heath.

The geological diversity, resulting in geomorphological diversity, allows the development of a variety of vegetation units. On well drained soils the heath community is dominated by the dwarf shrubs *Styphelia suaveolens* and *Drapetes ericoides*, not exceeding 30 cm in height (plot N°47, 48, 50; appendix IV: table 8). *Tetramolopium fasciculatum* and *Parahebe ciliata* are typical alpine species. Other shrubs present are *Trochocarpa dekockii, Tetramolopium klossii f.klossii* and *Tetramolopium klossii f.lanceolatum.*

Apart from these frutescent and suffrutescent species (fig. 16) common herbs are *Lepidium minutiflorum, Oreomyrrhis pumila, O. papuana, Cotula wilhelminensis, Poa papuana, Poa crassicaulis* and *Uncinia compacta* *var.alpina.* The high frequence of big rounded cushions of different *Potentilla spp.* is remarquable. These cushions have a size of 50 cm in diameter and 30 -50 cm high. Among the species observed have been *Potentilla irianensis* Kalkman *spec.nov., P. mangenii* Kalkman *spec. nov.* and *P. foersteriana* Laut. (N°494, 495b, 496 and 905, 913).

The sandstone parts of the 'False Peak' are strongly eroded and give a strange appearance to the landscape. On this well drained substratum develops an open dwarf shruh heath caracterized by *Rhododendron pusillum,* a very beautiful plant with its bright red coloured flowers. This species is restricted to sandstone bedrock and occurs only between 3800 and 4050 m altitude. Plot N°28 (appendix IV: table 8) situated at 4000 m, is typical for this *Rhododendron pusillum* heath (plate 17) and counts 32 species with a total cover of 70 %. *Coprosma novoguineensis, Rhododendron versteegii* and *Rh.oranjense* grow here at there altitudinal limit.

Finally we must mention dwarf shrub heath dominated by *Tetramolopium klossi f. klossii,* situated on a well drained mound at 3930 m on silty clay soil (plot N°2). *Astelia alpina* occurs also, which causes some classification problems. Only the presence of *Trochocarpa dekockii, Styphelia suaveolens* and the abundance of *Tetramolopium* made me range this plot within the dwarf shrub heath.

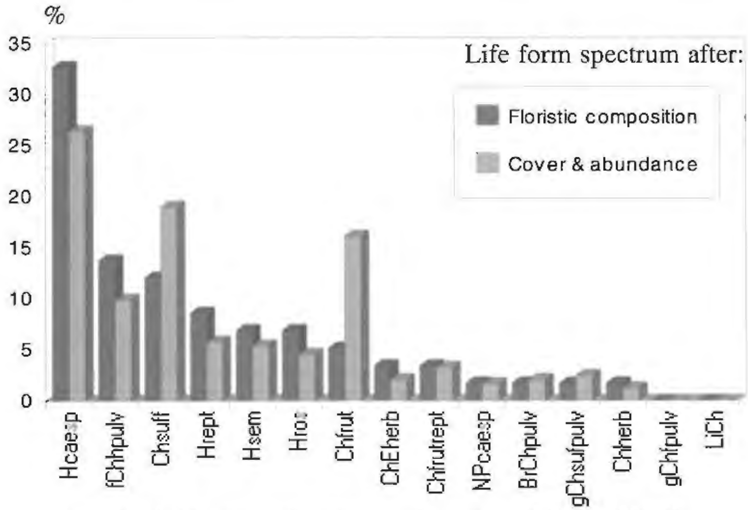


Fig. 16: Life form spectrum - Alpine Dwarf Shrub Heath

2. Alpine *Deschampsia klossii* Tussock Grassland

In the summit area of Mt Trikora, the well drained soils on old screes are covered by a dense savanna of *Deschampsia klossii*. Here and there, *Anthoxantum redolens* var.*longifolium* and *Poa nivicola* may form scattered, homogenous stands. Eight plots (N°4, 25, 26, 27, 63, 46, 49, 64; appendix IV: table 9) have been studied in this type of grassland between 4000 and 4150m, a vegetation type structurally not differing from the subalpine *Deschampsia tussock* grasslands.

Noteworthy is the fact that *Deschampsia* is mostly viviparous at these high altitudes, the young plantlets growing on the inflorescence of the mother plants. Although this phenomenon has been observed sporadically at lower altitudes (3500 m), this seems to be an adaption to high altitude conditions. Floristically we may point out that more typical alpine species grow in the gaps left by*Dechampsia klossii. Lepidium minutiflorum, Veronica archboldii, Myosotis australis, Geranium monticola* and *Epilobium detznerianum* are common. Noteworthy is the fact that in plot N°49, apert from *Deschampsia klossii, Anthoxanthum redolens* occupies about 50% of the surface!

The cushion forming *Poaceae: Poa clavigera, Danthonia oreoboloides, Poa inconspicua, Poa crassicaulis* and many semi-rosette or creeping Hemi-cryptophytes like *Cerastium papuana* ssp. *keysseri, Geranium monticola, Pilea johniana, Hydrocotyle sibthorpioides, Gnaphalium breviscapum* and *Sagina papuana* are strongly crowded together to constitute a good protection from frost damages.

3. *Astelia alpina* Alpine Herbfield.

On deep clay soils and often on fairly well drained ridge crests, a community in which the cushions of *Astelia alpina* cover about 50% of the soil surface, develops well in the alpine zone north of the summit (plot N° 24, 59, 62, 65; appendix IV: table 9). Wade & McVean (1969) included this community with the mire herblands, but we agree with Hope (in v.Royen, 1980) to range it with the herbfields « since almost all the alpine communities are occupying wet soils, and *Astelia* is not very tolerant of prolonged inundation ».

On Mt Trikora, apart *Astelia*, a number of small shrubs may be codominant. Among those, we find *Coprosma novoguineensis, Rhododendron versteegii, Styphelia suaveolens, Tetramolopium klossii*. The creeping *Trochocarpa decockkii* and *Vaccinium coelorum* are quite common. The frequency of the

Alpine *Astelia alpina* herbfield

Deschampsia klossii tussock grassland on old scree, 4150 m

Alpine scree community, 4200 m

grasses *Danthonia oreoboloides, Deyeuxia pusilla, Deyeuxia brassii, Poa nivicola* and *Deschampsia klossii*, although not covering a large surface, confirm the herbfield character of this community. Nevertheless, some typical bog species, like *Centrolepis philippinensis, Oreobolus pumilio* and *Potentilla brassii* could be registered, testifying the boggy everwet conditions at this altitude. A few other herbs like *Potentilla foersteriana, Cotula wilhelminensis, Plantago depauperata, Oreomyrrhis pumila, Keysseria radicans* and *Ranunculus consimilis* do also occupy the free space between the *Astelia* cushions.

In the 'Alpine Flora of New Guinea', Hope (in v.Royen 1980) differentiates two distinct communities : 'short alpine grasslands' and '*Astelia alpina* alpine herbfield'. In our opinion, such a distinction seems difficult to maintain, because in both *Astelia* and a number of shrubs are present. On Mt Trikora, we recognized such short grasslands, but well below the treeline, and with *Astelia* very scattered.

4. Alpine mire communities

In the valley bottom of 'Hanging Valley' immediately north of the summit of Mt Trikora, the drainage conditions are very bad and thus mire communities may develop. Two such vegetation units have been observed.

4.1 *Uncinia riparia* Closed Sedgeland

In the valley bottom, on waterlogged or even partly flooded terrain, a few hundred square meters are occupied by a closed sedgeland, where *Uncinia riparia* and several mosses codominate (Plot N°58; appendix IV: table 8). A few other species, like scattered tufts of *Deschampsia klossii* may occur and *Geranium lacustre, Ranunculus pseudolowii* have only been found in this high valley community.

4.2 Alpine short grass bog

Partly, the closed sedgeland gives place to a very prostrate vegetation unit (Plot N°57; appendix IV: table 8) caracterized by very small cushions or rosettes of *Ranunculus bellus, Keysseria pinguicula* var. *nana, Potentilla brassii, Uncinia compacta* var. *alpina* and a few scattered *Centrolepis* *philippinensis*. A number of flat moss cushions complete the picture (fig. 17). The community resembles structurally a hard cushion bog. On the other hand,

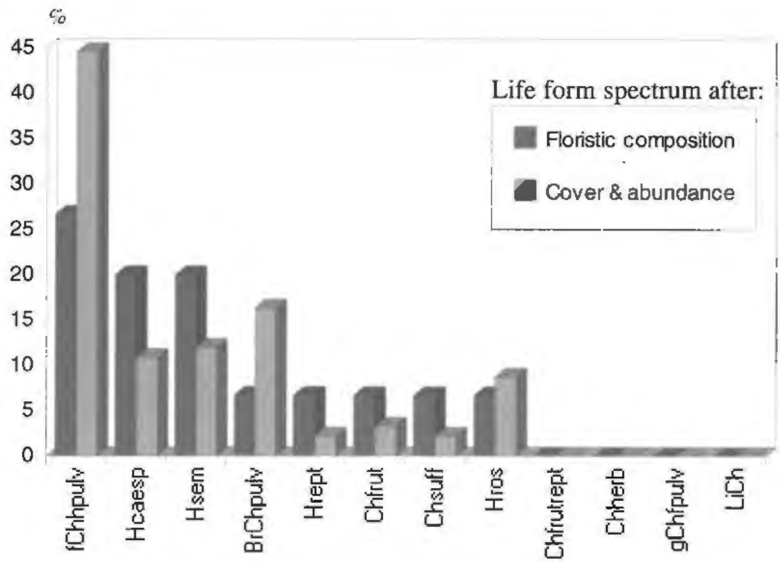


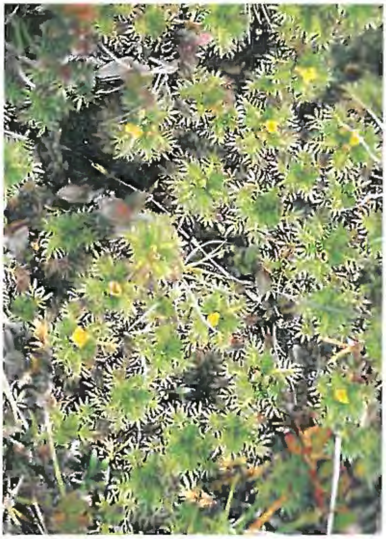
Fig. 17: Life form spectrum - Alpine Short Grass Bog

the high frequency of mosses could favour a classification within the 'Wet tundra' defined by Wade & McVean (1969) on Mt Wilhelm. But Hope (in v.Royen, 1980) remarks that « the alpine mossland alliance may be successional rather than a clear climax response to the contemporary cool wet conditions », and he concludes that the term 'tundra' should be used with caution. We agree with Hope and range the present vegetation type from Mt Trikora with the short grass bog communities.

5. Alpine scree communities

Close to the summit of Mt Trikora, young and older screes are quite common between 4150 and 4250 m. Three plots have been analysed. One on the edge of the 'Hanging Valley' (N°3, table 11), the two others on this summit ridge but exposed to the south (N°43, 45, table 11). For all three, soil creep and frost shattering are continuously modifying the environment. The soil structure is permanently exposed to frost and defrost, as shown by the numerous pipkrakes that could be seen, resulting in a free draining mixture of gravel and

Potentilla spp. cushions on alpine scree, north face of Mt Trikora, alt. ± 4150 m



Potentilla brassii Merr.& Perry *var.brassii*

blackish humus 10 cm thick. On the many solifluction terracettes parallel to the main slope, mosses and lichens are by far dominating this so called 'Alpine Mossland' (Hope, in v.Royen, 1980) or 'Dry Alpine Tundra' (Wade & McVean, 1969) and play a major role in fixing the screes (fig.18).

Among the mosses present, we may cite *Bartramia cubica, Campylopus cf.crispifolius, Ceratodon purpureus, Daltonia sp., Drepanocladus cf.revolvens, Rhacomitrium javanicum* and *Zygodon intermedius*. Three Poaceae, *Deschampsia klossii, Poa clavigera* and *Poa nivicola* are colonizing the moss cushions and contribute to the fixation of the terrace risers, whereas the terrace tread is mostly composed of bare ground or rocky fragments.

In the shelter of the moss cushions, typical alpine plants may grow. The pink flowered *Geranium monticola* cushions, tiny *Ischnea elachoglossa* f.*nana*, prostrate *Myosotis australis*, the creeping *Cerastium papuanum* ssp.*keysseri*, *Keysseria wollastonii, Epilobium detznerianum* and some rare prostrate

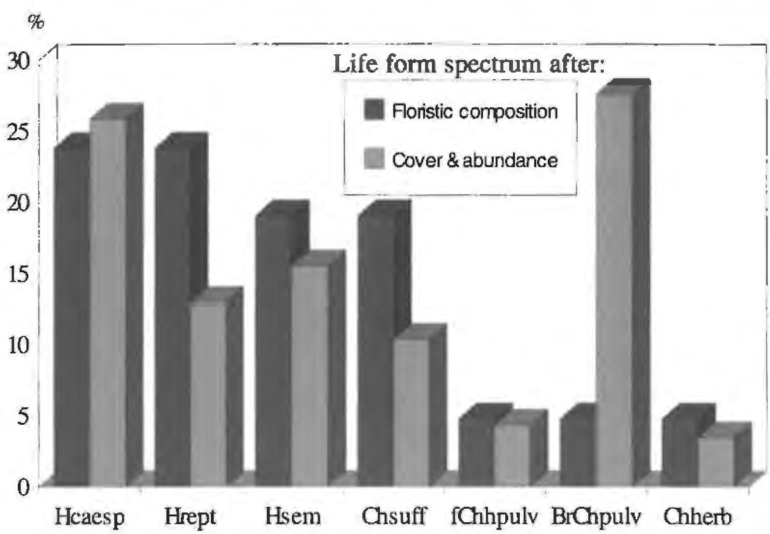
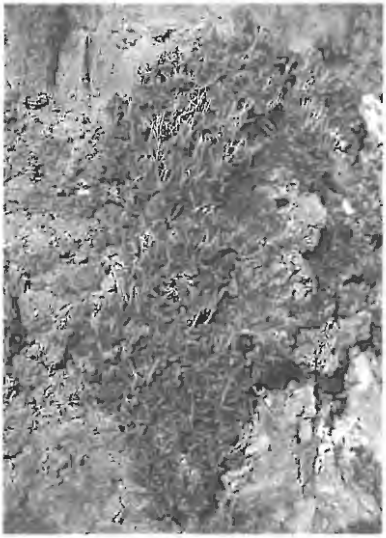


Fig. 18: Life form spectrum - Alpine Scree Communities

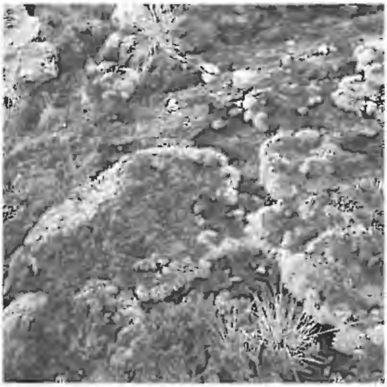
Parahebe ciliata or *Tetramolopium piloso-villosum* try to find a living on this ever moving substratum. We may admit that these screes will ultimately be covered by *Deschampsia klossii* tussock grassland comparable to the grassland observed on old screes at a somewhat lower altitude.



Coprosma archboldiana Merr.& Perry

Ranunculus bellus Merr.& Perry

Danthonia oreoboloides (F.Muell.) Stapf



Decaying cushions of *Danthonia oreoboloides* (F.Muell.)Stapf

6. *Rhacomitrium* heath and related vegetation

From 4100 to 4250 m up, the summit area of Mt Trikora is formed by nearly vertical limestone cliffs giving only little support for plant growth. Nevertheless some real pioneers are colonizing shallow soil on rocky ridge crests or in rock crevaces up to 4400 m. These chasmophyte communities are poor in species, only very specialised plants being able to survive in this rude climatic conditions. Bad weather in this summit area often hampered the work and stopped all our attempts to reach the summit.

Two plot's have nevertheless been studied. N°1 (appendix IV: table 8) in a crevace of the north cliff of the summit at 4200 m, and N°44 on a flat part of the summit ridge at 4230 m. The microclimatic and edaphic conditions are of course extreme. Temperature amplitude is high: every night frost occurs and during daytime a temperature of 20°C could be measured on the soil surface when the sun was shining.

Plot N°44 shows a total cover of 60%, to which the mosses contribute with about 27%, *Rhacomitrium javanicum, Campylopus cf.crispifolius, Bryum pachyathera, Ceratodon purpureus* being the most prominent. *Tetramolopium prostratum* is the only smal suffruticose shrub present among a number of herbaceous species like *Sagina papuana, Sagina belonophylla, Oreomyrrhis pumila, Keysseria wollastonii, Pilea johniana, Cerastium papuanum* ssp. *keysseri, Potentilla irianensis* and the two grasses *Poa clavigera* and *Poa cf.papuana*.

This plot N°44 comes close to the '*Rhacomitrium* heath' described by Wade & McVean (1969) on Mt Wilhelm. The continuous mat of mosses is typical for this association, although the two caracteristic species *Rhacomitrium lanuginosum* and *Oreobolus ambiguus* are absent from this alliance on Mt Trikora. Hope (in v.Royen,1980) states that this *Rhacomitrium* open heath alliance is present on many New Guinea mountains. On Mt Trikora, this stand has a very small extent limited to 10-20 square meters only.

In a crevace at 4400 m, the highest part where we collected on Mt Trikora, four species of flowering plants could still be observed, i.e. *Cerastium papuanum* ssp.*keysseri, Sagina belonophylla, Poa nivicola* and *Epilobium detznerianum*. At lower altitudes, at 4050m, globose cushions of *Oreomyrrhis buwaldiana* clutch to the limestone cliffs, creating progressively a support for other plants. On a sandstone crest of the 'False Peak' at 4100 m, eighteen species still occur, among those *Parahebe polyphylla, Tetramolopium prostratum* and *Gentiana carinicostata,* which have not been found in plots

Geranium monticola Ridl.

Cliffs with *Oreomyrrhis buwaldiana* M.& C.

Flowers of *Oreomyrrhis buwaldiana* M.& C.

studied in the neighbourhood. This small account on the alpine vegetation shows the variability of the vegetation cover eneountered. This variation is surely related to the fact that the alpine zone of Mt Trikora has only recently been free from premanent ice and that the evolution of the soils and vegetation is still going on.

IV Discussion

The present description of the subalpine and alpine vegetation on Mt Trikora corresponds on a large scale to the observations made by Brass (1942). The study of 86 phytosociological sample plots has nevertheless contributed to a more precise view of the vegetation units present; 26 of such communities have been distinguished and their altitudinal distribution was studied.

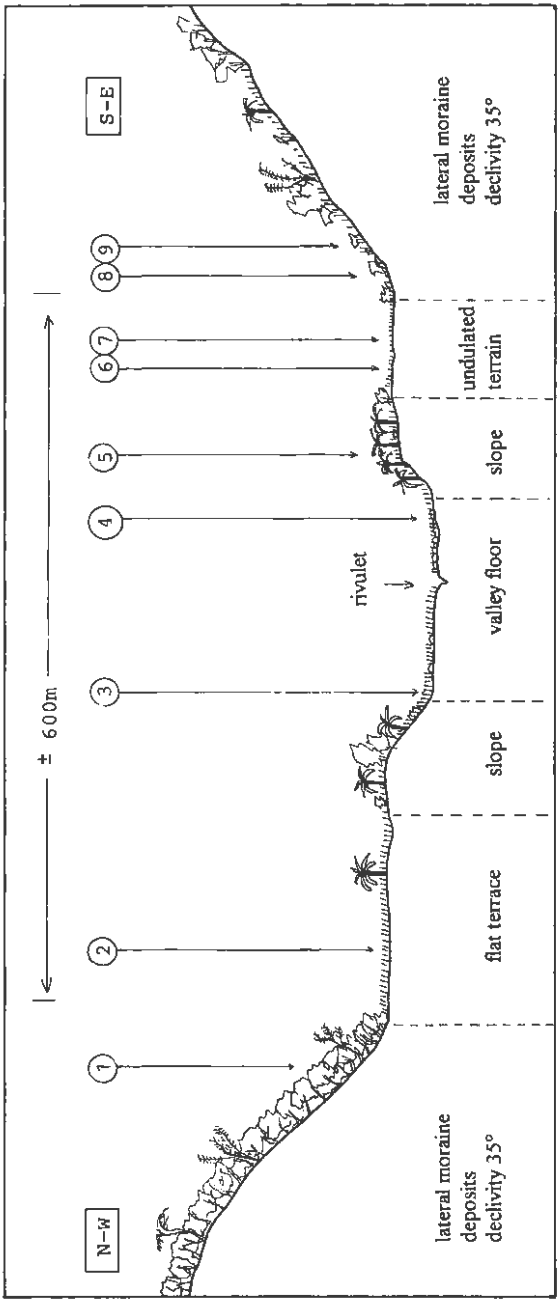
On Mt Wilhelm, Wade & McVean (1969) have established 307 plots and they distinguished 29 vegetation associations. The study of such a high number of plots being impossible in the time I had available, a comparably great accuracy could not be reached for Mt Trikora. Therefore I do not use the term 'association', but 'vegetation community'.

The comparison of vegetation communities, associations, or alliances described for Mt Jaya (Hope (1976) or Mt Wilhelm (Wade & McVean, 1969) to those seen on Mt Trikora, has caused a number of problems, especially nomenclatural and classificatory ones. I have not been able to visit the two other mountains mentioned, or other mountanous areas in New Guinea and thus I can compare only with descriptions in literature.

In order to show the general distribution of vegetation units in the main valleys north of the summit of Mt Trikora, a transect in the big U-shaped glacier valley east of Somalak valley has been laid out (fig. 19).

The subalpine forest on Mt Trikora is very distinctive by its dominance of the Myrtaceous shrubs (i.e. *Xanthomyrtus* and *Decaspermum*), *Vaccinium dominans* and the very prominent *Schefflera altigena*. Furthermore, the absence of *Dacrycarpus compactus* above 3400 m seems to be peculiar although it is present at lower altitudes in a *Libocedrus papuana* dominated transition forest.

Another interesting feature of the vegetation cover of Mt Trikora is the fact that *Gleichenia vulcanica* bog is quite common, although much more scattered than in the Star Mountains or on Mt Giluwe. Its occurance might reflect



1 : Subalpine Rainforest
2 : Closed sedgeland
3 : *Deschampsia klossii* Grassland
4 : *Astelia alpina* Bog
5 : *Cyathea tomentosissima* Shrubland
6 : Hard Cushion Bog
7 : *Gleichenia vulcanica* Bog
8 : Subalpine heath
9 : *Carex spp.* Open Fen

Fig. 19: Cross-section of a big U-shaped valley est of Somalak

frequent burning of bog areas. Indeed this fern has stolons and spreads readily after fire. The *Isoetes* aquatic fernland mentioned by Brass on the banks of Lake Habbema could not be examined in detail. Probably, it does not occur at higher altitudes on Mt Trikora.

The distribution and extent of the vegetation communities described above is mainly induced by four factors, i.e. the thermic gradient, the hydrological conditions of the soil, plant nutrition, and the anthropogenic influence. The thermic gradient determines the plant growth and the floristic composition of the communities. The abundance of cushion forming species, essentially in the alpine zone, is a consequence of the persistant low temperatures and periodical frost.

The fact that on open exposed terrain shrubs like *Eurya brassii* and *Xanthomyrtus compacta* may grow either as erect shrubs, 1-2 m high, or as prostrate creeping or mat forming shrubs, could not be explained. Cold air flow or waterlogging of soil might be a plausible explanation if we have to admit that there are no taxonomic differences involved. The relatively restricted extent of the alpine vegetation could, according to Brass (1942), be due to nutritional factors, as forest and shrublands develope better on limestone or marly-limestone substratum than on sandstone. In the higher parts of Mt Trikora, an alternation of sandy or marly bedrocks prevails.

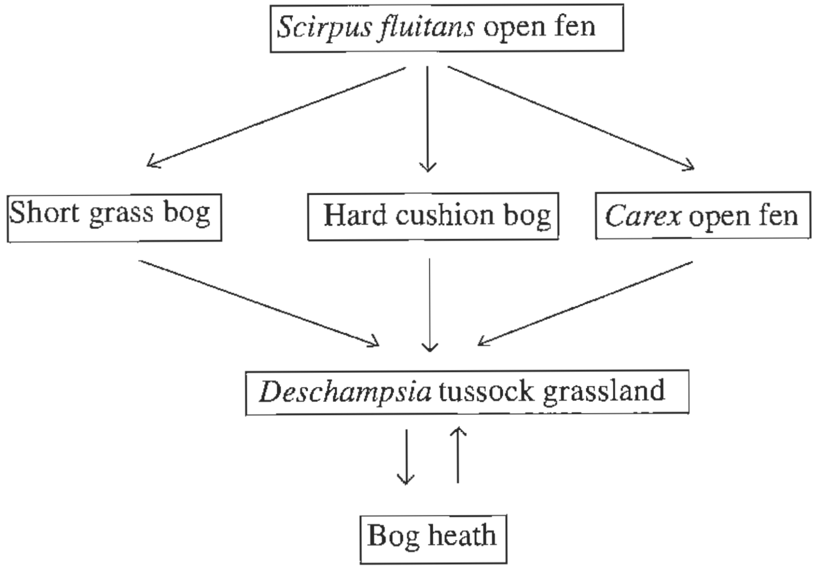
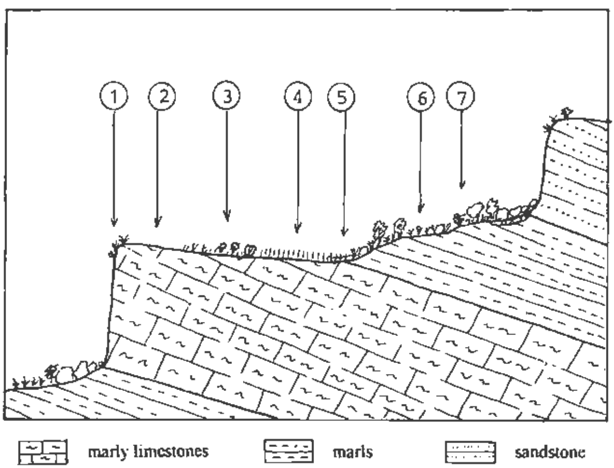


Fig.: 20: Succession of vegetation communities on waterlogged terrain

The large extent of subalpine grasslands and mire communities on Mt Trikora is correlated to the great number of landforms, which were created by the Pleistocene glaciaton. Big U-shaped valleys with large flat valley bottoms and slightly sloping glacial terraces, where waterlogging is nearly omnipresent, are common. The succession of vegetation communities during colonization of an area where waterlogging is continuous, has been shown in fig 20.

In each evolution scheme shown, there is an accumulation of unrotten organic matter, thus slowly raising the soil surface and creating hydrological conditons favourable to the development of savannas.

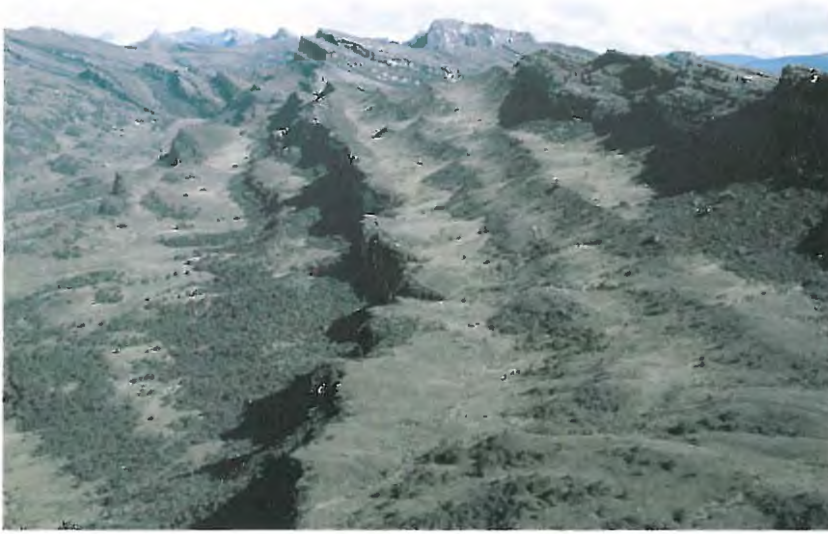
On the flat to slightly sloping rocky surfaces of the glacial terraces (plate 24) beyond Trikora Pass, the vegetation succession is of course determined primarily by the thickness of soil, and only secondarily by hydrological conditions of the substratum. The typical succession is well illustrated on the terraces west of 'Trikora Pass' as shown in the figure 21.



1. Rock overhang communities
2. *Stigonema panniforme* algal community (plot N°51)
3. Dwarf shrub heath (plot N°52,53)
4. *Carpha alpina* fen (plot N°54)
5. *Astelia alpina* bog (plot N°56)
6. *Deschampsia klossii* tussock grassland (plot N°55)
7. Open ericaceous woodland

Fig.21: Vegetation zonation on the glacial terraces west of 'Trikora Pass'

PLATE 24



Terraces west of Trikora Pass, 3790 m

Disturbance by fire in a *Cyathea* shrubland, 3100 m

On Mt Trikora, the subalpine grasslands seem much less diversified than those on Mt Wilhelm and Mt Jaya. Three types have only been recognized, i.e. *Deschampsia klossii* tussock grassland, *Gahnia javanica* tussock sedgeland and short grassland. The absence of *Poa nivicola* and *Poa lamii* continuous grassland, both present on Mt Jaya (Hope 1976), seems peculiar. Even if the type species are present, these grasslands, which normally form under better drainage conditions, have not been recognized by the author as a distinct homogenous community, although Hope (in v.Royen 1980) states that *Poa* tussock grasslands should be common or even dominant on suitable habitats.

In our view the only plausible reason for that lack of grassland diversity is that Mt Trikora is heavily visited by Papuan travellers or hunters and that thereby anthropogenic alterations are frequent.

The grasslands are regularly set afire, this either to oust small game or simply for fun. In this way, I have observed many times that my porters, after having made a small fire for liting a cigarette, just left without worrying. Consequently a light wind could easily set a few hectares of *Deschampsia* tussock grassland ablaze. This occurs mainly during the dry period of July-August. Although the soil may then be soaked with water, the dead leaves of the *Poaceae* dessicate rapidly. The tussocks of *Deschampsia* resist well to such glowing but short burning, a fact that surely enhances the large extension of such grasslands north of Mt Trikora. This could also be true for some areas where *Gleichenia* vulcanica bog is of some extent. This species has been observed on Mt Jaya and Mt.Albert Edward (Hope, 1976) but without dominating the mire communities on these less heavily visited mountains.

In the watershed basin of the Baliem-Wamena river, the influence of fires is well visible. Apart from the *Deschampsia* tussocks, only the well protected species may persist, forming thus a transitional scrub between the savanna and the forest. Gillison (1970) has showed that the *Ericaceae* are well adapted to this situation, using propagation by natural layering besides their natural fire resistance. Could this be an explanation of the dominance of the *Ericaceae* in the subalpine zone of Mt Trikora? In the Doma Peaks, Vink (pers.comm.) also observed a certain dominance of the *Ericaceae* in shrubberies. He links this to the fact that *Ericaceae* are very light demanding plants. At lower altitudes they may bee found in the forests but then mostly as epiphytes or lianas, thereby still reaching the light. This has also been ment ioned for the Anggi Lakes, at much lower altitudes (Vink, 1965) where Sleumer made extensive *Ericaceae* collections.

In the description of vegetation communities given above, I have already mentioned the particular role of the *Cyathea* shrublands. In fact, the trunks of *Cyathea tomentosissima* are covered by the dead leaf bases which provide a protection against fire. Even if the leaves are destroyed, the apical buds will remain alive. Finally, *Libocedrus papuana* seems also resistant to fire. On a recently burned area, I've observed a considerable number of*Libocedrus* seeds germinating. The germination of the seeds of this species might be fostered by these burnings, an assertion that needs of course verification.

Under the above assumptions, the following succession could be recognized in the watershed valley (fig. 22): *Deschampsia klossi* tussock grassland - *Cyathea tomentosissima* shrubland - *Libocedrus* forest - *Nothofagus* forest. Nevertheless, some more investigations still have to be undertaken to clarify completely this forest - grassland transition.

Fig. 22: Succession of vegetation units in the watershed basin (3100 m)

CHAPTER IV : Phytogeography of Mt Trikora

The geographical situation of New Guinea between Australia and south-east Asia is most interesting for the biogeographer as its flora shares a number of species with either area. But different zoogeographical or phytogeographical demarcations drawn west and south of New Guinea (cf. van Balgooy in Paijmans, 1976) illustrate also a break between New Guinea and Australia (Torres Strait) respectively New Guinea and West Malesia.

In the following chapter, I will try to evaluate the phytogeographical position of the subalpine and alpine vegetation of Mt Trikora (above 3000 m). This will be done by comparing it with such vegetations of several other mountains in New Guinea, i.e. Mt Jaya, Mt Wilhelm and the Owen Stanley Range, and to Mt Kinabalu in Borneo.

A precise recognition of the taxa is the first and indispensible requirement for biogeographical research. This of course is a major difficulty if working on the flora of New Guinea. Assuming that identifications are correct, we have to deal with changing nomenclature. Many synonyms had to be looked up in the herbarium to avoid double countings when statistically comparing the floras. Since the important collection of Brass (1942) many names have changed.

A good example of this problem is given by the genus *Rapanea (Myrsinaceae)*. In the Alpine Flora of New Guinea, van Royen (1980) described two new species, *Rapanea brassii* and *Rapanea communis*. Six years later when making a revision of the genus *Rapanea*, Sleumer (1986) allocated the two species to the old name *Rapanea cacuminum* Mez. Furthermore, continuous findings of new records makes the compilation of a complete list nearly impossible.

For the present work sources of compilation included Hope (1976) for Mt Jaya, Johns & Stevens (1971) for Mt Wilhelm, two unpublished reports by L.Craven (1977) and H.Turner (1978) for the Owen Stanley mountains and finally the publications by Gibbs (1914), Meijer (1963), van Steenis (1964) and J.M.B.Smith (1980) for Mt Kinabalu. This comparison may reveal a few inaccuracies and omissions which I want to apologize for. Furthermore only flowering plants have been considered because ferns and mosses are far less well known. In order to be able to compare the floras of these mountains, the most suitable unit for statistical purposes is the genus, as knowledge on species is very incomplete (van Steenis, 1934-36, and van Balgooy, 1976).

In his work about the phytogeography of New Guinea in general, van Balgooy (1976) has defined 15 different distribution types grouped in four categories (after van Steenis, 1954 and Keng, 1970), a subdivision I will also use in the present work. The results have been shown in the Tables 4 & 5. Finally a

		J	T	W	O-St	N-G in general	K
Cat.	**Genera**	%	%	%	%	(after van Balgooy)	%
A	Widespread genera (types 1, 1a,3)	44.0	44.1	43.4	41.2	43.7	41.6
B	Tropical amphipacific genera (type 2)	0.0	0.0	0.6	0.0	2.0	0.0
C	Genera centering north and west of New Guinea (types 2a,4,4a,5)	19.0	18.4	17.6	20.4	28.6	33.2
D	Genera endemic to, or centering in New Guinea (types 6, 6a)	11.0	8.6	8.8	9.6	13.3	1.4
E	Genera centering south or east of New Guinea (types 7,7a,8,8a,9)	26.0	28.3	29.5	29.0	12.4	23.6

Table 4 : Distribution categories of genera (cat.after: van Balgooy, 1976) (J: Mt Jaya; T: Mt Trikora; W: Mt Wilhelm; O-St: Owen Stanley Range; N-G: New Guinea; K: Mt Kinabalu/Borneo)

distribution table of all genera considered has been drawn up and is presented in appendix V. We used besides the strictly high altitude genera also genera defined by van Balgooy (1976) as « genera that are best developed in the mountains but have a few lowland species, or species descending to the lowlands ». The reason for this inclusion is the fact that these genera contribute to a large extent to the subalpine and alpine vegetation of Mt Trikora. Such genera with lowland species have been underlined in the table of appendix V.

The study of the 1465 genera recognized by van Balgooy as constituting the flora of New Guinea, shows that this flora may be included into the Indo-Malesian Floral Region, an assertion nearly unanimously approved by other botanists who did floristic research in the area. Analysing Table 4 we may see that for New Guinea in general only 2% of the genera are tropical amphipacific, which seems in disaccord with present day geography. Only 12.4% are centering in countries south or east of New Guinea and a relatively large number of genera (13.3%) is endemic to or centering in New Guinea itself.

Zoologists however, place New Guinea in the Australian Region, a statement that gave rise to much controversy. Although Diels (1930) recognised since long ago the southern affinities of the montane flora of New Guinea, this assertion never had been expressed in figures (van Balgooy, 1976). If we consider the high altitude floras of the mountains we observe the combination of genera from the northern hemisphere (*Rhododendron, Vaccinium, Ranunculus, Potentilla, Gentiana, Deschampsia , Carex, etc.*) and genera from the southern hemisphere (*Drimys, Drapetes, Styphelia, Gonocarpus, Astelia, Oreomyrrhis, Carpha, Oreobolus, Abrotanella,* etc.). This confers a particular interest to the mountains of New Guinea.

The statement by Jacobs (1974) that « the montane forests are in many regards the poor relatives of the lowland forests » is confirmed when we consider the

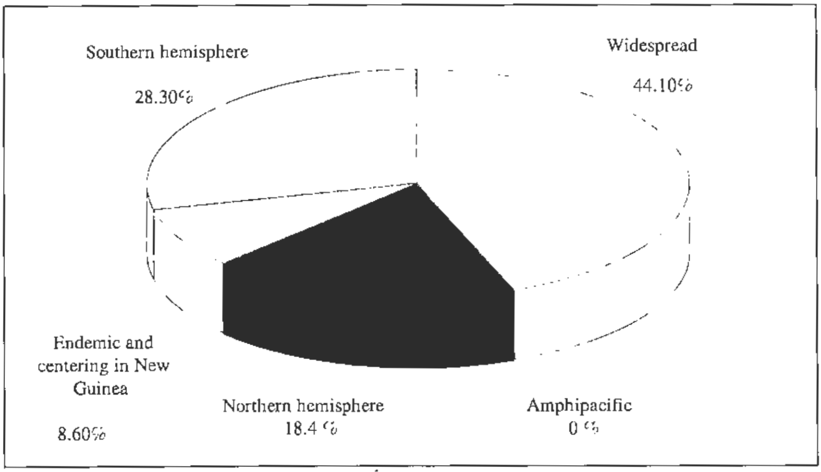


Fig. 23: Distribution spectrum of genera from Mt Trikora (> 3000 m)

Types	Distribution of the geneara	J %	T %	W %	O-St %	K %
1	Cosmopolitan and pantropical	15	17.8	15.7	13.2	20.8
1a	Temperate wides	24	19.1	17.6	21.9	13.9
2	Tropical amphipacific	0	0.0	0.6	0.0	0.0
2a	Northern temperate, extending into the tropics	10	7.9	5.7	8.8	9.7
3	Old world generally	5	7.2	10.1	6.1	6.9
4	Paleotropical and Indo-Malesian	1	1.3	3.1	2.6	6.9
4a	As above, but not in Australia	5	5.9	6.3	7.0	9.7
5	Strictly Malesian	3	3.3	2.5	1.8	6.9
6	Subendemic, centering in New Guinea, some species also in adjacent areas (Moluccas ...)	8	6.6	6.3	7.0	1.4
6a	Strictly endemic to New Guinea	3	2.0	2.5	2.6	0.0
7	Centering in Australia but also represented elsewhere	5	3.3	4.4	3.5	5.6
7a	Confined to Australia and New Guinea	0	0.7	1.3	0.9	0.0
8	Centering in the Pacific	2	2.0	2.5	1.8	0.0
8a	Equally well represented in Australia and the Pacific	5	7.2	7.5	7.9	6.9
9	Subantarctic/southern hemisphere	14	15.1	13.8	14.9	11.1

Table 5 : Phytogeographical distribution types of the genera (types after van Balgooy, 1976) (J: Mt Jaya; T: Mt Trikora; W: Mt Wilhelm; O-St: Owen Stanley Range; K: Mt Kinabalu)

subalpine and alpine regions of Mt Trikora. The actual checklist of flowering plants for this mountain comprises 395 species in 152 genera (cf.appendix III), thus representing only 10.4 % of the whole flora of New Guinea. Within these 152 genera 64, i.e. 42% have lowland species !

Looking at the affinities of the genera as shown in Tables 4 & 5, we may see that for Mt Trikora the widespread genera are predominant (fig.23) and within this group, the temperate wides (type 1a: *Prunus, Rubus, Schefflera, Saurauia, Drosera,* etc.) are best represented. The northern hemisphere plants, i.e.

genera centering in countries to the north and west of New Guinea (types 2a,4,4a and 5) yield only 18.4% of the high altitude flora. Examples to be cited are the genera *Vaccinium, Rhododendron, Eurya* and *Dacrycarpus*. Nevertheless if we consider the vegetation cover of the subalpine zone, we may see that the *Ericaceae* dominate the subalpine forests and scrubs. This is an example showing that floristic composition alone is not representative for the vegetation encountered in the field. A plant sociological study is indispensable to the knowledge of the vegetation cover of the area.

Another look at Table 5 shows that 28.3 % of the genera are centering in countries south or east of New Guinea (types 7, 7a, 8, 8a and 9), a value more than twice as high as for New Guinea in general (12.4 %). So, talking about the high altitude flora the botanists agree with the zoologists in including New Guinea into the Australian Biogeographical Region. This tendency could be confirmed when considering the mountain genera s.s. (cf. appendix V). The genera *Gonocarpus, Evodiella, Trimenia, Quintinia* and *Drapetes* are good examples for this.

Finally we may say that genera like *Sericolea* and *Xanthomyrtus* which are endemic to, respectively centering in New Guinea, are quite well represented (8.6%). On the other hand the amphipacific genera (type 2), those centered in the Pacific (type 8), as well as the strictly Malesian ones (type 5) have a rather poor occurence. The subantarctic/southern hemisphere element (type 9) with *Astelia, Nertera* or *Nothofagus* is well developed (15.1%). This might show the resemblance of the ecological conditions on the high mountains of New Guinea with those prevailing in the southern hemisphere islands with temperate oceanic climate.

For a generalisation of these results obtained for Mt Trikora a comparative study of several other mountains seemed necessary. For such a study I chose Mt Jaya, west of Mt Trikora, and Mt Wilhelm and the Owen Stanley Range of Papua New Guinea. The distribution of genera as shown in tables 4 & 4, confirms in general what has been said for Mt Trikora. The percentages of distribution categories are varying insignificantly indeed. Only the occurance of the genus *Perottetia (Celastraceae)* on Mt Wilhelm indicates that the tropical amphipacific element is also present in the mountains of New Guinea.

It seems furthermore that Mt Jaya has the highest endemic rate, that Mt Wilhelm has a large number of old world genera (type 3) and last but not least the genera centering to the north and west of New Guinea seem to be best represented on the Owen Stanley Range. This is of course an unexpected result as the Owen Stanley Range is on the easternmost edge of New Guinea.

To study the differencies or similarities beween the different mountains a simple look at the tables 4 and 5 is not sufficient. A statistical comparison of the mountains two by two revealed to be necessary. From the four sites considered, we made a floristic comparison by using Colgan's Index of Floral Diversity (Praeger, 1911, Wace & Dickson, 1965). For all pairs of mountain sites, the index has been calculated as (a+b)/(a+b+x), where (a) is the number of species found in flora A but not B, (b) is the number of species in B and not A, and (x) is the number of species in common to both floras.

Totally different floras would thus have an index = 1 and identical floras an index = 0. For the present study I have not only compared the genera but also the species. More caution has of course to be attributed to the results of species comparison.

Mt Jaya / Mt Trikora:

Genera:	Mt Trikora only	50	
	Mt Jaya only	4	Colgan's Index = 0.36
	genera in common	96	
Species:	Mt Trikora only	202	
	Mt Jaya only	66	Colgan's Index = 0.64
	species in common	154	

Mt Wilhelm / Mt Trikora:

Genera:	Mt Trikora only	34	
	Mt Wilhelm only	45	Colgan's Index = 0.41
	genera in common	116	
Species:	Mt Trikora only	215	
	Mt Wilhelm only	154	Colgan's Index = 0.72
	species in common	141	

Comparing the genera we see little differences between both Mt Jaya and Mt Wilhelm with Mt Trikora (Colagan's Index: 0.36 respectively 0.41). Looking at the species Mt Jaya and Mt Trikora are quite similar but Mt Wilhelm and Mt Trikora, with an index of 0.72 have a quite different species composition.

Another way to make a comparison between Mt Jaya, Mt Trikora and Mt Wilhelm at specific level is:

Mt Jaya has 154 species out of 210 in common with Mt Trikora (73%); Mt Wilhelm has only 141 out of 295 species in common with Mt Trikora (48%)! These comparisons must of course be treated with caution as the number of species collected on Mt Jaya is far less high than on Mt Trikora resp. Mt Wilhelm.

Using the same method, J.M.B.Smith (1974) has compared a total of 252 species of herbaceous plants of seven mountain areas of Papua New Guinea and Irian Jaya. The mountain chain of Irian Jaya was taken as a single unit. The index for the pair Bismarck Mts (Mt Wilhelm) / Owen Stanley Range is 0.44. The index for the pair Bismarck Mts / Irian Jaya is clearly higher with 0.65. These results tend to indicate a floristic gap between the mountains of Irian Jaya and those of Papua New Guinea. That would suggest the existance of a barrier to the natural exchange between the two areas.

Taking up this idea, H.Turner (1978) compared two mountains west of the Star Mountains and four east of them. The results have not shown significant differences, thus a clear gap immediately east of the Star Mountains could not be confirmed. This might be because either that such a gap does not exist, or that the floras are not well known enough for such a comparison. Whatever the reason might be, it seems clear to us that, except for Mt Wilhelm and Mt Trikora our knowledge of the floras is insufficient for an attempt to statistical comparison.

Trying to compare the montane flora of Mt Trikora to other parts of Malesia, we found it interesting to have a look at Mt Kinabalu in North Borneo. This is the only mountain exceeding 4000 m between the Himalayas and New Guinea. In 1980 I had the opportunity to visit Mt Kinabalu although a detailed study was impossible. Apart from the different nature of substratum, Mt Kinabalu being an intrusive granodiorite bloc, the significant difference is the complete lack of huge grasslands and mires on Mt Kinabalu.

This may be explained by the rather limited extent of the higher parts of that mountain. Nevertheless 72 genera have been counted above 3000 m. This number might rise in future as the northern and eastern parts of Mt Kinabalu are relatively unexplored. For a detailed description of the vegetation from Mt Kinabalu the reader is referred to the publications by Stapf (1894), Gibbs (1914), van Steenis (1964), Meijer (1963) and J.M.B.Smith (1980).

Although the evaluation of Colgan's index (generic level) shows a rather big difference between the two floras (Colgan's index = 0.71) - 52 genera being only in common - a certain number of species are shared between the two mountains: *Anthoxanthum horsfieldii* var. *angustum*, *Agrostis rigidula* var.

remota, Brachypodium sylvaticum, Danthonia oreoboloides, Poa papuana, Lactuca laevigata var. *pygmaea, Pilea johniana, Erigeron sumatrensis, Potentilla parvula, Coelogyne sp., Carex breviculmis, Carex capillacea, Carex filicina, Uncinia compacta* var. *compacta, Oreobolus ambiguus, Scirpus subcapitatum, Centrolepis philippinensis, Gonocarpus micranthus, Drimys piperita, Myriactis cabrerae* and *Phyllocladus hypophyllus.*

The distribution categories for Mt Kinabalu (Table 4) show a clear dominance of northern hemisphere genera with higher proportions of strictly Malesian genera (type 5) and no amphipacific genera (type 2) nor genera centering in the Pacific (type 8). Nevertheless the subantarctic/ southern hemisphere genera (type 9) are well represented (11.1 %) but probably reach here their northernmost limit.

The comparison of the different mountain floras of New Guinea immediately rises the question of the origin and history of these floras. Of course trying to explain the history of a flora on the basis of present day distribution is speculative, as fossil records are scarce or inexistent. Furthermore for Mt Trikora no pollen analytical studies have been done until now.

When we are looking at the aerial oblique photographs (cf. chapter II), we may easily recognize the impact of Pleistocene glacial erosion. Indeed, during the last glacial period the glaciers reached down as far as the big watershed basin north of the summit of Mt Trikora, at 3000 m. The lowering of the snowline on New Guinea mountains to about 3500 m as advanced by Hope (1986), would have resulted in a lowering of temperature of 6-8°C. The total extent of ice caps reaching 2000 square km during the last glacial period (Hope in van Royen, 1980). These climatic variations probably created much larger areas for colonization by tropicalpine plants than are present today. The following retreat of the ice masses also left much free space for colonization either by immigration or evolution *in situ* of lower altitude species.

The actual flora of the mountains of New Guinea is indeed an assembly of different floristic elements indicating various patterns of colonization during different ages. This is shown best by the high proportion of widespread plants in the alpine floras of New Guinea. Accepting the idea that mountains that are closer to a source area have a stronger representation of that element in its flora than more distant mountains (J.M.B.Smith, 1986), we have to consider the high percentage of southern hemisphere plants. Indeed, as shown above, New Guinea mountains have many genera in common with regions as far away as South-Australia, Tasmania or New Zealand. But the distance between New Guinea and the 'Victoria Alps' in Australia is about 3300 km, and these alps themselves are 2000 km away from New Zealand! How may the alpine plants have crossed such distances? This question has since long interested the biogeographers of the area and has not yet been answered to the full agreement of all. Seed dispersal seems to be the core problem. Van Steenis, in a series of essays (1934-1936), has always opposed the idea of long-distance (>100 km) dispersal of seeds. He proposed the idea of short distance dispersal from Eurasia via 'stepping stone' mountains in Malesia. The floras from eroding i.e. lowering mountains would have passed over to rising mountains next to them. He considered Mt Kinabalu as such a 'stepping stone' for southern hemisphere plants on their migration further north.

In contrast other authors stressed that a long distance transport of seeds by birds may have occured. As we are confronted with a long term evolution, even a single successful dispersal in about 8000 years time would have been sufficient to establish the actual flora on Mt Wilhelm (J.M.B. Smith, 1982, 1986).

Many phytogeographical studies by van Steenis (1934-36, 1962, 1964, 1971, 1979, etc.), Hope (1976a, 1976b, 1979, 1986), Smith (1974, 1979, 1982, 1986), Whitmore (1981, 1982, 1986), Raven & Axelrod (1974), Schuster (1972), van Balgooy (1976) and others have tried to explain the history of distribution of plants using taxonomical, ecological and phytogeographical arguments, with more or less success indeed.

With recent progress of the theory of plate tectonics, botanists have been confronted with new theories concerning the palaeogeography of the area. Hence it is most likely that geologists might give the key arguments to the resolution of this most interesting question. Actually the geological evolution of New Guinea is well understood and widely known (cf. chapter II).

With the fragmentation of Gondwanaland and subsequent shifting of the landmasses the climatic conditions for plant growth changed considerably. The only survivors were plants that adapted to arid conditions or that found shelter in the mountainous areas. If the flora of the New Guinea mountains is indeed much older than the actual mountains themselves, this might make sense.

On the other hand, the lowering of the see level of some 180 m (Whitmore 1981) during the last glacial period would have enabled colonization by malesian plants from the indonesian archipelago. Following this author, the plants originating from the north would have reached the mountains of New Guinea only in recent times. But how to explain the distribution of a genus like

Nothofagus ? Van Steenis (1971) advances an origin in south-east Asia although fossil records exist from the Cretaceous in Australia and New Zealand. He stipulates an immigration from the north via the mentioned 'stepping stones'. In that case a lost continental mass situated further north in actual Indonesia figured as a cradle for the genera like *Fagus* and *Nothofagus* and families like *Magnoliaceae* and *Winteraceae*. But where has this mass come from and where has it gone?

The answer might be given by recent geological discoveries. Indeed, Audley-Charles et al. (in Whitmore, 1981 & 1987) suggest that « there are now sufficient geological indications to allow us to consider with a high level of confidence that South Tibet, Burma, Thai-Malay Peninsula and Sumatra formed part of the eastern Gondwanaland attached to northern Australia-New Guinea during the late Palaeozoic ». This land mass seperated from the continental margin of northern Australia-New Guinea during the Jurassic and drifted north carrying the ancient flora. Would this have been the potential Noah's ark for the early angiosperms and by the way the starting point of later migration via east Malesia to New Guinea?

Although the details of the palaeogeographical reconstruction of this hypothesis remains a matter of specultaion (Audley-Charles, 1987), a big step has been made in solving the enigma concerning the evolution of the tropicalpine flora of New Guinea.

Final Comments

In the present study I tried to evaluate the ecological characteristics and the vegetation cover of the higher parts of Mt Trikora, in order to understand the structure and distribution of the major vegetation units that are present. It appeared difficult to say to what extent the nature of the substratum favoured the establishment of a special vegetion formation excluding another one. Nevertheless, the differences observed with Mt Jaya like the abundance of *Vaccinium dominans* in the subalpine forest, the absence of *Dacrycarpus compactus* above 3400 m and the small extent of treeline shrublands might be a consequence of the more sandy substratum on Mt Trikora.

Temperature and rainfall are surely more important factors. They have an immediate influence on plant growth. This is shown by the abundance of cushion plants, a typical life form of the cool and humid climate encountered also on the southern hemisphere/subantarctic islands. Apart from the direct influence on life forms, the climatic factors control the soil formation and thus the mineral nutrition of plants. Nevertheless, on Mt Trikora the fluctuating water table plays a major role. It is indeed a determinative factor in the establishment of the shrubs and trees.

The diversity of ecological conditions is expressed in the considerable number (26) of vegetation units that develop above 3000 m. But probably the impact of man will strongly reduce this diversity. Apart from the hunting parties crossing the area north of the summit of Mt Trikora, increasing tourism is also threatening the subalpine forest, particularly in the surroundings of the shelters. The frequence of fire may have contributed to the disappearance of *Poa nivicola, Danthonia vestita* and *Cortaderia archboldii* grasslands well known from Mt Wilhelm in Papua New Guinea.

It is in fact very important to realize the conservation plan for Irian Jaya established by the World Wildlife Fund (Petocz, 1982). This is the more pressing as the population of Irian Jaya province is increasing rapidly (1980: 1.173.875 inhabitants; estimation for 1990: 2.2-2.4 million). This increase is mainly due to the transmigration programmes (138.300 families during PELITA IV) essentially in the coastal areas but also in the Baliem Valley. There, the threat to montane forests is great due to increasing needs for firewood. A study on the carrying capacity for the Baliem valley is by now indispensable.

A mountain research program for Indonesia proposed by Kilmaskossu & Hope (1986) anticipates the creation of a center for environmental studies within Cenderawasi Univerity, Irian Jaya. Collaboration between national and international institutions appears to be preponderant. Further research in poorly explored areas in the Vogelkop, the Weyland Mts, or Mt Mandala will be necessary to understand the origins and distribution of present day floras.

We finally hope that the present work contributes to the knowledge of the altimontane vegetation of New Guinea even though it is incomplete in many regards.

REFERENCES

Allègre, Cl. (1980): Les Ophiolites, ou la Recherche des Océans perdus. - La Dérive des Continents, Bibl. 'Pour la Science', 83-105.

Allison, I. & J. Bennett (1976): Climate and Microclimate (Mt Jaya). - In : G. Hope et al.: The Equatorial Glaciers of New Guinea. Balkema / Rotterdam, 61-80.

Anas, M. (1960): The Highlands of Australian New Guinea. - The Geographical Review, Oct. 467-490.

Archbold, R. (1941): Unknown New Guinea. - National Geographic Magazine, March 1941, 315-344.

Askew, G.P. (1964): The Mountain Soils of the East Ridge of Mt Kinabalu. - Proc. of the Royal Soc. (London) B, vol.161, 65-75.

Audley-Charles, M.G. (1981): Geological history of the region of Wallace's line. - In: T.C.Whitmore, Wallace's line and plate tectonics, Clarendon Press, Oxford, 24-35.

——— (1987): Dispersal of Gondwanaland: relevance to evolution of the angiosperms. - In: T.C.Whitmore, Biogeographical evolution of the Malay archipelago, Oxford Science Publications, Clarendon Press, Oxford, 5-25.

Baal, J.van (1984): West Irian, A Bibliography. - Foris Publ. Dordrecht/ Holland.

Balgooy, M.M.J.van (1966): Pacific Plant Areas (vol. 2). - Blumea Suppl.V, 312 pp. 173 distr. maps.

——— (1971): Plant Geography of the Pacific. - Blumea Suppl. VI, 222 pp.

——— (1975): Pacific Plant Areas (Vol. 3). - Rijksherbarium Leiden, 386 pp.

——— (1976): Phytogeography. - In: K.Paijmans: New Guinea Vegetation, Elsevier, 1-25.

——— (1984): Pacific Plant Areas (Vol. 4). - Rijksherbarium, Leiden, 270 pp.

Barlow, B. (1986): Flora and fauna of alpine Australasia, ages and origins. - C.S.I.R.O. & Austr. Sys. Bot. Soc., Melbourne, 543 pp.

Barnett, E.C. (1944): Quercus, Lithocarpus, Castanopsis de l'Asie de l'Est. - Trans. Proc. Bot. Soc. Edinburgh 34, 159-205.

Barry, R.G. (1978): Aspects of the Precipitation Characteristics of the New Guinean Mountains. - J. Trop.Geogr. 47, 13-30.

Barry, R.G. (1980): Mountain Climates of New Guinea. - In : P. van Royen, The Alpine Flora of New Guinea, 75-111.

Blasco, F. (1971): Montagnes du Sud de l'Inde (Forêts, savanes, écologie). - Trav. Sect. Scientif. et Techn. Inst. Fr. de Pondichéry, Tome X, Fasc.1, 436pp.

Bleeker, P. (1980): The Alpine Soils of the New Guinea High Mountains. - In: P. van Royen, The Alpine Flora of New Guinea, 59-75.

Bowler, J.M., G.S. Hope, J.N. Jennings, G. Singh & D. Walker. (1976): Late Quaternary Climates of Australia and New Guinea. - Quat.Res. 6, 359-394.

Braak, C. (1931): Klimakunde von Hinterindien und Insulinde. - In: W. Koepper & R. Geiger (ed), Handbuch der Klimatologie 4, R.Borntraeger, Berlin.

Brass, L.J. (1941): The 1938-1939 Expedition to the snow mountains, Netherlands New Guinea. - J. Arnold Arbor. 22, N° 2+3, 271-345.

——— (1956): Results of the Archbold Expedition, New Guinea (1953). - Bull. Am. Mus. Nat. Hist., 111, 83-152.

——— (1959): Results of the Archbold Exp. to New Guinea (1956-57). - Bull. Am. Mus. Nat. Hist. 118, 1-70.

——— (1964): Results of the Archbold Exp. No86 (1959). - Bull. Am. Mus. Nat. Hist. 127, 149-212.

Brookfield, H.C. (1961): The Highlands People of New Guinea (Distribution, Localization). - Geogr. Journal 27, 436-448.

——— (1964): The Ecology of Highland Settlement, New Guinea:The Central Highlands. - In: J.B. Watson. (ed.), Am. Anthrop. 66 (4), Pt. 2, spec. publ., 20-38.

Brookfield, H.C. & D. Hart (1966): Rainfall in the Tropical Southwest Pacific. - A.N.U./B.G. 3, 25 pp.

Brown, W.H.B. (1919): Vegetation of Philippine Mountains. The Relation between the Environment and Physical Types at Different Altitudes. - Manila, Bureau of Printing, 454 pp.

Burnham, C.P. (1974): The Role of the Soil Forming Factors in Controlling Altitudinal Zonation on Granite in Malaysia. - In: Flenley, Altitudinal Zonation of Forests in Malesia, 59-75.

Chase, A. (1943): Papuan Grasses Collected by L.J.Brass. - J. Arnold Arbor., 24, 77-89.

Coe, M.J. (1967): The Ecology of the Alpine Zone of Mt Kenia. - Monographiae Biologicae, 17, W. Junk Publ., The Hague.

Collins, N.M., J.A.Sayer, & T.C.Whitmore (1991): The consevation atlas of tropical forests, Asia and the pacific. - I.U.C.N., Simon & Schuster, New York, London, 256 pp.

Coode, M.J.E. & Stevens, P.F. (1972): Notes on the Flora of two Papuan Mountains. - Papua New Guin. Sci. Soc. Proc. 23, 18-25.

Cooper, D.E. (1971): Some Botanical and Phytochemical Observations in Netherlands New Guinea, "New Zealand-New Guinea Expedition 1961". - Econ. Bot. 25, 345-356.

Costin, A.B. (1968): Alpine Ecosystems of the Australian Region. - in: H.E. Wright and W.H.Osborn eds., Arctic and Alpine Environments, Bloomington, Indiana 1967, 55-87.

Cuatrecasas, J.(1968): Paramo vegetation and its Life Forms.- In: Troll C., Geo-ecology of the Mountainous Regions of the Tropical Americas, (Symposium UNESCO Mexico,1966), Colloquium Geographicum, Bonn, N° 9, 163-186.

Diels, L. (1921): Die Pflanzengeographische Stellung der Gebirgsflora von Neuguinea. - Ber. freien Verein. Pfl. Geogr. und Syst. Bot. für die Jahre 1919-1921, 45-59.

——— (1929): Beitraege zur Flora des Saruwaged-Gebirges. - Englers Bot. Jahrb. 62, 452-501.

Dozy, J.J. (1938): Eine Gletscherwelt in Niederländisch Neuguinea. - Zeitschrift für Gletscherkunde, 26, 1938, 45-51.

——— (1939): Geological Results of the Carstensz Expedition 1936. - Leidse Geol. Meded. 11, 68-131.

Duchaufour, Ph. (1977): Pédologie / 1. Pédogenèse et Classification. 2. Constituants et Propriétés du Sol. - Masson, Paris.

Dudal, R & M. Soepraptohardjo. (1957): Soil Classification in Indonesia. - Contr. Gen. Agric. Res. Stn, Bogor, 148.

Du Rietz, G.E. (1931): Life Forms of Terrestrial Flowering Plants. - Acta Phytogeographica Suecica, Uppsala, III, 1(4), 95 pp.

Ellenberg, H. & D. Mueller-Dombois (1967): A Key to Raunkiaer Plant Life Forms with Revised Subdivisions. - Ber. Geobot. Forsch. Inst. der ETH Stiftung Rübel, Zürich, Band 36, 56-73.

Flenley, J.R. (1972): Evidence of Quaternary Vegetational Change in New Guinea. - in: P.&M. Ashton ed., The Quaternary Era in Malesia, Trans. 2nd Aberdeen-Hull Symp. Males. Ecol., 99-108.

——— (1969): The Vegetation of the Wabag Region, New Guinea Highlands, a Numerical Study. - J. Ecol. 57/2, 465-490.

Fontanel, J. et A. Chantefort. (1978): Bioclimats du Monde Indonesien. - Inst. Fr. de Pondichéry, Tome XVI.

Geesink, R. et al. (1981): Thonner's Analytical Key to the Families of

Flowering Plants. - Leiden Botanical Series N° 5.
Gibbs, L.S. (1914): A Contribution to the Flora and Plant Formations of Mt. Kinabalu and the Highlands of British North Borneo. - Journ. Linn. Soc. Bot., 42, 240 pp.
——— (1917): A Contribution to the Phytogeography and Flora of the Arfak Mountains (Dutch N.W. New Guinea). - Taylor & Francis London, 226pp.
——— (1920): Notes on the Phytogeography and Flora of the Mountain Summit Plateaux of Tasmania. - J. Ecol. 8, 1-17, 89-117.
Gillison, A.N. (1969): Plant Succession in an Irregularly Fired Grassland Area, Doma Peaks Region. - Papua. J. Ecol. 57, N° 2, 415-427.
——— (1970): Structure and Floristics of a Montane Grassland / Forest Transition, Doma Peaks Region, Papua New Guinea. - Blumea, 18, 71-82.
Godley, E.J. (1978): Cushion Bogs. - In: C.Troll & W. Lauer (ed.): Geoecological relations between the southern temperate zone and the tropical mountains, XXX, Erdwiss. Forschung, Vol.11, 563 pp.
Good, R. (1960): On the Geographical Relationships of the Angiosperm Flora of New Guinea. - Bull. Brit. Mus. Nat. Hist., Botany 2 N°8, 205-226.
——— (1964): The geography of Flowering Plants, 3rd ed. - Longman's, London, 518 pp.
Gressit J.L. & Nadkarni (1978): Background to Montane New-Guinea Ecology, Guide to Mt.Kaindi (Papua N-G.). - Wau Ecol. Inst. Handbook No 5.
Gressit, J.L.(ed.) (1981): Biogeography and Ecology of New Guinea. - Kluwer Acad. Publ., Dordrecht, Vol. 1 + 2, 1008 pp.
Grubb, P.J. (1971): Interpretation of the 'Massenerhebungseffekt' on Tropical Mountains. - Nature 229, 44-45.
——— (1973): Factors Controlling the Distribution of Forest Types on Tropical Mountains - New Facts and New Perspective. - In : J.R. Flenley ed., Altitudinal Zonation of Forests in Malesia. Dept. of Geogr., Uni. of Hull, 13-47.
Grubb, P.J. & P.F. Stevens, (1985): The Forests of the Fatima Basin and Mt Kerigomna, and a Revision of Montane and Subalpine Forests elsewhere in New Guinea. - A.N.U. / B.G.8, Canberra.
Haantjens, H.A., J.J. Reynders, W.N.L.P.J. Mouthaan, F.A. Van Baren (1967): Major Soil Groups of New Guinea and their Distribution. - Communication 55, Dep. Agr. Research, Roy. Trop.

Inst.Amsterdam.

Haantjens, H.A. (1970): Soils of the Goroka-Mount Hagen Area. - In: R.G. Robbins ed., Lands of the Goroka-Mount Hagen Area, C.S.I.R.O. Land Res. Ser. 27, 80-103.

Hamilton, W. (1979): Tectonics of the Indonesian Region. - Geological Survey, Professional Paper 1078, Washington.

Harrer, H. (1963): Ich komme aus der Steinzeit. - Brockhaus, Stuttgart.

Haumann, L. (1933): Esquisse de la Vegetation des Hautes Altitudes sur le Ruwenzori. - Bull. Acad. Roy. Belgique (Sciences), 5e serie, XIX, 602-616, 702-717, 900-917.

Hauri, H. & C. Schröter (1914): Versuch einer Uebersicht der siphonogamen Polsterpflanzen. Bot. Jahrb. 50, 618-658.

Hauri, H. (1916): Anatomische Untersuchungen an Polsterpflanzen, nebst morphologischen und ökologischen Notizen. - Beiheft Bot. Zentralbl.. Abt. Anatomie, Histologie, Vol. 33,1, 275- 293.

Hedberg, O. (1964): Features of Afro-Alpine Plant Ecology. - Acta Phyto. Suecica 49, 144 pp.

——— (1969): Evolution and Speciation in a Tropical High Mountain Flora. - Biol. J. Linn. Soc. 1, 135-148.

Heider, Karl G., (1970): The Dugum Dani, a Papuan Culture in the Highlands of West New Guinea. - Aldine, Chicago.

Heilborn, O. (1925): Contribution to the ecology of the Ecuadorian Páramaos with special reference to cushion-plants and osmotic pressure. - Svensk Botanisk Tidskrift, 19, Heft 2, 153-170.

Henty, E.E. (1969): A Manual of the Grasses of Guinea. - Botany Bull. 1, Dept. of Forests, Papua New Guinea.

Herderschee, F.A. (1913): Verslag der 3de Zuid-Nieuw-Guinea expeditie vanaf 5 December 1912. - In : Bulletin 68, Maatsch. t. Bevord. Nat. Onderz. Ned. Kol.

Hiepko, P. & W.Schultze-Motel (1981): Ethnobotanische Untersuchungen im Eipomek-Tal, Irian-Jaya, Indonesien. - Beitrag zur Schriftenreihe: Mensch, Kultur und Umwelt im Zentralen Bergland von West Neu-Guinea, N 7, D.Reimer Verlag, Berlin, 72 pp.

Hnatiuk, R.J., J.M.B. Smith & D.N. Mc Vean, (1976): The Climate of Mt Wilhelm. - Mt Wilhelm Studies 2, A.N.U. BG/4, Canberra.

Hoffmann, G. (1985): Klimatologische Beobachtungen in Eipomek. - Beitrag zur Schriftenreihe: Mensch, Kultur und Umwelt im Zentralen Bergland von West-Neuguinea, No 9, 410 pp. Brill, Leiden.

Hoogland, R.D. (1958): The Alpine Flora of Mt Wilhelm (New Guinea). - Blumea Suppl.4, 220-238.

——— (1972): Plant Distribution Patterns Across the Torres Strait. - In: D.Walker ed., Bridge and Barrier: the Natural and Cultural History of Torres Strait, A.N.U. BG/3, Canberra.

Hope, G.S. (1975): Some Notes on the Non-Forest Vegetation and its Environment, Northern Flank of Mt.Albert Edward, Central District, Papua New Guinea. - Unpublished Report, A.N.U., Canberra.

——— (1976): The Vegetation of Mt Jaya. - In: G.S.Hope et al., The Equatorial Glaciers of New Guinea, A.A.Balkema, Rotterdam, 113-172.

——— (1976): Mt Jaya: The area and its exploration. - In: G.S.Hope et al., The Equatorial Glaciers of New Guinea, A.A. Balkema, Rotterdam, 1-14.

——— (1976): The Vegetational History of Mt Wilhelm, Papua New Guinea. - J.Ecol. 64, 627-664.

——— (1977): Observations on the History of Human Usage of Subalpine Areas near Mt Jaya. Irian - Bulletin of Irian Jaya Development. (Inst.for Anthropology Cenderawasih Univ.) 6, N°2, 41-72.

——— (1980): Historical Influences on the New Guinea Flora. - In: P.van Royen, The Alpine Flora of New Guinea, Vol.I, 223-249.

——— (1980): New Guinea Mountain Vegetation Communities. - In: The Alpine Flora of New Guinea, P.van Royen, Vol. I, 153-223.

——— (1986): Development of Present Day Biotic Distributions in The New Guinea Mountains. - In : B. Barlow ed., Flora and Fauna of Alpine Australasia, ages and origins, C.S.I.R.O., Melbourne, 129-146.

Hope, G.S. & J.A. Peterson. (1975): Glaciation and Vegetation in the High New Guinea Mountains. - in: R.P. Suggate & M.M. Cresswell eds., Quaternary Studies, The Royal Society of New Zealand, Wellington, 155-162.

Hubrecht, P.F. (1913): Geologie van Mt. Wilhelmina (Kremer & van Overeem expedities). - Maatsch. t. Bevord. Nat. Onderz. Ned. Kol., Bull. N° 68, 37-48.

——— (1922): Het Hooggebergte van Nieuw-Guinea (Geologie). - Report of 2d. Ned. Ind. Natuurwetensch. Congr. Bandung, May 13th, 1922, p.38.

Hynes, R.A. (1974): Altitudinal Zonation of Forests in Malesia. - in: J.R.

Flenley ed., Altitudinal Zonation of Forests in Malesia, Dept. Geogr. Univ. of Hull, 75-120.

Jacobs, M. (1972): The Plant World on Luzon's Highest Mountains. - Rijksherbarium, Leiden.

——— (1974): Panorama Botanique de l'Archipel Malais (Pltes.Vasc.). - Ressources Naturelles de l'Asie Trop. Humide, UNESCO, Recherches sur les Ress. Nat. XII, 285-320.

Jacobs, M. & T.J.J. De Boo (982): Conservation Literature on Indonesia. Selected Annoted Bibliography. - Rijksherbarium, Leiden, 274 pp.

Johns, R.J. & P.F. Stevens (1971): Mt Wilhelm Flora: A Checklist of the Species. - Botany Bull. 6, Div.of Botany, Dept.of Forests, Lae, P. N.G.

Johnson, R.W. & A.L. Jacques (1980): Continent - Arc Collision and Reversal of Arc Polarity : New Interpretations from a Critical Area. - Tectonophysics 63, 111-124.

Kalkman, C. (1955): A Plant-Geographical Analysis of the Lesser Sunda Islands. - Acta Bot. Neerl. 4, 200-225.

——— (1963): Description of Vegetation Types in the Star Mountains Region,West New Guinea. - Nova Guinea, Botany 15, 247-261.

——— (1989): *Potentilla* (*Rosaceae*) in New Guinea: census, key, and some new taxa. - Blumea 34, 143-160.

Kalkman, C. & W. Vink (1970): Botanical Exploration in the Doma Peaks Region, New Guinea. - Blumea 18, 87-135.

Keng, H. (1970): Size and Affinities of the Flora of the Malay Peninsula. - J. Trop. Geogr. 41, 43-56.

Kilmaskossu, M.St.E. & G.S. Hope (1985): A Mountain Research Programme for Indonesia. - Mountain Res. and Development, Vol.5, USA, No 4, 339-348.

Krajina, V.J. (1933): Die Pflanzengesellschaften des Mlynica -Tales, Vysoke Tatry 1. Teil. - Beih. Bot. Zbl. 50, 774-975.

Kramer, P.J. (1956): Physical and Physiological Aspects of Water Absorption. - Handb. Pflanzenphysiologie, Vol.3, 124-159.

Kremer, J.H.G. (1922/23): De Expeditie naar het centraal Gebergte van Nieuw-Guinea (Wilhelminatop), 1920-22. - Onze Vloot,14, 15.

Lam, H.J. (1924): Vegetationsbilder aus dem Innern von Neuguinea. - In: Dr.G.Karsten & H.Schenck, Vegetationsbilder, 15.Reihe, Heft 5/6 + Heft 7.

——— (1927-29): Fragmenta Papuana. - Natuurk. Tijdsehr. v. Nederl. Indie, N° 87, 88, 89, engl. transl. by L.M. Perry, 1945, Sargentia

V, Arnold Arboretum, 196 pp.
——— (1934): Materials towards a Study of the Flora of the Island of New Guinea. - Blumea 1, 115-159.
Langeler, J.W. & L.A.C.M. Doorman (1918): Nieuw-Guinea en de Exploratie der "Meervlakte" 1913-1915 (Doorman Top). - De Aarde en haar Volken, 141-208.
Laubenfels, D.J.de. (1980): The Endemic Species of Podocarpus in New Guinea. - Blumea 26, 139-143.
Laumonier, Y. (1980): Contribution a l'Etude Ecologique et Structurale des Forêts de Sumatra. - Thèse, Univ.Paul Sabatier,Toulouse, France, 137 pp.
Lebrun, J. (1957): Sur les Elements et Groupes Phytogeogr. de la Flore du Ruwenzori (vers. occid.). - Bull. Jardin Bot. Etat, Bruxelles, XXVII, 453-477.
Legris, P. et F. Blasco (1969): Variabilité des Facteurs du Climat, Cas des Montagnes du Sud de l'Inde et de Ceylan. - Trav. Sect. Sci. et Techn., VIII (1), Inst. Franc. de Pondichéry. 95 pp.
Löffler, E. (1972): Pleistocene Glaciation in Papua and New Guinea. - Z. Geomorph. N.F. Suppl. Bd 13, Berlin-Stuttgart, 32-58.
——— (1980): Geology and Geomorphology of the New Guinea High Mountains. - In: P. van Royen, The Alpine Flora of New Guinea, Vol.I, 29-59.
Lorentz, H.A. (1911): An Expedition to the Snow Mountains of New Guinea. - Geogr. Journal 37, No 5, 477-500.
——— (1913): Zwarte Menschen-Witte Bergen. Verhaal van den Tocht naar het Sneeuwgebergte van Nieuw-Guinea.(Mt Wilhelmina). - Leiden, Brill.
Mangen J.-M. (1986): A new *Eriocaulon* (*Eriocaulaceae*) from New Guina. - Blumea 31, 487-489.
Matthiessen, P. (1962): Under the Mountain Wall. - New York, Viking.
Mc Vean, D.N. (1969): Alpine Vegetation of the Central Snowy Mountains of New South Wales. - J. Ecol.57, 67-86.
——— (1974): Mountain Climates in the Southwest Pacific. Altitudinal Zonation in Malesia. - Proc. 3rd Aberdeen-Hull Symp. Males. Ecol. (ed. J.R. Flenley) Geogr. Dept. Univ. Hull Miscell. Ser. 16, 47-57.
Meijer, W. (1963): A botanical guide to the flora of Mt Kinabalu. - UNESCO Symp. Kuching, Sarawak, 325-376.
——— (1975): Indonesian Forests and Land Use Planning. - Report on N.S.F. Travel Grant. USA, 1973.

Merrill, E.D. (1907): The Flora of Mt Halcon, Mindoro / Philipines. - Philippine Journal of Science, Botany vol.2, 1907, 251-309.

Merril, E.D. & L.M. Perry (1939): On the Brass Collection of Pandanaceae from New Guinea. - J. Arn. Arb. 20, 139-186.

Merrill, E.D. & L.M. Perry (1939-1951): Plantae Papuanae Archboldianae. - J. Arnold Arbor.,

N°	I	1939	Vol. XX	pages 324-345
	II	1940	Vol.XXI	163-201
	III	id.	id.	292-327
	IV	id.	id.	511-527
	V	1941	Vol.XXII	32-59
	VI	id.	id.	253-270
	VII	id.	id.	375-388
	VIII	id.	id.	529-542
	IX	1942	Vol.XXIII	233-297
	X	id.	id.	383-416
	XI	1943	Vol.XXIV	34-59
	XII	id.	id.	207-217
	XIII	id.	id.	422-439
	XIV	1944	Vol.XXV	183-205
	XV	1945	Vol.XXVI	1-37
	XVI	id.	id.	229-266
	XVII	1946	Vol.XXVII	193-233
	XVIII	1946	Vol.XXX	139-165
	XX	1951	Vol.XXXII	369-389

Mohr, E.C.J & F.A.v. Baren (1954): Tropical Soils. - The Hague: N.V. Uitgeverij. W.van Hoeve.

Mueller-Dombois, D. & H. Ellenberg (1974): Aims and Methods of Vegetation Ecology. - Wiley and Sons, New York.

Nouhuys, J.W. van (1910): Kort Topographisch-Geologisch en Meteorologisch Verslag. III. Zuid Nieuw-Guinea Expeditie 1909 (H.A.Lorenz). - Maatsch. t. Bevord. Nat. Onderz. Ned. Kol., Bull. N° 62, 49-57.

Oldeman, L.R. (1977): Climate of Indonesia. - Proc. 6th Asian Pacific Weed Science Soc. Conf., Jakarta, Vol.I, 14-30.

Oyama M. & H. Takehara (1967): Revised Standard Soil Color Chart (Munsell).

Paijmans, K. (1975): Explanatory Note to the Vegetation Map of Papua New Guinea. - C.S.R.I.O., Land Res. Series N° 35, Melbourne.

——— (1970): An Analysis of Four Tropical Rain Forests Sites in New Guinea. - J.Ecol. 58(1), 77-101.

——— (1976): New Guinea Vegetation. - Elsevier Scientific Publishing Company, Amsterdam.

Paijmans, K. & E. Loeffler (1972): High-Altitude Forests and Grasslands of Mt.Albert Edward, New Guinea - J. Trop. Geogr. (Singapore), 34, 55-64.

Peterson, J.A. & G.S. Hope (1972): Lower Limit and Max. Age for the Last Major Advance in the Carstensz Glaciers. - West Irian Nature, London, 240 (5375), 36-37.

Peterson, J.A. G.S. Hope & R. Mitton. (1973): Recession of Snow and Ice Fields of Irian Jaya, Rep. Indonesia. - Zeitschr. Gletscherkunde Glazialgeol. 9, 73-87.

Petocz, R. (1984): Conservation and development in Irian Jaya, a strategy for rational resource utilization. - WWF/IUCN Conservation for Development Programme in Indonesia, Project 1528: Irian Jaya Conservation Programme, for Directorate General of Forest Protection and Nature Conservation, Bogor, 1-279.

Pieters, P.E. (1982): Geology of New Guinea. - In: J.L.Gressit (ed.) Biogeography and Ecology of New Guinea. De Junck Publ. The Hague, 15-38.

Praeger, R.L. (1911): Clare Island Survey 10, Phanerogamia and Pteridophyta. - Proc. Roy. Irish Acad.,31, 1-112.

Pulle, A. (1915): Naar het Sneeuwgebergte van Nieuw-Guinea. - Wereldbibliotheek Amsterdam.

Rauh, W. (1939): Über Polsterförmigen Wuchs. - Nova Acta Leopoldina, Neue Folge, Band 7, N° 49, 266-530.

——— (1988): Tropische Hochgebirgspflanzen, Wuchs- und Lebensformen. - Springer Verlag, Berlin, 206 pp.

Raunkiaer, C. (1934): The Life Forms of Plants and Statistical Plant Geography, being the collected Papers of C. Raunkiaer. - Oxford, Clarendon Press, 1934.

Raven, P.H. (1973): Evolution of Subalpine and Alpine Plant Groups in New Zealand. - New Zealand J. Botany 11, 177-200.

Raven, P.H. & D.I. Axelrod (1974): Angiosperm Biogeography and Past Continental Movements. - Ann. Missouri Bot. Garden 61, 539-673.

Reiner, E. (1960): The Glaciation of Mt Wilhelm, New Guinea. - The Geographical Review, Oct., 490-503.

Reynders, J.J. (1962): Shifting Cultivation in the Star Mountains Area. -

Nova Guinea, Anthropology 10 (3), 45-73.
——— (1964): A Pedo-ecological Study of Soil Genesis in the Tropics, from Sea Level to Eternal Snow, Star Mountains, Central New Guinea. - Nova Guinea, Geology, N° 6, Brill, Leiden.
Richardson, S.D. (1970): Mission to West Irian. - Commonw. For. Rev.49(2), 139-149.
Ridley, H.N. (1916): Report on the Botany of the Wollaston Expedition to Dutch New Guinea,1912-13 (Plants collected+description). - Transact. Linn. Soc., 2nd Ser., Botany 9, part 1, 1-269.
Rickwood, F.K. (1955): The Geology of the Western Highlands of New Guinea. - Journal Geol. Soc. of Australia 2, 63-82.
Robbins, R.G.(1960): Montane Formations in the Central Highlands of New Guinea. - Proc. UNESCO Symp.on Humid Tropics Vegetation, Tjiawi (Indonesia) 1958, 176-195.
——— (1961a): The Montane Vegetation of New Guinea. - Tuatara, 8, 3, 121-133.
——— (1961b): Correlations on Plant Patterns and Popular Migrations into the Australian New Guinea Highlands. - Proc. 10th Pacific Sci.Congress Hawaii, 45-59.
——— (1964): The Montane Habitat in the Tropics. - I.U.C.N. (N.S.), N°4, 163-171.
——— (1970): Vegetation of the Goroka-Mt.Hagen Area. - C.S.I.R.O. Land Res. Ser., 27, Melbourne, 104-118.
——— (1971): On the Biogeography of New Guinea. - Austr. Ext. Terr., 11(3), 31-37.
Robbins, R.J. & R. Pullen (1965): Vegetation of the Wabag-Tari Area. - C.S.R.I.O. Land. Res. Ser.15, Melbourne, 110-115.
Royen, P.van (1963): The Papuan Area (New Guinea). - Typewritten Report of the Rijksherbarium, Leiden, 79pp.
——— (1965): An Outline of the Flora and Vegetation of the Cyclops Mountains (Irian Jaya, Jayapura). - Nova Guinea, Botany 21, 451-469.
——— (1967): Some Observations on the Alpine Vegetation of Mount Biota (Papua). - Acta Bot. Neerl. 15, 530-34.
——— (1980-1983): The Alpine Flora of New Guinea. - J.Cramer Verlag, Vaduz, Liechtenstein, 4 Vols., 3516p.
Ryan, P. (ed.) (1976). Encyclopaedia of Papua and New Guinea. - Melbourne Univ.Press. in Assoc. with Univ. of P.N.G.
Salt, G. (1954): A Contribution to the Ecology of Upper Kilimandjaro. - J. Ecol. 42, 375-423.

Schuster, R.M. (1972): Continental Movements, "Wallace's Line" and Indomalayan-Australasian Dispersal of Land Plants : Some Eclectic Concepts. - The Botanical Review 38, N.-Y. Bot. Gardens, 3-85.

Schweinfurth, U. (1962): Studien zur Pflanzengeographie von Tasmanien. - Bonner Geogr. Abhandl., Heft 31.

——— (1966): Neuseeland, Beobachtungen und Studien zur Pflanzengeographie und Oekologie der Antipodischen Inselgruppe. - Bonner Geogr. Abh., Heft 36.

——— (1970): Verbreitung und Bedeutung von *Pandanus sp.*in den Hochtälern der Zentralkordillere im Östlichen Neu Guinea. - Bonn. Colloq. Geogr., 12. Argumenta Geographica(Festschrift C.Troll zum 70. Geburtstag), 132-151.

Scott, A.J. (1984): Two New Species of Myrtaceae from New Guinea. - Kew Bull. 39 (3).

——— (1985): *Decaspermum (Myrtaceae)* in New Guinea. - Kew Bull., Vol.40 (1).

Seifritz, W. (1923): The Altitudinal Distribution of Plants on Mt.Gedeh, Java - Bull. Torrey Bot. Club 50, 283-305.

Sleumer, H. (1986): A Revision of the Genus *Rapanea* Aubl. (*Myrsinaceae*) in New Guinea. - Blumea 31, 245-269.

Smith, A.C. (1941/42): Studies of Papuasian Plants, Parts I-V. - J. Arnold Arbor. 22, 60-80, 231-252, 343-374, 497-528; 23, 417-443.

Smith, J.M.B. (1974): Origins and Ecology of the Non-Forest Flora of Mt. Wilhelm, New Guinea. - Ph.D. Thesis, Australian Nat.Uni. Canberra, 270p.

——— (1975): Mountain Grasslands of New Guinea. - J. Biogeography 2, 27-44.

——— (1977): Vegetation and Microclimate of East- and Westfacing slopes in the Grasslands of Mt Wilhelm, Papua New Guinea. - J. Ecol. 65, 39-53.

——— (1977a): An Ecological Comparison of Two Tropical High Mountains (Mt Wilhelm, Mt Kinabalu). - J. Trop .Geogr. 44, 71-80.

——— (1980): Origins, Affinities and Distribution of the High Altitude Flora (N.G.). - In : P.van Royen ed., The Alpine Flora of New Guinea, Vol. I, 133-153.

——— (1980): Ecology of the High Mountains of New Guinea. - In : P.van Royen ed., The Alpine Flora of New Guinea., Vol. I, 111-133.

Souter, G. (1963): New Guinea, The Last Unknown. - Angus & Robertson, London.

Stapf, O. (1894): On the Flora of Mt Kinabalu in North Borneo. - Transact. Linn. Soc. London, 2nd Ser., Botany 4, 69-263.

Steenis, C.G.G.J. van (1934-1936): On the Origin of the Malaysian Mountain Flora. Part.1: Facts and Statements of the Problem. - Bull. Jard. Bot. Buitenzorg, Ser.III, Vol. 13., livre 2, 1934, 135-262, Part.2 : Altitudinal Zones, General Considerations and Renewed Statement of the Problem. Id. Ser. III, Vol. 13, livre 3, 1935, 289-417, Part 3 : Analysis of the Floristic Relationships. Id. Ser. III, Vol. 14, Part 1, 1936, 56-72.

———— (1937): Over de Flora van den Carstensztop. - In : Dr A.H.Colijn (ed.), Naar de Eeuwige Sneeuw van Tropisch Nederland, Scheltens & Giltay, Amsterdam, 254-279.

———— (1953): Papuan Nothofagus. - J. Arnold Arbor. 34, 301-374.

———— (1954): Vegetatie en Flora van Nieuw Guinea. - In : Nieuw Guinea, W.C.Klein (ed.), Staatsdrukerij - s'Gravenhage / Netherlands. (English Summary), Vol 2, 218-253.

———— (1957): Outline of Vegetation Types in Indonesia and some Adjacent Regions. - Proced. 8th Pacif. Sci. Congr., 4, 61-97.

———— (1961): An Attempt towards an Explanation of the Effect of Mountain Mass Elevation. - Proc. Kon. Ned. Ak. Wet. A'dam, Ser. C 64, 435-442.

———— (1962): The Mountain Flora of the Malaysian Tropics. - Endeavour 21, 183-193.

———— (1962): The Landbridge Theory in Botany.(With Particular Reference to Tropical Plants). - Blumea 11, 235-372.

———— (1963): Pacific Plant Areas (vol.1). - Manila Bureau of Printing, Nat. Inst. of Science and Technology, 297 pp.

———— (1964): Plant Geography of the Mountain Flora of Mt Kinabalu. - Proc. R. Soc. Lond., B 161, 7-38.

———— (1967): The Age of the Kinabalu Flora. - Malayan Nature Journal 20, 39-43.

———— (1971): Nothofagus, Key Genus of Plant Geography in Time and Space, Living and Fossil, Eeology and Phylogeny. - Blumea 19, 65-98.

———— (1972): The Mountain Flora of Java. -Brill, Leiden.

———— (1979): Plant Geography of East Malesia. - Bot. J. Linnean Soc. 79, N°2, 97-178.

———— (1985). The Australasian Generic Element in Malesia. -

Brunonia 8, 349-372.
Steenis, C.G.G.J.van (1986): An interesting new species of *Nothofagus* from New Guinea (*Fagaceae*). - Kew Bull.441, 732.
Stevens, P.F. (1982): Phytogeography and Evolution of the Ericaceae of New Guinea. - In: J.L. Gressitt (ed.), Monogr. Biology, 42, 331-354.
———— (1985): Malesian *Vireya* Rhododendrons - Towards an Understanding of their Evolution. - Notes Royal Bot. Garden, Edinburgh 43, No 1, 63-80.
Stevens, P.F. & J.F.Veldkamp (1980): The Mount Suckling Expedition 1972 (with Notes on the Flora and Vegetation of the Subalpine Region). - Botany Bull. 10, Div. of Botany, Office of Forests, Lae, P.N.G.
Streimann, H. (1983): The Plants of the Upper Watut Watershed of Papua New Guinea. - Nat.Bot. Gardens, Canberra, Australia, 209 pp.
Sturm, H. (1978): Zur Ökologie der andinen Páramoregion. - W.Junk Publ., The Hague, 121 p.
Touw, A. & J.F. Veldkamp, (1975): Een botanische Expeditie naar de Star Mountains, P.N.G. - Rijksherbarium, Leiden.
Taylor, B.W. (1957): Plant Succession on Recent Volcanoes in Papua New Guinea. - J. Ecol. 45, 233-243.
Temple, Ph. (1962): Nawok ! The New Zealand Expedition to New Guinea's Highest Mountains, (Mt Carstensz). - J.M. Dent. & Sons, London.
Trochain, J-L. (1980): Ecologie végétale de la zone intertropicale non désertique. - Univ. Paul Sabatier, Toulouse.
Troll, C. (1959): Die Tropischen Gebirge, ihre Dreidimensionale Klimatische und Pflanzengeographische Zonierung. - Bonner Goegr. Abhandl., Heft 25.
Turner, H. (1978): Enige Opmerkingen over Verspreidingspatronen in de Grasslandvegetaties in het Hooggebergte van Nieuw Guinea. - Unpublished Report, Rijksherbarium Leiden, 18pp.
UNESCO, (1958): Proc. Symp. on Humid Tropics Vegetation. Tjiawi, Indonesia, 312 pp.
UNESCO, (1963): Symposium on Ecological Research in Humid Tropics Vegetation. Kuching, Sarawak.
Vareschi, V. (1980): Vegetationsökologie der Tropen. - Ulmer Verlag, Stuttgart.
Veldkamp, J.F. (1978): A Botanical Trip to the Burgers Mt. and Mt Kegum P.N.G., 1977. - Rijksherbarium, Leiden.

——— (1984): A New *Poa (Graminaceae)* from New Guinea. - Blumea 30, 71-72.

Verstappen, H.Th. (1952): Luchtfotostudies over het Centrale Bergland van Nederlands Nieuw-Guinea. - Tijdschrift Koninklijk Nederlands Aardrijk Genootschap, 336-363, 425-431.

——— (1964): Geomorphology of the Star Mountains. - Nova Guinea, Geology 5, 101-158.

Versteegh, C. (1971): List of Plant names in the Dani Language. - Rijksherbarium Leiden, 2nd edition.

Vink, W. (1963): Report on the W.O.N.G.-Sponsored Participation in the 1963 C.S.I.R.O. Exp. to the Kubor Range (T.P.N.G.). - Rijksherbarium Leiden, unpubl. report.

——— (1965): Botanical Exploration of the Arfak Mountains. - Nova Guinea, Botany 22, 471-494.

——— (1985): The *Winteraceae* of the Old World: V. *Exospermum* links *Bubbia* to *Zygogynum*. - Blumea 31, 39-55.

Visscr, W.A. & J.J. Hermes (1962): Geological Results of the Exploration for Oil in Netherlands New Guinea, carried out by the 'Nederlandsche Nieuw Guinee Petroleum Maatschapij', 1935-1960. - Staatsdrukkerij - en Uitgeverijbedrijf, 265pp.

Wace, N.M. & J.H. Dickson (1965): The Terrcstrial Botany of the Tristan Da Cunha Islands. - Phil. Trans. Roy. Soc., B, 249, 273-360.

Wade, L.K. & D.N. Mc Vean, (1969): Mt Wilhelm Studies 1. The Alpine and Subalpine Vegetation. - A.N.U./B.G.1, 225 pp.

Waddel, E. (1972): Agricultural Evolution in the New Guinea Highlands. - Pacific Viewpoint No 1, 18-29.

Walker, D. (1966): Vegetation of the Lake Ipea Region, New Guinea Highlands : I. Forest, Grassland and 'Garden'. - J. Ecol. 54, 503-533.

——— (1968). A Reconnaissance of the Non-Arboreal Vegetation, Pindaunde Catchment, Mt Wilhelm, New Guinea. - J. Ecol. 56, 445-466.

——— (1970): The Changing Vegetation of the Montane Tropics. - Search, Australia and New Zeal. Ass. for the Advancement of Sci. I, 217-221.

Walker, O. (1972): Bridge and Barrier : The Natural and Cultural History of Torres Strait. - A.N.U./B.G. 3.

Warburg,O. (1893): Bcrgpflanzen aus Kaiser Wilhelmsland. - Bot. Jahrb. 16, 1-32.

Wasscher, J. (1941): The Genus *Podocarpus* in the Netherlands Indies. -

Blumea 4, 359-481.
Werner, W.L. (1984): Die Höhen- und Nebelwälder auf Ceylon, (Sri Lanka). - Thesis, Ruprecht Karls Univ. Heidelberg, Tropische und Subtropische Pflanzenwelt; Akademie der Wissenschaften und der Literatur, vol. 46, 226 pp.
White, T.C. (1942): Some Papuan Myrtaceae. - J. Arnold Arbor. 23, 79-93.
Whitmore, T.C. (1975): Tropical Rainforests of the Far East. - Clarendon Press, Oxford.
——— (1981): Wallace's Line and Plate Tectonics. - Clarendon Press / Oxford, 1-91.
——— (1982): Wallace's Line : A Result of Plate Tectonics (Surveying Major Plant-geogr. Trends). - Ann. Missouri Bot. Gard. 69, 668-675.
——— (1987): Biogeographical evolution of the Malay Archipelago. - Oxford Science Publications, Clarendon Press, Oxford, 147 pp.
Whitmore, T.C. & J.A.Sayer (eds.) (1992): Tropical deforestation and species extinction. - I.U.C.N., Chapman & Hall, London, 153 pp.
Wirz, P. (1931): Im Lande des Schneckengeldes. Errinnerungen und Erlebnisse einer Forschungsreise ins Innere von Holländisch Neuguinea. - Stuttgart.
Wollaston, A.F.R.(1914): An Expedition to Dutch New Guinea. - The Geogr. Journal 43, N°3, 248-273.
——— (1914): Mountaineering in Dutch New Guinea. - The Alpine Journal 28 (205), 296-304.

Appendix I: Meteorological records from Wamena (Baliem Valley):

138°55' E / 4°06' S

Altitude: 1550 m

Rainfall (mm):

	J	F	M	A	M	J	J	A	S	O	N	D	TOTAL
1973	212	277	305	284	116	78	45	34	48	85	156	128	**1768**
1974	124	139	172	166	102	82	78	51	45	42	78	199	**1278**
1975	216	281	346	197	107	74	52	123	68	81	177	338	**2060**
1976	194	163	219	114	89	136	127	180	49	165	208	240	**1884**
1977	--	--	--	--	--	--	--	--	--	--	--	--	**----**
1978	166	89	145	226	203	57	48	158	135	79	175	117	**1598**
1979	122	243	315	92	147	56	100	74	32	131	83	152	**1577**
1980	402	118	170	143	171	220	163	185	141	174	116	205	**2208**
1981	160	264	134	218	71	141	28	78	172	280	169	167	**1882**
1982	102	209	219	236	212	75	17	44	19	20	1	101	**1255**
1983	279	148	214	226	248	96	155	134	59	138	200	153	**2050**
1984	92	170	172	190	141	174	69	--	--	--	--	--	----
MEAN	**198**	**193**	**224**	**190**	**147**	**102**	**81**	**106**	**77**	**120**	**136**	**180**	**1754**

Number of rainy days:

	J	F	M	A	M	J	J	A	S	O	N	D	TOTAL
1973	19	23	22	24	11	13	11	11	10	11	13	13	**181**
1974	16	28	19	23	15	12	20	10	9	11	13	22	**198**
1975	18	22	23	28	17	18	6	15	15	29	22	23	**241**
1976	20	20	21	18	17	17	20	17	12	22	19	22	**227**
1977	--	--	--	--	--	--	--	--	--	--	--	--	**----**
1978	17	17	13	14	22	10	12	16	19	17	22	24	**203**
1079	16	23	29	11	19	9	13	6	5	11	12	18	**172**
1980	17	18	17	17	18	20	18	21	16	22	12	19	**215**
1981	19	19	15	20	9	13	4	10	15	16	17	15	**172**
1982	10	17	19	22	11	14	5	9	5	5	1	15	**133**
1983	25	16	18	19	16	17	16	17	18	18	20	12	**204**
1984	11	21	17	20	2	21	11	--	--	--	--	--	**----**
MEAN	**17**	**23**	**20**	**20**	**16**	**15**	**12**	**13**	**12**	**16**	**15**	**26**	**195/17**

Temperatures (°C): (mean) and (max/min)

	J	F	M	A	M	J	J	A	S	O	N	D	Mean
1973	18	18	19	19	20	20	20	20	20	19	18	18	19,1
	26/15	26/15	26/16	26/16	26/15	27/15	27/15	27/14	27/14	27/15	26/16	26/15	26.4/15.2
1974	18	19	19	19	19	19	20	20	20	19	19	18	19
	26/15	25/15	25/14	25/14	26/15	27/15	27/16	27/14	27/15	27/15	26/15	26/15	25.6/14.8
1975	18	18	18	19	20	20	21	20	20	20	19	19	19.3
	26/15	25/15	25/16	26/16	26/16	27/15	27/16	27/15	27/15	26/16	26/16	26/15	26/15.5
1976	19	19	19	19	19	19	20	20	20	19	19	20	19.4
	25/14	25/15	25/15	25/15	26/15	27/15	27/15	26/16	27/16	26/16	26/16	26/16	25.9/15.3
1977	--	--	--	--	--	--	--	--	--	--	--	--	-----
1978	20	19	20	19	20	21	21	22	19	20	21	20	20.2
	26/15	26/15	26/15	26/15	26/15	27/15	27/15	26/16	26/15	27/15	27/16	26/15	25.3/15.3
1979	20	20	20	21	20	20	20	20	--	--	--	--	20
	27/15	27/15	24/15	27/16	25/16	26/15	25/15	25/14	--	--	--	--	25.8/15.1
1980	21	21	21	21	22	21	20	20	20	21	22	21	20.8
	27/16	27/12	26/15	27/16	27/16	25/15	25/15	25/15	27/13	25/13	27/14	26/15	26.3/14.6
1981	19	19	20	20	21	20	19	19	19	20	20	21	19.7
	26/14	26/15	27/15	26/15	26/15	25/15	--/15	22/14	26/15	26/16	27/14	27/14	25.8/14.8
1982	20	19	18	20	19	19	17	18	19	20	20	20	19
	26/15	27/15	26/15	26/15	26/14	24/13	25/10	26/12	28/12	27/12	28/12	27/13	26/13
1983	19	20	20	20	20	19	18	19	19	19	19	20	19
	26/11	26/13	27/13	26/12	--/16	--/16	--/15	--/16	--/15	--/15	--/15	--/17	--/15
1984	20	20	20	20	19	19	--	--	--	--	--	--	-----
	--/15	--/16	--/16	--/15	--/16	--/16	--	--	--	---	--	--	-----
MEAN (11 YEARS)	19.3	19.3	19.5	19.7	19.9	19.7	19.6	19.8	19.4	19.7	19.8	19.7	19.6

Appendix II: Plants collected < 3000 m

Collection J-M.Mangen
1982,1983,1984

Acanthaceae	Sp. non id.	346
Apocynaceae	Parsonsia cf. alboflavescens (Denn.)Mabb.	353
	Parsonsia cf. cyathocalyx MGF	337
Aquifoliaceae	Ilex versteeghii Merr.& Perry	325
	Ilex sp.1	152
	Ilex sp.2	304
Araliaceae	Sp. non id. (sterile)	387
	Schefflera cf.setulosa Harms	273
Araucariaceae	Araucaria cunninghamii Sw.	390
Asteraceae	Arrhenechtites novoguincensis (Moore) Matff. ssp. novoguineensis Koster	1190
	Olearia velutina Mattf.	263, 270
Bignoniaceae	Tecomanthe volubilis Gibbs	249
Burmanniaceae	Burmannia disticha L.	351
Casuarinaceae	Gymnostoma sp.	368
Clusiaceae	Garcinia sp.	351
Cunoniaceae	Acsmithia reticulata (Schltr.) Hoogland	371
	Caldcluvia fulva (Schltr.) Hoogl.	383
Cyatheaceae	Cyathea sp.	265
Dicksoniaceae	Dicksonia hieronymi Brause	663
Ebenaceae	Diospyros sp.	355
Elaeocarpaceae	Elaeocarpus sp.	290
Epacridaceae	Trochocarpa nutans	243
Ericaceae	Dimorphantera obtusifolia Sleumer	351 A
	Dimorphantera amblyornidii (Becc.) F.v.M. var.steinii (Sleumer)Stevens	352
	Rhododendron beyerinckianum Koord.	322
	Rhododendron herzogii Warb.	327
	Rhododendron macgregoriae F.v.M.	336
	Rhododendron sp.	310
	Vaccinium acrobracteatum K.Schum.	348, 358
	Vaccinum convallariifolium J.J.S.	318
	Rhododendron scabridibracteum Sleumer	253
	Rhododendron villosulum J.J.S.	254, 266
	Vaccinium brachygyne J.J.S.	255
Euphorbiaceae	Acalypha hellwighii Warb.in Engl. cf.var.mollis (Warb.)Schum.&Ltb	168
	Acalypha sp.	354
	Bischoffia javanica Bl.	367

	Breynia sp.	283
	Glochidion sp.1	135
	Glochidion sp.2	163
	Glochidion sp.3	166
	Glochidion sp.4	382
	Glochidion sp.5	386
	Glochidion sp.6	392
	Homalanthus sp.	288
	Macaranga sp.1	297
	Macaranga sp.2	394
	Homalanthus arfakensis Hutch. in Gibbs	252
Fagaceae	Castanopsis sp.	362, 384
	Lithocarpus sp.	391
	Nothofagus brassii van Steenis	389
	Nothofagus grandis	385
	Nothofagus rubra	317
	Nothofagus stylosa v.Steenis sp.n.	280
	Nothofagus sp. sterile	334
	Sp. non id.	364
Gesneriaceae	Cyrtandra spp	293, 302
Googeniaceae	Scaevola oppositifolia R.Br.	378
Hymenophyllaceae	Hymenophyllum odontophyllum Copel.	1184
	Hymenophyllum reinwardtii V.d.B.	278
Lauraceae	Cryptocarya sp. (sterile)	286
	Sp. non id.(sterile)	359
Leguminoseae	Strongylodon archboldianus Merr.&Perry	316
Liliaceae	Dianella ensifolia L.	377
	Pleomele sp.	165
Lindsayoidaceae	Lindsaya rigida J.Sm.in Hook	335
Loganiaceae	Fagraea bodenii Wernh.	319
	Fagraea ceilanica	1193
	Geniostoma anterotrichum Gelg. (Bened.) var.archboldianum Conn.	158
Loranthaceae	Amyema finisterrae (Warb.) Danser	616
	Amyema strongylophyllum Danser ssp.risidiflorum	151
	Amyema wichmannii (Krause) Danser	636
	Macrosolen suberosus	345
Lycopodiaceae	Lycopodium cernuum L.	373
	Lycopodium volubile Forst.	375
	Lycopodium clavatum L.s.l.	247
Marattiaceae	Marattia sp.	300
Melastomaceae	Medinilla rubiginosa Cogn.	321
	Medinilla spp.	308 (sterile),323,339

Monimiaceae	Steganthera parvifolia (Perk.)Kan.& Hat.	268
	Steganthera hirsuta (Warb.) Perk.	305
	Spec. non id. (sterile)	344
	Palmeria hypargyrea	257
Moraceae	Ficus spp.	311, 341, 348, 369
Myrsinaceae	Rapanea leucantha K.Schum.	307
	Rapanea acrostica Mez.	267
	Rapanea cacuminum Mez.	275
	Baeckea frutescens L.	332
	Eugenia spp.	357, 363 (sterile),395
	Metrosideros ? sp. (sterile)	329
	Octomyrtus pleiopetala (F.v.M.)Diels	150
	Xanthomyrtus montivaga Scott	372
	Xanthomyrtus sp.	620
Nepenthaceae	Nepenthes maxima Reinw.	328
Orchidaceae	Glossorhyncha spp.	330, 376
	Glossorhyncha sp.	262
	Mediocalcar sp.	260
Pandanacea	Freycinetia cf.sterrophylla M.v.P.	282
Piperaceae	Piper gibbilimbum DC.	167
	Piper spp.	285, 301
Pittosporaceae	Pittosporum berberoides Burk.	1192
	Pittosporum ramiflorum(Z.&Mor.)Z.ex Miq.	365, 164
Poaceae	Isachne myosotis Nees in Hooker	422
	Pennisetum macrostachyum (Bron.)Trim.	370
	Isachne arfakensis Ohwi	1186
Podocarpaceae	Dacrycarpus imbricatus (Bl.) Laut.	279
	Podocarpus archboldii Gray	320
	Dacrycarpus compactus (Was.)Laut.	261
	Dacrycarpus sp.(juv.)	246
	Phyllocladus hypophyllus Hook f.	271
	Podocarpus brassi Pilger	256
Polygonaceae	Muehlenbeckia monticola Pulle	248
Polypodiaceae	Crypsinus taeniatus (Su.) Copel.	277
Proteaceae	Grevillea papuana Diels	157
	Helicia sp.	303
Ranunculaceae	Clematis phanerophlebia M. & P.	314
	Ranunculus brassii Eichler	1187
Rhamnaceae	Rhamnus nipalensis (Wal.)Laws.ex Hook.	159, 350b
Rosaceae	Prunus costata (Hemsl.) Kalkman	403
	Prunus spp.(sterile)	296, 361
	Prunus costata (Hemsl.) Kalkman	245
	Prunus grisea (C.Muell.) Kalkm.var.grisea	276
Rubiaceae	Amaracarpus sp.	299

	Psychotria spp.	360, 366
	Timonius belensis Merr.& Perry	356
	Timonius carstenensis Wernh.	294, 381
	Wendlandia paniculata Roxb.	349
	Wendlandia spp.	379, 156
Rutaceae	Evodia spp.	162, 274,291,298
	Tetractomia tetrandum (Roxb.)Merr.	289
	Evodia sp. (sterile)	274
	Melicope sp./ Tetractomia sp.?	272
Santalaceae	Cladfomyza kaniensis (Pilg)Stauff.	160
	Exocarpus pullei (Pilg)?	340
Sapinadeae	Spp.non id.	338, 342
	Dodonea angustifolia L.f.	154
Saurauiaceae	Saurauia sp.1 (sterile)	287
	Saurauia sp.2	315
	Saurauia sp.3	326
	Saurauia sp.4	343
Saxifragaceae	Carpodetus arboreus (K.Sch.& Ltb.)Schl.	324
	Carpodetus cf.major Schltr.	258
Selaginellaceae	Selaginella caulescens (Spr.)	347
Sphenostemonaceae	Sphenostemon sp.	312
Sterculiaceae	Heritiera/ Tarrieta sp.	281
Symplocaceae	Symplocos cochinchinensis Lour.ssp. leptophylla (Brand) Noot. var. orbicularis (Hemsl.) Noot.	244
	Symplocos cochinchinensis Lour. ssp. leptophylla (Brand)Noot.var. reginae (Brand) Noot.	259
	Symplocos sp.	259
Theaceae	Eurya brassii Kobuski	264
Thelipteridaceae	Thelipteris sp.	374
Trimeniaceae	Trimenia papuana Ridl.	388
Urticaceae	Cypholophus cf.vestitus Miq.	284
	Lecanthus sp.	309
	Cypholophus sp.	1188, 1191
Violaceae	Viola papuana Beck. & Pulle	1189
Winteraceae	Zygogynum sp.(Bubbia)	306
Zingiberaceae	Alpinia sp.	333
	Sp.non id.	292

Appendix III:

Flora of Mt Trikora: A checklist of the species (> 3000 m)

	L.J. BRASS, BRASS & MEIJER-DREES,1939	J-M. MANGEN 1982; 1983; 1984
SPERMATOPHYTA		
GYMNOSPERMAE		
Cupressaceae		
Libocedrus papuana (F.v.Muell.)Li	9241,9242,9243,9667,10431	222, 235, 404
Podocarpaceae		
Dacrycarpus compactus (Wassch.)Laubenfels	9291	—
Phyllocladus hypophyllus Hook.f.	9058,9090,10432	220
Podocarpus brassii Pilger	9341,9342,9560,10435,10436	615
ANGIOSPERMAE		
Monocotyledonae		
Centrolepidaceae		
Centrolepis fascicularis Labill.	9173,9760	881, 882, 1166
Centrolepis philippinensis Merr.	9593,10022	446,480,532,566,568,695,696,697,912, 987,996,999,1012,1047,1055,1067,1077, 1119,1120,1167,1227
Cyperaceae		
Carex appressa R.Br.	9248	—
Carex bilateralis Hayata		551, 957, 1110, 1132, 1136
Carex brachyathera Ohwi	9803,9970	593, 597, 803, 964, 1135,1144,1150
Carex breviculmis R.Br.var.montivaga (S.T.Blake)Noot.	9032,9339,9582,9759	575, 1057

Carex breviculmis R.Br.var.perciliata Kük.	—	462, 512, 517, 692, 693,805,1235
Carex capillacea Boott.	9751	1129
Carex capillacea Boott.var.sachalinensis (F.Sch.)Ohwi	9085	—
Carex celebica Kuk.	—	806, 810
Carex cf.celebica Kuk.	—	542
Carex curta Good.	9037,9119,9539	—
Carex echinata Murr.	9583	809
Carex filicina Nees.	9210	802, 807, 818
Carex gaudichaudiana Kunth	9923,9234	537, 579, 582, 808,1034,1062,1149, 1234
Carex pseudocyperus L. var. fascicularis (Sol.ex Boott.)Boott.	9211	—
Carex sarawaketensis Kuk.	9828,10046,10080	—
Carex sp.	9235	
Carpha alpina R.Br.	9925,10078	460, 799, 804, 979, 1160
Gahnia javanica Zoll.& Mor.	9047,9704,9989	181, 545, 1070
Machaerina sp.?	—	815, 816
Machaerina teretifolia (R.Br.)Koyama	—	618, 817
Oreobolus cf.ambiguus Kük.& Steen.	9579	1118
Oreobolus pumilio R.Br.	9244	400, 442, 511, 561, 814
Schoenus curvulus F.Mueller	9973	—
Schoenus maschalinus R.& S.	9236	691, 1080, 1140, 1233
Schoenus nitens (R.Br.)Poir.	9724	564
Schoenus setiformis S.T.Blake	9478,9998,9724pp.	—
Scirpus crassiusculus (Hooker)Bentham	9324,9984	—
Scirpus fluitans L.	—	438, 995
Scirpus mucronatus L.ssp.clemensiae Kuk.	9069,9439	—
Scirpus subcapitatus Thw.	—	546, 813, 995
Scirpus subtilissimus (Boeck.)S.T.Blake	9238	—

Scirpus sp.	9443	—
Uncinia compacta R.Br.var.alpina Noot.	—	909
Uncinia compacta R.Br.var.compacta	—	800, 848, 1026
Uncinia riparia R.Br.	—	801, 1095, 1230
Eriocaulaceae		
Eriocaulon alpinum v.Royen	9226,9956	428, 449, 563, 668, 1065,1156,1260
Eriocaulon distichoides Mangen sp.nov.	—	1164
Eriocaulon pulvinatum v.Royen	9997	565, 997, 1157
Eriocaulon tubiflorum v.Royen	9231,9282,9288,9318	423, 1058
Iridaceae		
Sisyrinchium pulchellum Jansen	9216	206, 635, 1123
Juncaceae		
Juncus effusus L.	—	734
Juncus prismatocarpus R.Br.	9046,9578	617
Luzula papuana Jansen	9175	730, 963, 993, 1106
Liliaceae		
Astelia alpina Skottsb.	9188,9679,10217,10332	196, 459, 906, 977
Orchidaceae		
Bulbophyllum muricatum J.J.S.	—	1169
Bulbophyllum sect.Megaloglossum	—	1173
Bulbophyllum ssp.	9017,9229,9247,9314,9369,9507 9531,9595,9905	655, 746
Calanthe sp.	9055,9112,9673,9115	—
Ceratostylis sp.	9056,9350,9503	242, 419
Coelogyne sp.	9227	—
Dendrobium sect.Latourea	—	744
Dendrobium sp.	9020,9022A,9031,9076,9404,9458 9532,9533,9596,9675,9953,10430	—
Giulianettia sp.	9351	—
Glomera sp.	9041,9042,9057,9073,9212,9405	654, 1097

	9526,9534,10013	
Glossorhyncha spp.	—	212, 238
Habenaria sp.	9013	—
Mediocalcar crenulatum J.J.Sm.	—	603
Microtathorchis sp.	9347,9407,9670,9860,9924	—
Octarrhena cf.lorentzii J.J.S.	—	1100
Octarrhena spp.	—	239, 604, 645
Pedilochylus sp.	—	1075
Phreatia sp.	9086,9289,9527	619
Platanthera elliptica J.J.S.	—	747
Pterostylis sp.	—	681, 745
Poaceae		
Agrostis avenacea Gmel.	9821,10116	1107
Agrostis rigidula Steud.var.remota	9050,9576,9674,9717,9864,9928,10064, 10069	469,509,515,536,539,540,509,558,574, 669,698,702,710,724,726,731,732,733, 739,949,1074,1128,1199,1217,1257
Anthoxanthum horsfieldii(Ben.)Reed.var. angustum (Hitch.)Schouten	9117,9577, 9712, 9830, 10075,10062, 10075	514,541,592,690, 701,705,711,725,735, 1001,1050,1109,1244,1245
Anthoxanthum redolens (Vahl)Royen var. longifolium (Hitchc.)Schouten	9049pp, 9461pp	707, 720
Anthoxanthum redolens (Vahl)Royen var. redolens	9049pp, 9461pp	712,934,960,963b,1225
Brachypodium sylvaticum (Huds.)Beauv.	—	1213
Brachypodium sylvaticum (Huds.)Beauv.var. pubifolium (Hitchc)Jansen	9310,9714,9827	—
Bromus insignis Buse var.scopulorum (Chase)	9127,9825	1251
Cortaderia archboldii (Hitchc)Con. & Edgar	9822	628
Danthonia oreoboloides (F.v.M.)Stapf	9184,9818,9941,10159	427, 447, 448, 530, 580, 728,835,945, 1014,1060,1160
Danthonia vestita Pilger	—	717

Deschampsia klossii Ridl.	9048,9312,9425,9846,10060,10063, 10162,10311	474, 538, 549, 703, 709,714,722,737
Deschampsia klossii Ridl.f.prolifera	9848, 10065	704, 721
Deyeuxia brassii (Hitchc)Jansen	9711,9927,10213,	470, 550, 719, 723, 733,962,980,1072
Deyeuxia pusilla (Reed)Jansen	9185	510, 562
Deyeuxia stenophylla Jansen var.chaseana (Bor.)Veldk.	---	706, 716, 1134
Deyeuxia sp.	9969	
Dichelachne crinata (L.f.)Hooker	9802	---
Dichelachne rara (R.Br.)Vickery var.rara	---	736, 1133
Festuca crispato-pilosa Bor.	9425,9547,9747,9823,9824,9976	547, 700, 708, 718, 978,989,1071,1108, 1247,1249
Festuca? jansenii Mgf-Dbg.	9128,9715	591, 715, 961, 1105, 1127, 1224,1248
Festuca parvipaleata Jansen	10061,10066,10070,10071	727,950,1250
Imperata conferta (Presl)Ohwi	10235	1161
Isachne arfakensis Ohwi	---	1079
Isachne myosotis Nees in Hooker	9556	---
Poa clavigera Veldkamp	---	452, 473, 490, 894,924, 1025
Poa crassicaulis Pilg.	9338,10079	497, 589, 743, 901, 1258
Poa epileuca (Stapf)Stapf	9581,9816,10074	---
Poa erectifolia Hitchc.	9945	---
Poa hentyi Veldkamp	---	461, 989,1198, 1201, 1202, 1252
Poa inconspicua Veldkamp	---	445, 689, 981
Poa jansenii Veldkamp	9929	---
Poa keysseri Pilg.var.keysseri	---	740, 742
Poa keysseri Pilg.var.brassii (Hitchc.)Veldk.	9844	---
Poa lamii Jansen	---	513, 559, 573, 1063
Poa lunata Chase	10067	594,614,994,1024, 1226
Poa multinodis Chase	9584	---
Poa nivicola Ridl.	10040,10068,10073,10206,10347	741, 845, 928
Poa papuana Stapf	---	1204, 1205, 1207,1255,1259

Poa parva Veldk.	—	1002,1206
Poa pilata Chase	9554,9580,9942,10153,10205	560, 569, 1021
Poa rigidula Veldk.	—	951, 1203
Poa wisselii Jansen	—	1146
Trisetum bifidum (Thunb.)Ohwi	9118	—
Dicotyledoneae		
Apiaceae		
Hydrocotyle sibthorpioides Lamarck	9320,9473,9474,9545,9687,9811,9812, 98110088,10349	840, 976, 1114, 1147, 1238?
Oreomyrrhis bifida sp.nov.	—	918
Oreomyrrhis brassii	10095,10207	457
Oreomyrrhis buwaldiana M.et C.	10082	454
Oreomyrrhis papuana Buw.	9323,9708	662, 885, 899, 1041, 1126,1148
Oreomyrrhis pumila Ridl.	9517,9982,10083	491, 842, 843, 844, 904,923,929,1006, 1023,1216,1228
Oreomyrrhis sp.	—	841
Trachymene flabellifolia Buw.	9586	1078
Trachymene koebrensis (Gibbs)Buw.	9529	1117
Trachymene novoguineensis (Domin)Buw.	9343,9944,9985,10019,10387	495, 940, 947, 1040
Trachymene papillosa Buw.	9754	778, 779
Trachymene pulvilliforma Buw.	9426	660, 680, 1221
Trachymene sp.	—	218
Apocinaceae		
Alyxia cacuminum Markgraf	9114	—
Parsonsia vaccinioides (Markgr.)Markgr.	9306	—
Araliaceae		
Schefflera altigena Frodin	9091, 9601, 9639	1242
Schefflera pagiophyllla Harms	9424,9988	—
Schefflera setulosa Harms	9377	—

Schefflera sp.	—	228
Asteraceae		
Abrotanella papuana Moore	10157,10388	482, 578, 827, 938, 969,1010,1053,1068
Anaphalis hellwigii Warb.	9222,10115,10234	1083
Anaphalis mariae F.Muell.	10117,10699	187, 768, 971, 1165
Anaphalis papuana (Laut.)Koster	10017,10048,10348	—
Bedfordia versteeghii Mattf.	9146,9832	169, 656
Cotula altilitoralis v.Royen & Lloyd	9975	—
Cotula wilhelminensis v.Royen	10034	828, 829,1011
Erigeron sumatrensis Retz.	—	786
Gnaphalium breviscapum Mattf.	9025,9587	502, 581, 825, 884, 900,1159
Gnaphalium cf.brassii v.Royen	—	492, 498, 824
Gnaphalium heleios v.Royen	10216	—
Gnaphalium involucratum Forst.	—	788
Gnaphalium japonicum Thunb.	9120	1121
Ischnea elachoglossa F.Muell.f.elachoglossa	9177,9739	823, 1168
Ischnea elachoglossa F.Muell.f.nana Koster	9396,9978,9980,100039,10096,10155	450, 674, 919, 974, 985
Keysseria extensa Koster	10161	—
Keysseria gibbsiae (Merr.)Cabrera ex Steenis	—	1222
Keysseria pinguiculiformis Koster f.nana	10085,10158	477, 503, 821, 983
Keysseria pinguiculiformis Koster f.ping.	9922	602, 793, 888, 973
Keysseria radicans (F.Muell.)Mattf.	9190,9209,9742,9862,9981,10160	194, 595, 769, 1029
Keysseria wollastonii (Moore)Mattf.	9837,10077,10208	202, 485, 921
Lactuca laevigata (Bl.)DC. var. laevigata	—	791, 1125
Lactuca laevigata (Bl.)DC.var.pusilla(Mat.)Koster	9204,9193,9732	415, 464, 831, 911, 1000,1052
Lactuca laevigata (Bl.)DC.var.pygmaea(Z.et Mor.)K.	9588,10084,9729	830
Myriactis cabrerae Koster	9083A	1170
Olearia durifolia Koster	9935,10110	—
Olearia velutina Mattf.	9143,9659,9820,10438	170, 659, 780
Olearia sp.	9968	—

Rhamphogyne papuana Koster	9191,9555	—
Senecio brassii Belcher	—	557, 1104
Senecio sp.	9393,9552,9719,9799	—
Senecio versteegii Mattf.	9146,9832	—
Tetramolopium coralloides Koster	10047	205
Tetramolopium fasciculatum Koster	10097,10238	849, 886
Tetramolopium klossii (S.Moore)Mattf. forma klossii Koster	9419,9418,9420,9428,9805,9919,10134, 10212,10344	173, 458, 1142, 1214
Tetramolopium klossii (S.Moore)Mattf. forma lanceolatum Koster	9025,9657	676, 1045,1154, 1218, 1231
Tetramolopium lanatum Koster	9349,9765	—
Tetramolopium piloso-villosum (S.Moore)Mattf.	10050	471
Tetramolopium prostratum Mattf.	9979,10049,10051,10052,10130,10052, 10154,10346	204, 476, 756, 822, 889
Tetramolopium sp.	10183	1044, 1122
Tetramolopium tenue Koster	9327	—
Tetramolopium wilhelminae Koster	9413	—
Brassicaceae		
Cardamine altigena Schltr.ex Schultz.	9285,9472,9741,10026	556
Lepidium minutiflorum (Ridl.)Hewson	9986,10053,10334	435,935,956
Boraginaceae		
Myosotis australis R.Br.	9124,9718,10076	416, 472, 790, 922, 1103
Myosotis sp.	—	1007
Trigonotis abata Johnston	9477,9838,9541	—
Trigonotis culminicolis v.Royen	—	436
Trigonotis papuana (Hemsl.)Johnston	9176,10042,10105,10106,10215	430, 528, 6799, 965
Trigonotis sp.	—	895
Campanulaceae		
Lobelia angulata Forst.	9222,9287,9735	1197
Wahlenbergia confusa Merr.& Perry	9399,9721	607

Caryophyllaceae		
Cerastium papuanum Schltr. ssp. keysseri (Schltr.)Moschl.	10089	455,488,781,883,926,1229
Cerastium papuanum Schltr. ssp. papuanum	10081	--
Cerastium papuanum Schltr. ssp. sphaenops Mattf.var.eciliatum Mattf.	9122,9720	585, 834, 1115, 1211
Sagina belonophylla Mattf.	10021,10086	456, 489, 930, 931, 935,1004,1008
Sagina papuana Warb.	9202,9438a,9744,10041	444, 925, 1020, 1022, 897
Sagina sp.	—	499
Clusiaceae		
Hypericum japonicum Thunb.ex Murr.	9198,9753	—
Hypericum macgregorii F.Muell.	9043,9681,10119	177, 402, 970
Hypericum papuanum Ridl.	9261	1185
Daphniphyllaceae		
Daphniphyllum gracile Gage	9525	—
Dipsicaceae		
Triplostegia glandulifera Wallich in DC.	9208	839, 870, 1048
Droseraceae		
Drosera peltata J.E.Sm.	9195	832, 1061
Elaeocarpaceae		
Elaeocarpus arfakensis Schlechter	9092,10434	—
Sericolea calophylla (Ridl.)Schltr.ssp.	9267	634
Epacridaceae		
Styphelia suaveolens (Hook.f.)Warb.	9033,9135,9459,9460,9911,9931,9932, 10099,10302	175, 463, 519, 670, 675,892
Trochocarpa dekockii (J.J.Sm.)Lam	9034,9185A,9677,9930,9996,10343	467, 527, 672, 785, 914
Trochocarpa nubicola (Wernh.)Sleumer	9065,9096,9101,9574,9665,9910,10341	669
Trochocarpa nutans (J.J.Sm.)Lam	9640	233, 263
Trochocarpa sp.(sterile)	—	751

Ericaceae		
Dimorphantera alpina J.J.Sm.var.alpina	—	232
Dimorphantera alpina J.J.Sm.var.pubigera Sleum.	9363	—
Dimorphantera amblyornidis (Becc.)F.Mueller var. steinii (Sleumer)P.F.S.	—	352
Dimorphantera obtusifolia Sleumer	9201,9573	—
Dimorphantera sp.	—	227
Diplycosia edulis Schlechter	9067	—
Diplycosia sp.	—	230
Gaultheria mundula F.Muell.	10128,10324	190
Gaultheria mundula F.Muell.var.tanytherix(Sl.)Sl.	9223	749, 752
Gaultheria novaguineensis J.J.S.	10114	—
Gaultheria pullei J.J.S.	9056,9763	209, 648, 753
Rhododendron agathodaemonis J.J.S.	9271	1179
Rhododendron beyerinckianum Koorders	9200,9280,9281,9570	223
Rhododendron brassii Sleumer	9026,9130,9139,10232	208, 748, 1180
Rhododendron caespitosum Sleumer	9039,9692	—
Rhododendron correoides J.J.S.	9093,9095,9276,9277,9400,9402,9416, 9417,9644,9652,9800,9833,9835	518, 657, 1033
Rhododendron culminicolum F.Muell.	9403,9668	643
Rhododendron culminicolum F.Muell. var.culminicolum	—	1084
Rhododendron culminicolum F.Muell. var. nubicola (Wernh.)Sleumer	9141,9569	—
Rhododendron disterigmoides Sleumer	9022	—
Rhododendron flavoviride J.J.S.	9378	—
Rhododendron gaultheriifolium J.J.S.	9024,9661	—
Rhododendron gaultheriifolium J.J.S. var. expositum Sleumer	9415,9918,10113,10122,10331	188, 600, 1155
Rhododendron haematophthalmum Sleumer	9023,9094,9151,9571	638

Rhododendron helodes Sleuemr	9014a,9284,9316	—
Rhododendron microphyllum J.J.S.	9486	—
Rhododendron oreites Sleumer	9627,9654,9992	—
Rhododendron pusillum J.J.S.	9917,10091,10093,10118,10120,10121	200, 958
Rhododendron revolutum Sleuemr	9528	—
Rhododendron rhodochroum Sleumer	9152,9572	—
Rhododendron rubrobracteatum Sleumer	9278,9279	—
Rhododendron saxifragoides J.J.S.	9565,9566,9748,10184	182, 1208
Rhododendron scabridibracteum Sleumer	—	642
Rhododendron schizostigma Sleumer	9275,9567	—
Rhododendron subcrenulatum Sleumer	9274,9315,9568	—
Rhododendron tuberculiferum J.J.S.	—	1172
Rhododendron versteegii J.J.S.	9014,9081,9916,10059,10333,10059,	179, 1031
Rhododendron yelliotii Warb.	—	171
Rhododendron sp.	—	185
Vaccinium brachygyne J.J.S.	9366,9558	—
Vaccinium capillatum (Sl.)Sleumer	10442	—
Vaccinium cf.sororium J.J.S.	9054,9317	795, 1137
Vaccinium coelorum Wernh.	10209	946, 1009, 1137b, 1138
Vaccinium crassiflorum J.J.S.	9181,9575,10038	—
Vaccinium debilescens Sleumer	9307,9352,9480	625
Vaccinium decumbens J.J.S.	9018,9653	219, 796, 1178
Vaccinium densifolium J.J.S.	9421,9643,9653A,9961a,9913,9913a, 10329	819
Vaccinium dominans Sleumer	9066,9290,9422,9484,9636,9663, 9938,10440	172, 651, 750, 1175
Vaccinium minuticalcaratum J.J.S. f.glabrum	9364,9502	—
Vaccinium oranjense J.J.S.	9622,9666,9865	193, 652
Vaccinium oranjense J.J.S. var. marginellum (Sl.)Sleumer	9224,9804,9904A	—

Vaccinium oreites Sleumer	9053,9150,9270,9642	649
Vaccinium quinquefidum J.J.S.	9654,9994	641, 1086
Vaccinium subulisepalum J.J.S.	—	1032, 1091b
Vaccinium wollastonii Wernh.	9624,10386	—
Vaccinium spp.	—	236, 529, 623, 629,794
Fagaceae		
Nothofagus stylosa Steen.	—	229
Gentianaceae		
Gentiana alpinipalustris v.Royen	9237,9591	605
Gentiana carinicostata Wernh.	9726A	876, 1018
Gentiana cf.lorentzii Koorders	9591	—
Gentiana cf.nerteriifolia v.Royen	—	466
Gentiana cruttwellii H.Smith	—	890, 966, 1005, 1049
Gentiana ettingshausenii F.Muell.	?	777, 877, 1013, 1038, 1056
Gentiana cf.ettingshausenii F.Muell.	?	898, 908, 944, 967, 1069,1130,1153, 1239,1240,1241
Gentiana macgregorii Hemsl.	—	605b, 879
Gentiana pungens v.Royen	9180	—
Gentiana spp.	9726,9793,986610389	408, 577, 878
Geraniaceae		
Geranium balgooyi Veldkamp	—	687
Geranium lacustre Veldkamp	—	990, 1243
Geranium monticola Ridl.	9868,10185	399, 493, 717, 738, 910
Geranium wilhelminae Veldkamp	9207,9813,10186	553, 688,1112,1027,1212
Haloragaceae		
Gonocarpus halconensis (Merr.)Orchard	9262	—
Gonocarpus micranthus Thunb.	9194,9435	576, 887, 955, 1051, 1066,1196
Lauraceae		
Endiandra sp.(sterile)	—	237
Litsea alveolata	9559,9959	—

Loranthaceae		
Amyema wichmannii (Krause)Danser	9361,9489	231
Myrsinaceae		
Rapanea cacuminum Mez	9080,9550	269, 761, 762, 763, 765, 766,767,1088
Rapanea papuana (Hemsl.)Mez	9638,9791,9936	650, 762b, 764
Rapanea sp.	10441,10433	
Myrtaceae		
Decaspermum nivale (Ridl.)Merr.& Perry	9225,9142,9479,9734,9810	621, 1237,405
Decaspermum sp.	—	632
Xanthomyrtus compacta (Gibbs)Diels	9018,9074,9269,9462,9625,9641,9904, 10125,10377	184,211,406,420,544,610b,611,673,757, 759,760
Ongraceae		
Epilobium detznerianum Schltr.ex Diels	9206,9408,9615,10016,10043,10045	201, 432, 451, 937, 1016, 1143
Epilobium hooglandii Raven	9814,10015	771, 1131
Epilobium keysseri Diels	9148,9546,9592,9750	—
Epilobium prostratum Warb.	9686	—
Epilobium sp.	—	418, 785, 789
Oxalidaceae		
Oxalis magellanica Forst.f.	9475,10025	686, 606
Piperaceae		
Piper trombek v.Royen	9309,9134	—
Pittosporaceae		
Pittosporum pullifolium Burk.	9087A,9798,9955,9993,10129,10211	180, 1177
Pittosporum ramiflorum (Zoll.& Mor.) Miq.	9387	—
Plantaginaceae		
Plantago aundensis v.Royen	9457,9819,10220	500, 571, 572, 772, 773,784
Plantago depauperata Merr.& Perry	9199,9921,10135	478, 820, 915, 939
Plantago stenophylla Merr.& Perry	9456,9920	—
Polygonaceae		
Muehlenbeckia monticola Pulle	—	624, 774

Polygonum benguetense Merr.& Perry	9036,9437	---
Polygonum minus Huds. ssp.decipiens Danser	9436,9512	---
Polygonum minus ssp. depressum Danser	9544	---
Polygonum nepalense Meissn.	---	792
Polygonum runcinatum D.Don ssp.papuanum Dans. var. alpinum v.Royen	9123,9260	---
Polygonaceae non id.	---	1171
Portulacaceae		
Montia fontana L.	9972	838
Potamogetonaceae		
Potamogeton sp.	9513	---
Ranunculaceae		
Ranunculus amerophylloides Eichler	9245,9792	555, 685, 1037, 1076,1030
Ranunculus angustipetalus Merr.& Perry	9866A	413, 501, 570, 678,1054
Ranunculus basilobatus Eichler	---	396, 414, 1111
Ranunculus bellus Merr.& Perry	9867	426, 982
Ranunculus cf.pseudolowii Eichler	9395,10030,10132	412, 596, 1174
Ranunculus coacervatus Merr.& Perry	9727A	---
Ranunculus consimilis Eichler	---	486, 588, 682, 847, 1113
Ranunculus habbemensis Merr.& Perry	9689	216,411, 683, 1116
Ranunculus perindutus Merr.& Perry	9727,10027,10132	587, 684, 920
Ranunculus perpusillus Merr.& Perry	10381	---
Ranunculus psilophyllus Eichler	9709	410
Ranunculus tridactylus Eichler	9740	---
Ranunculus tridens Ridl.	---	968
Ranunculus spp.	---	992, 1017
Thalictrum papuanum Ridl.var.oranjense	---	424
Rosaceae		
Acaena anserinifolia (J.R.& G.Forst.)Domin	9137	584
Potentilla brassii Merr.& Perry var. brassii	9839,10133	661, 941, 986, 1232,1046b,1264

Potentilla brassii Merr.& Perry var. simplex Kalkman	—	531,1043,1046
Potentilla foersteriana Laut.var.foersteriana	—	397, 535,903,905,1028
Potentilla habbemana Merr.& Perry	9553,9590,9594	441,783,917
Potentilla indivisa Kalkman	—	1163
Potentilla irianensis Kalkman	—	398,494,927
Potentilla mangenii Kalkman	—	495b,902
Potentilla papuana Focke	9543, 9746	—
Potentilla parvula Hook.f.ex Stapf	9394,9863	552, 836, 837, 984, 1152, 1162
Potentilla simulans Merr.& Perry	9594a	590
Potentilla wilhelminensis van Royen	Versteeg 2534	—
Potentilla sp. (enigmatic!)	—	496
Prunus costata (Hemsl.)Kalkman	9035,9103,10428,	215, 627
Prunus grisea (C.Muell.)Kalkman var.microphylla Kalkman	—	221
Prunus pullei (Köhne)Kalkm. var. pullei	9647,9995	—
Rubus ferdinandi-muelleri Focke	9132	—
Rubus lorentzianus Pulle	9131	838, 1094
Rubus papuanus Schltr.ex Diels	—	1124
Rubus tsiri v.Royen	9133	—
Rubus sp.(sterile)	—	631
Rubiaceae		
Coprosma archboldiana Merr.& Perry	9411,9817,9831	520, 671, 972, 975
Coprosma brassii Merr.& Perry	9807,9809,9842,9843,10221	431, 846
Coprosma habbemensis Merr.& Perry	9367	775, 1182
Coprosma novoguineensis Merr.& Perry	9028,9063,9144,9145,9705,9706,9707, 9933,9939,9940,10378,10380	1195, 1210
Coprosma sp.	—	437, 653
Galium novoguineense Diels	9511,9548,9859	—
Galium rotundifolium L.	9321	—
Galium subtrifidum Reinw.	9268	—

Hedyotis trichoclada Merr.& Perry	9197,9752	425, 880
Hedyotis valetoniana Merr.& Perry	9326	---
Hedyotis ? sp.	---	1219
Hydnophytum archboldianum Merr.& Perry	9240,9492,9586	---
Myrmecodia brassii Merr.& Perry	9446	---
Myrmecodia cf.lamii Merr.& Perry	9445	646
Nertera granadense (Mutis)Druce	9397,10382,9398,9476	---
Psychotria lorentzii Valeton	9239	225
Timonius trichocladus Merr.& Perry	9504,9505	---
Rutaceae		
Acronychia murina Ridl.	9309,9537	226
Evodia oligantha Merr.& Perry	9365	---
Tetractomia tetrandrum (Roxb.)Merr.	---	217, 647,626
Rutaceae non id.	---	626, 776
Santalaceae		
Cladomyza microphylla (Laut.)Danser	9016,9664	210, 637, 1098
Saurauiaceae		
Saurauia alpicola A.C.Smith	9140,9552	1085
Saurauia sterrolepida Diels	9353	---
Saxifragaceae		
Astilbe rivularis D.Don	9263	1183
Carpodetus arboreus (K.Sch.& Laut.)Schltr.	---	639
Quintinia altigena Schltr.	---	1176
Scrophulariaceae		
Euphrasia cf.culminicola Wernh.	---	465
Euphrasia humifusa Pennell	9971,10187	609, 896
Euphrasia mirabilis Pennell	9794,9191	---
Euphrasia spatulifolia Pennell	9731,10044	---
Euphrasia versteegii (Diels) Du Rietz	9412,10118	440, 605b, 943, 1145
Parahebe ciliata (Pennell)Royen & Ehrend.	9682,10092,10094,10098,10101,10104	203, 483, 907, 1141

Parahebe polyphylla (Pennell)Royen & Ehrend.	9401,9414,9934	677, 1015, 1209
Parahebe rigida (Pennell)Royen & Ehrend.	10090	—
Parahebe sp.	—	417, 433, 782
Veronica archboldii Pennell	9313,9683,9749,9861,10163	1215
Symplocaceae		
Symplocos cochinchinensis Lour.ssp.leptophylla (Brand)Noot.var.orbicularis (Hemsl.)Noot.	9019,9027,9340,9518,9549,9912,9937, 10014,10127,10237,10429,10437	613, 622, 811, 1091,1093
Theaceae		
Eurya brassii Kobuski	9189,9658	191, 554, 770, 851, 1087
Eurya brassii Kobuski ssp.subrotunda (Kob.)Bar.	9808	—
Eurya platyptera Barker	9906,9909,10124,10330	—
Thymeleaceae		
Drapetes ericoides Hook.f.	9183,9671,9806,9977	183, 534, 567, 797, 893,1064,1081
Urticaceae		
Parietaria debilis Forster	9826,10345	—
Pilea alpestris Ridl.	10087	954, 1019
Pilea johniana Stapf	9099,9815	443, 453, 487, 504, 875,891
Pilea sp.	9292,9293,10020	—
Urtica dioica L.	9129	—
Violaceae		
Viola arcuata Blume	9521	787
Winteraceae		
Drimys piperita Hook.f.entity 'reducta'	9068,9536	178, 612, 640, 644
Drimys piperita Hook.f.entity 'reticulata'	—	234
Drimys piperita Hook.f.entity 'rubiginosa'	9104	—
Drimys piperita Hook.f.entity 'subpittosp.'	10111,10126	953
Drimys piperita Hook.f.entity? 'reticulata'	9362,9491	224a, 224b

PTERIDOPHYTA		
Aspidiaceae		
Polystichum alpinum Ros.	9344,9483,9766,9967,10338	—
Polystichum archboldii Copel.	9850	—
Polystichum cheilanthoides Copel	9801,10102	952
Polystichum meyer-dreesii Copel.	10037	—
Polystichum papuana C.Chr.	9136,10055,10112	—
Aspleniaceae		
Asplenium brassii C.Chr.	9854	—
Asplenium hepalophyllum Ros.	9220,9296,10029	—
Asplenium minutum Copel.	10107	—
Asplenium setisectum Bl.	9297	—
Asplenium sp.	—	611b
Athyrium minutum Copel	—	522, 525, 610, 1220
Athyrium meyer-dreesii Copel.	9851	—
Athyrium setiferum C.Chr.	9857	—
Diplazium thunbergii Nakai ex Momose	9303	—
Blechnaceae		
Blechnum hieronymi Brause	9600,9442	—
Blechnum nudius Copel	9328,9966	526, 871
Blechnum revolutum (v.A.v.R.)C.Chr.	—	1090
Cyatheaceae		
Cyathea aeneifolia (v.A.v.R.)Domin	9311	—
Cyathea atrox C.Chr.	9444	—
Cyathea macgregorii F.v.M.	9283	
Cyathea muelleri Bak.	9423,9430,10023	599
Cyathea tomentosissima Copel.	9113,9116	186, 598

Davalliaceae		
Humata brassii Copel.	9097,9678	—
Humata pusilla (Mett.)Curr.	—	856, 857, 858, 859, 872
Dennstaedtiaceae		
Hypolepis archboldii Copel.	9852	—
Dicksoniaceae		
Dicksonia costalixora Copel.	9488	—
Dicksonia hieronymi Brause	9485	—
Dryopteridaceae		
Dryopteris beddomei (Bak.)Kuntze	9319	—
Dryopteris paleacea C.Chr.	9138	—
Equisetaceae		
Equisetum ramosissimum Ceesf.	9429,9628,9685	1139
Gleicheniaceae		
Gleichenia bolanica Ros.	9044,9626,9655,10123	861, 1089
Gleichenia erecta C.Chr.	9100	630
Gleichenia vulcanica Blume	9082,9182	192, 543, 1035
Gleichenia sp.	—	601
Grammitidaceae		
Calymnodon cf.cucullatus (N.&Bl.)Presl.	9374	401, 484, 860
Calymnodon fragilis Copel.	9943,10035	—
Calymnodon ramifer Copel.	9616,9943A	—
Ctenopteris allocata (v.A.v.R.)Copel.	9466	—
Ctenopteris bipinnata Copel.	9433	—
Ctenopteris bipinnatifida (Bak.)Copel.	9903	—
Ctenopteriy blechnoides (Grev.)Wagn.& Greth.	—	1101
Ctenopteris brassii Copel.	9302,9463,9564,9651	—
Ctenopteris fusca Copel.	9897	523, 865
Ctenopteris nutans (Bl.)J.Sm.	9218	866
Ctenopteris pendens (Ros.)Copel.	9300,9301,9464,9465,9467,9469,9856	—

Ctenopteris sesquipinnata Copel.	9510	—
Ctenopteris solida (Mett.)Copel.	9174	—
Ctenopteris whartoniana (C.Chr.)Copel.	9468,9470,9764,9895	—
Grammitis caricifolia Copel.	9410	—
Grammitis debilifolia Copel.	10036	195
Grammitis dictymioides Copel.	9059,9375	—
Grammitis fasciata Blume	—	1200
Grammitis fasciculata Blume	10042A	—
Grammitis frigida(Ridl.)Copel.	9111	506, 1236
Grammitis integra (Brause)Copel.	9358	—
Grammitis knutsfordiana (Bak.)Copel.	9376	—
Grammitis locellata (Bak.)Copel.	9219,9848A	—
Grammitis meyer-dreesii Copel.	9898	—
Grammitis mollipile (Bak.)Copel.	9841	
Grammitis novoguineensis Copel.	9853	—
Grammitis rigida (Ridl.)Copel.	9631,9858,9899,10037,10108	—
Grammitis scabristipes (Bak.)Copel.	9102,9676,9849	—
Grammitis stomatocarpa Copel.	9630	—
Grammitis subrepanda (Brause)Copel.	9266	—
Grammitis trochophylla Copel.	9855	—
Prosaptia davalliacea (Bak.)Copel.	9650	—
Scleroglossum pusillum (Blume)v.A.v.R.	9329	—
Hymenophyllaceae		
Hymenophyllum bismarckianum	9250	—
Hymenophyllum brassii	9106,9249,9299,9345	—
Hymenophyllum denticulatum v.d.B.	—	1003
Hymenophyllum foersteri Ros.	9797,9900	507, 853
Hymenophyllum imbricatum Bl.	9373	—
Hymenophyllum melanosorum	9172,9602,9797A,9901,9902,10210 10327	—

Hymenophyllum ooides Muell.&Bak.	10106A,10204	505, 855
Hymenophyllum rubellum Ros.	9107,9298,9648	240, 665, 873, 1099
Hymenophyllum sp.	---	852, 854
Pleuromanes? pallidum (Blume)Copel.	9392,9535	---
Isoetales		
Isoetes habbemensis Alston	9440,9441,9974	---
Lamaropsidoideae		
Elaphoglossum bolanicum Ros.	---	1223
Elaphoglossum habbemense Copel.	9083	---
Elaphoglossum sclerophyllum v.A.v.R.	9088,9354,9355,10032	---
Lycopodiaceae		
Lycopodium carolinianum L.	9187	575, 869
Lycopodium cernuum L.f.pungens	9186,9540	---
Lycopodium clavatum L.s.L.	9075,9105,9632,9646,9840,10028, 10031,10379	374, 633, 666, 1096
Lycopodium complanatum L.f.corniculatum	9179	---
Lycopodium kaysseri Hert.&Schltr.	---	508
Lycopodium scariosum Forst.	9084A	---
Lycopodium selago L.f.minor	9213	---
Lycopodium selago L.f.groenlandicum	9038,9999	
Lycopodium ssp.	---	521, 867, 1042, 1082
Lycopodium versteegii v.A.v.R.	9896,9915	---
Plagiogyriaceae		
Plagiogyria glauca (Bl.)Mett.	9482	---
Plagiogyria papuana C. Chr..	---	174
Plagiogyria tuberculata Copel. var.decrescens C.Chr.	---	664
Plagiogyria sp.	10335,9660,9954	---
Polypodiaceae		
Belvisia spicata (L.f.)Mirbel ex Copel.	9071,9684,10010,10011,10054	---
Belvisia squamata (Hieron.ex C.Chr.)Copel.	9072	---

Belvisia validinervis Copel.	—	213, 862
Crypsinus albido-squamatum (Bl.)Copel.	9432	—
Crypsinus gracilipes (v.A.v.R.)Copel.	9061,9196	—
Crypsinus lamprophyllus (C.Chr.)Copel.	9447	—
Crypsinus subundulatus (Ros.) Copel.	9060	864
Loxogramme subselliguea (Bak.)Alston	9221	—
Polypodium subrepandum Brause	9266	—
Polypodium crassimarginatum Copel.	9030	—
Selliguea crassisova (C.Chr.)Copel.	9070	—
Selliguea feei (Bary)Mett.	9029,9487,9629,9649,10009,10109?, 10337	—
Selliguea plantaginea Brak.	—	613 b, 667, 863
Selliguea werneri (Ros.)	—	1102
Pteridaceae		
Histiopteris caudata (Copel.)Holttum	9294	—
Pteris montis-wilhelminensis Alston	9045,10056	197, 475
Schizaeaceae		
Schizaea fistulosa	—	868,1158
Schizaea malaccana Bak.	9089,1018,10385	942
Schizaea sp.	—	1158
Selaginellales		
Selaginella sp.	9471	—
Synopteridaceae		
Cheilanthes papuana C.Chr.	9147,9767,9965,10057,10058,10339	524, 583
Tectarioideae		
Ctenitis habbemensis (Copel.)Copel.	9217,9304	—
Ctenitis hypolepioides (Ros.)Copel.	9295	—
Thelypteridaceae		
Thelypteris oligolepia (v.A.v.R.)Ching	9062	—

BRYOPHYTA		
Acanthocladum hornschuchii (D.& M.) Fl.	9386	---
Anoectangium anomalum Bartr.	—	P44R
Anomobryum hyalinum T.Kop.& Norris	—	P44S
Anomobryum bulbiferum Bartr.	10164	—
Atractylocarpus dicranoides Dix.	9258, 9454, 9455, 9757,9790,	---
	9889,10199,10315,10328c	---
Barbula wisselii Dix.	10167	936E
Bartramia conica Bartr.	10419	—
Bartramia cubica Dix.	—	P45B
Bartramia halleriana Hedw.	9869, 9962,10352	—
Blindia myer-dreesii Bartr.	10356	---
Brachymenium gracile Bartr.	10167a	---
Brachymenium nepalense Hook.	9878, 9880	---
Brachythecium cymbifolium Bartr.	9875	---
Braunfelsia dicranoides (Doz. et Molk.)Brot.	—	P55D
Breutelia aristifolia Zant.	—	P55A
Breutelia roemeri Fleisch.	9699b	—
Breutelia roemeri Fleisch.	---	P55B
Brotherobryum macgregorii (Broth. Diels)Fl.	9158	---
Brotherobryum dekockii Fl.	9745	---
Bryum longidecurrens Bartram	9254	---
Bryum novo-guineense Bartr.	10164a	---
Bryum pachytheca C.Müll.	---	P44E
Bryum rugicollum Bartr.	9691, 9725, 9891, 10005,10369a	—
Bryum sclerodictyon Dix.	10000	—
Bryum truncorum Brid.	10320	—
Bryum sp.	---	P44E, 936G
Calliergonella cuspidata (Hedw.)Loeske	—	P43A, P44N

Campylopus cf. crispifolius Bartr.	---	P44P
Campylopus cf.aureus Bosch ez Lac.	---	P44D
Campylopus cf.austro-subulatus Broth.et Geh.	---	P46B
Campylopus macgregorii Broth.et Geh.	---	P47A
Campylopus sp.	---	P44C
Ceratodon purpureus (Hedw.)Bri.	---	P44B
Chaetomitrium longisetulum Bartr.	9870a,9890,10002a,10024	P44G, P46A
Cirriphyllum sp.	---	936C
Daltonia angustifolia D.& M.	9877, 9891a, 10004	---
Daltonia sp.		P43C
Dawsonia beccarii Broth.	9251, 9991	---
Dawsonia limbata Dix.	9723	---
Dicnemon archboldii Bartr.	9450	---
Dicranodontium nitidum (D.& M.)Fl.	9387a	---
Dicranoloma arfakianum (C.M.)Broth.	9384, 9768, 9886	---
Dicranoloma assimile (Hop)Broth.	9500a	---
Dicranoloma blumii (Nees)Par.	9496, 9699, 9885,10317	P55C
Dicranoloma rugifolium Bartram	9252	---
Didymodon recurvirostra (Hedw.)Jennings	10419a	---
Distichium capillaceum (Hedw.)B.S.G.	10201, 10364,10370	936A
Distichophyllum cucullatum Bartr.	9500	---
Distichium capillaceum (Hedw.) Bry.Eur..	9874, 10140, 10141,10203	---
Ditrichum colignii Dix.	9874b	---
Ditrichum flexifolium (Hook.)Hpe.	9259	---
Ditrichum sericeum Bartr.	10393a, 10398	---
Ditrichum sp.	---	P88C
Drepanocladus cf.revolvens (Sw.)Warnst.	---	P44H, P45C
Ectropothecium palustre Bartr.	9255	---
Ectropothecium palustre Bartr.	---	P88D
Ectropothecium sp.	---	P44K

Encalypta vulgaris Hedw.	10190	P45A, 936F
Eriopus parviretis Fl.	10366	—
Eutosthodon brassii Bartr.	10416	—
Eutosthodon cavifolius Bartr.	9452	---
Eutostodon contortus Bartr.	10399a	---
Eutosthodon subulatus Bartr.	1036510399	---
Funaria hygrometrica Hedw.	9253	---
Grimmia apocarpa Hedw.	10200a	---
Gymnostomum anomalum Bartr.	9497, 9736, 9796,10372	---
Holomitrium cirrosum Bartr.	9498, 9498, 9697, 9876,9888,	---
	10001,10148, 10189,10196,10198	—
Holomytrium austro-alpinum Bartr.	9257, 10008,10166,10202,10411	P55E, P80A
Hylocomium sp.	—	P88A
Hypnodendron auricomum Broth. & Sch.	9382,9493	---
Hypnodendron dendroides (Brid.)Touw	10507	---
Isopterygium novo-guineense Bartr.	9873, 10326,10328a	---
Leptostomum perfectum Bartr.	9561, 9871,10321,10324	---
Leskeodon rotundifolius Bartr.	10319	---
Macrohymenium novo-guineense Reimers	9453, 9692, 9701, 9702a,9775	---
Macromitrium altipapillosum Bartr.	9155a, 9156, 9563	---
Macromitrium archboldii Bartr.	1018810323	---
Macromitrium erubescens Bartr.	9891, 9892	---
Macromitrium sp. (sterile)	—	P80C, P87
Macrothamnium hylocomioides Fleisch.	9385, 9389, 9698, 9699a,	—
	9870, 10024a	—
Meesea triguetra (Hook.&Tayl.) Aongstr.	9256	—
Meteorium miguelianum (C.M.)Fl.	9872a	—
Mnium rostratum Schrad.	9773	—
Orthotrichum brassii Bartr.	10136, 10165	—
Plagiomnium cordatum T.Kop.& Norris	—	P43D

Plagiothecium neckeroideum Bry.Eur.	9790a, 10313,10328b	---
Pogonatum alpinum (Hedw.)Roehl.	10393	---
Pogonatum humile Bartr.	9690	---
Polytrichadelphus archboldii Bartr.	9689	---
Polytrichum gracile Diels	9154, 9743	---
Racomitrium crispulum	10200, 10201a	---
Racomitrium javanicum Dozy et Molk.	---	P43E, P44A, P45
Racomitrium lanuginosum (Hedw.)Brid.	---	P51A
Rhacocarpus purpurascens (Brid.)Par.	---	P51B
Rhodobryum giganteum (Hook.)Schp.	9383, 9585	---
Schlotheimia pilicalyx Broth. & Geh.	9161, 9171, 9695a, 9696,	P80B
	9883, 9884, 9887, 10197,	---
	10322, 10373	---
Sphagnum antarcticum Mitt.	9737	---
Sphagnum cuspidatum Ehrh.	9448, 9758	---
Sphagnum junghuhnianum Doz.& Molk.	9738	---
Spiridens reinwardtii Nees.	9494	---
Streptopogon sp.	---	936B
Taphoria novo-guineensis Bartr.	9499	---
Tayloria longiseta Bartr.	9693, 9872	---
Tetraplodon lamii Reimers	9160, 9431, 9987, 10002,10397	---
Tetraplodon mnioides (Hedw.)B.et S	---	936D
Trichostomum cf. subulifolium Bartr.	9874a, 10369	P44Q
Ulsta rubella Bartr.	10374	---
Ulsta splendida Bartr.	10137	---
Warburgiella subleptorrhynchoides (Fl.)Fl.	---	P55F
Wijkia hornschuchii (Dozy et Molk.)Crum.	---	P88B
Zygodon intermedius B.S.G.	9756, 9774, 9879, 9882,10226	P43
Zygodon novo-guineensis Bartr.	10139, 10141a	P43B, P45D,
Zygodon hookeri Hpe.	9700, 9789,10328	---

APPENDIX IV: Table 1: Phytosociological records

VEGETATION UNIT :		UM transition forest	Subalpine Rain Forest				
RELEVE N°		**39**	**36**	**78**	**22**	**30**	**32**
ALTUTUDE (m)		3150	3400	3460	3650	3680	3740
NUMBER OF SPECIES		38	37	30	34	23	36
TOTAL COVER (%)		100	100	100	100	100	80
DECLIVITY (°)		5	45	35	30	50	45
EXPOSURE		N	S-E	E	N	S-E	S
SOIL PROFILE N°		39	36	78	22	30	32
SPECIES	**LIFE FORM**	**COVER AND ABUNDANCE**					
TREES AND SHRUBS:							
Saurauia alpicola	MesPscap	.	.	4	.	.	.
Dacrycarpus compactus	MesPscap	4	.	.	.	.	.
Schefflera altigena	MesPscap	2	2	4	6	6	2
Libocedrus papuana	MesPscap	8	.	.	.	.	.
Vaccinium dominans	MiPcaesp	.	.	4	7	4	5
Pittosporum pullifolium	MiPcaesp	1	2	.	2	3	2
Rhododendron brassii	MiPcaesp	1	2	.	.	.	.
Rapanea cacuminum	MiPcaesp	4	3	4	5	5	4
Rhododendron cul.var.cul.	MiPcaesp	.	.	4	.	.	.
Rhododendron correoides	MiPcaesp	.	.	4	5	4	5
Symplocos coch. var.orb.	MiPcaesp	.	.	2	.	1	3
Rapanea papuana	MiPcaesp	.	4	.	.	.	6
Sericolea calo.ssp.calo.	MiPscap	.	4	.	.	.	.
Prunus costata	MiPscap	2	2	3	.	.	.
Phyllocladus hypophyllus	MiPscap	4	.	.	.	.	.
Eurya brassii	NPcaesp	.	.	4	1	.	4
Bedfordia versteeghii	NPcaesp	.	+	2	3	.	.
Drimys piperita 'reducta'	NPcaesp	4	2	3	2	3	4
Gaultheria m. var.tanytherix	NPcaesp	.	2	.	.	.	.
Vaccinium cf.subulisepalum	NPcaesp	.	.	2	.	.	.
Tetractomia tetrandum	NPcaesp	.	4	.	.	.	.
Olearia velutina	NPcaesp	.	3	2	4	.	3
Vaccinium quinquefidum	NPcaesp	.	.	4	.	.	.
Rhododendron gaultheriifolium	NPcaesp	6	2	3	2	4	3
Coprosma brassii	NPcacsp	1	3	2	3	2	3
Vaccinium densifolium	NPcaesp	.	4	.	.	.	.
Vaccinium debilescens	NPcaesp	.	+	.	.	.	.
Vaccinium cf.oreites	NPcaesp	.	4	.	.	.	.
Trochocarpa nubicola	NPcaesp	1	3	2	2	3	2
Xanthomyrtus compacta	NPcaesp	2	6	4	.	7	.

RELEVE N°		39	36	78	22	30	32
Gaultheria mundula	NPcaesp	.	.	.	+	.	3
Rhododendron versteegii	Chfrut	1	2	.	.	.	.
Styphelia suaveolens	Chfrut	2	4	1	3	3	2
Vaccinium oranjense	Chfrutrept	4	2	.	3	4	4
Vaccinium decumbens	Chfrutrept	.	1	.	5	.	4
Trochocarpa dekockii	Chfrutrept	.	.	.	.	.	2
Euria brassii(creeping)	Chfrutrept	.	.	.	.	2	.
Vaccinium coelorum	Chfrutrept	.	.	.	.	.	3
Xanthomyrtus compacta(creeping)	Chfrutrept	.	.	.	.	3	.
Tetramolopium k.f.klossii	Chsuff	2	.	.	.	3	2
LIANAS:							
Rubus lorentzianus	PLsuff	1	.	.	1	.	.
Tecomanthe volubilis	PLsuff	4	.	.	.	.	.
Rubus sp.	PLsuff	.	+	.	.	.	.
Alyxia cacuminum	PLfrut	1	1	.	.	.	.
Lycopodium clavatum	Lherb	.	.	2	.	.	.
FERNS:							
Cyathea tomentosissima	MiPros	.	2	.	.	.	.
Cyathea muelleri	MiPros	.	.	.	+	.	1
Gleichenia sp.	Grhiz	.	3	.	.	.	.
Gleichenia bolanica	Grhiz	.	.	2	.	.	.
Blechnum revolutum	Grhiz	.	.	4	.	.	.
Plagiogyria tub.var.decrescens	Grhiz	3	5	.	4	.	.
Asplenium sp.	Grhiz	.	.	.	.	3	1
Ctenopteris blechnoides	Grhiz	.	.	2	.	.	.
GRASSES:							
Deschampsia klossii	Chherb	.	.	.	+	.	2
Danthonia oreoboloides	fChhpulv	.	.	.	.	.	3
Poa cf.multinodis	Hcaesp	.	.	.	+	.	.
Agrostis rigidula var.remota	Hcaesp	2	.	.	.	3	2
Anthoxantum r.var.redolens	Hcaesp	.	.	.	1	.	.
OTHER MONOCOTS.:							
Machaerina sp.	Chherb	3	.	.	.	.	.
Gahnia javanica	Chherb	5	1	.	.	2	3
Oreobolus pumilio	fChhpulv	.	.	.	.	2	4
Astelia alpina	fChhpulv	.	.	.	1	.	5
Uncinia c.var.compacta	Hcaesp	.	.	.	+	.	.
Uncinia riparia	Hcaesp	.	.	1	1	.	.
Sisyrinchium pulchellum	Hcaesp	2	.	.	.	.	.
Carex sp.	Hcaesp.	.	.	.	.	.	3

RELEVE N°		39	36	78	22	30	32
DICOT.HERBS:							
Trachymene papillosa	Chherb	2	.	.	.	.	.
Anaphalis mariae	Chsuff	.	.	.	1	.	+
Keysseria radicans	Hrept	.	.	.	2	.	+
Ranunculus habbemensis	Hsem	1	.	.	.	.	.
Potentilla foersteriana	Hsem	.	.	.	.	2	+
EPIPHYTES:							
Myrmecodia cf. lamii	ChEsucc	2	2	.	.	.	.
Calymnodon cf.cucullatus	ChEherb	.	.	.	+	.	.
Ctenopteris fusca	ChEherb	.	.	.	+	.	.
Selliguea werneri	ChEherb	.	.	3	.	.	.
Hymenophyllum ooides	ChEherb	.	.	.	+	.	.
Latourea sp.	ChEherb	+	.	.	.	.	.
Dendrobium sp.	ChEherb	+	.	.	.	.	.
Hymenophyllum sp.	ChEherb	+	1	.	.	.	+
Grammitis frigida	ChEherb	.	.	.	+	.	.
Humata pusilla	ChEherb	2	.	.	.	3	.
Bulbophyllum sp.	ChEherb	.	.	.	.	.	2
Selliguea plantaginea	ChEherb	3	4	.	.	.	.
Octarrhena cf.lorentzii	ChEherb	.	1	.	.	.	.
Hymenophyllum rubellum	ChEherb	4	.	3	.	.	.
Lycopodium sp.	ChEherb	.	3	.	+	.	2
Octarrhena sp.	ChEherb	.	.	3	.	.	.
Grammitis fasciata	ChEherb	2	.	.	.	.	.
Glomera sp.	ChEherb	.	.	2	.	.	.
Phreatia sp.	ChEherb	3	.	.	.	.	.
Platanthera elliptica	ChEherb	+	1	.	.	.	.
Hymenophyllum foersteri	ChEherb	.	.	.	2	.	.
Cladomyza microphylla	ChEfrut	.	1	3	.	.	.
MOSSES AND HEPATICS:							
unidentified taxa	BrChsph	9	8	8	8	7	4

APPENDIX IV: Table 2: Phytosociological records

VEGETATION UNIT		Treefern Shrublands				Treeline Shrubland	
RELEVE N°		**42**	**40**	**41**	**85**	**29**	**60**
ALTITUDE (m)		3000	3050	3000	3420	3950	3940
NUMBER OF SPECIES		28	28	22	25	33	24
TOTAL COVER %		100	100	100	100	90	100
DECLIVITY (°)		35	10	20	0	45	35
EXPOSURE		S	N	S-W	-	N	N
SOIL PROFILE (N°)		42	-	-	-	-	-
SPECIES	**LIFE FORM**	**COVER AND ABUNDANCE**					
TREES AND SHRUBS:							
Prunus costata	MiPcaesp	.	.	3	.	.	.
Vaccinium dominans	MiPcaesp	.	4	.	.	.	.
Rapanea cacuminum	MiPcaesp	2	.	.	.	.	.
Cyathea tomentosissima	MiPros	5	6	4	6	.	.
Drimys piperita 'reducta'	NPcaesp	5	.	4	.	.	.
Coprosma habbemensis	NPcaesp	4	.	.	.	.	.
Decaspermum nivale	NPcaesp	.	.	3	.	.	.
Xanthomyrtus compacta	NPcaesp	.	.	4	.	.	.
Coprosma novoguineensis	NPcaesp	.	.	.	.	7	4
Olearia velutina	NPcaesp	4	.	4	.	.	.
Vaccinium sp.623	NPcaesp	.	.	2	.	.	.
Tetractomia tetrandum	NPcaesp	3	.	4	.	.	.
Vaccinium sp.629	NPcaesp	.	.	1	.	.	.
Coprosma brassii	NPcaesp	.	.	.	4	.	.
Vaccinium debilescens	NPcaesp	.	.	3	.	.	.
Eurya brassii	NPcaesp	.	4	.	.	.	.
Rhododendron brassii	NPcaesp	+	.	.	.	.	.
Coprosma sp.	NPcaesp	.	.	2	.	.	.
Symplocos coch.var.orbicularis	NPcaesp	6	.	2	.	.	.
Rhododendron gaultheriifolium	NPcaesp	.	.	2	.	.	.
Rubus sp.(sterile)	PLfrut	2	.	.	.	.	.
Dimorphantera sp.	PLfrut	1	.	.	.	.	.
Rubus lorentzianus	PLsuff	2	2	.	.	.	.
Muehlenbeckia monticola	PLsuff	3	.	2	.	.	.
Myrmecodia lamii	ChEsucc	.	.	2	1	.	.
*Hypericum macgregorii**	Chfrut	.	3	.	.	.	.
Gaultheria pullei var.pullei	Chfrut	3	.	.	.	.	.
Styphelia suaveolens	Chfrut	4	.	2	4	5	5
Rhododendron versteegii	Chfrut	4	.	4	.	.	.
Rhododendron pusillum	Chfrut	.	.	.	.	2	.
Gaultheria mundula var.tanytherix	Chfrut	2	.	.	.	3	.
Eurya brassii (creeping)	Chfrept	.	.	.	3	.	.
Vaccinium oranjense	Chfrept	.	.	.	.	1	2

RELEVE N°		42	40	41	85	29	60
Trochocarpa dekockii	Chfrept	.	.	.	.	3	.
Rhododendron saxifragoides	gChfrutpulv	.	.	.	.	1	4
Drapetes ericoides	Chsuff	.	.	.	.	3	.
Parahebe ciliata	Chsuff	.	.	.	.	2	.
Tetramolopium prostratum	Chsuff	.	.	.	.	1	.
Tetramolopium klossi f. klossii	Chsuff	.	.	.	3	2	.
FERNS:							
Ctenopteris cf.fusca	ChEherb	2	.	.	.	.	.
Crypsinus subundulatus	ChEherb	2	.	.	.	.	.
Athyrium minutum	ChEherb	.	.	.	.	3	.
Hymenophyllum sp.	ChEherb	2	.	.	.	.	.
Selligua plantaginea	ChEherb	5	.	2	.	.	.
Belvisia validinervis	ChEherb	.	1	.	.	.	.
Hymenophyllum ooides	ChEherb	.	.	.	.	.	2
Ctenopteris nutans	ChEherb	2	.	.	.	.	.
Humata pusilla	ChEherb	3	.	.	.	.	.
Gleichenia bolanica	Grhiz	5	2	.	.	.	.
Gleichenia erecta	Grhiz	.	.	3	.	.	.
Gleichenia vulcanica	Grhiz	.	4	.	.	.	.
Lycopodium clavatum	PLherb	2	.	.	.	.	.
GRASSES:							
Deschampsia klossii	CHherb	.	4	.	2	5	3
Danthonia oreoboloides	fChhpulv	.	.	.	.	3	.
Agrostis rigidula var.remota	Hcaesp	.	4	.	2	1	2
Anthox.horsfieldii var.angustum	Hcaesp	.	2	.	.	.	.
Anthox.redolens var.lonifolium	Hcaesp	.	.	.	2	.	1
Bromus insignis	Hcaesp	.	.	.	2	.	.
Cortaderia archboldii	Hcaesp	.	.	2	.	.	.
Deyeuxia brassii	Hcaesp	.	.	.	2	.	3
Deyeuxia pusilla ?	Hcaesp	.	.	.	.	1	2
Deyeuxia.stenophylla var.chaseana	Hcaesp	.	.	.	.	4	.
Dichelachne rara var.rara	Hcaesp	.	6	.	.	.	.
Festuca ? jansenii	Hcaesp	.	.	.	3	.	.
Festuca parvipaleata	Hcaesp	.	.	.	4	4	.
Poa nivicola	Hcaesp	.	.	.	.	.	2
Poa sp.2	Hcaesp	.	.	.	.	.	2
OTHER MONOCOTS.:							
Gahnia javanica	Chherb	.	.	3	.	.	.
Astelia alpina	fChhpulv	.	.	.	4	4	4
Centrolepis philippinensis	fChhpulv	.	.	.	.	1	.
Carex filicina	Hcaesp	.	5	3	.	.	.
Carex capillacea	Hcaesp	.	.	.	1	.	.
Carex echinata	Hcaesp	.	1	.	.	.	.

RELEVE N°		42	40	41	85	29	60
Carex gaudichaudiana	Hcaesp	.	4	.	.	.	3
Carex celebica	Hcaesp	.	.	.	.	+	.
Juncus effusus	Hcaesp	.	3	.	.	.	.
DICOT.HERBS:		.	.	.	.	.	.
Lepidium minutiflorum	gChsufpulv	.	.	.	.	.	3
Sagina belonophylla	fChhpulv	.	.	.	.	.	2
Epilobium sp.	Chsuff	.	2	.	.	.	.
Epilobium detznerianum	Chsuff	.	.	.	.	+	1
Epilobium cf.hooglandii	Chsuff	.	.	.	4	.	.
Potentilla hooglandii	Hcaesp	2	.	.	.	3	.
Gentiana cf.ettingshausenii	Hcaesp	.	.	.	1	.	.
Polygonum nepalense	Hcaesp	.	2	.	.	.	.
Oreomyrrhis papuana	Hcaesp	.	.	.	2	.	.
Cerastium papuanum pap.var.ecil.	Hcaesp	.	+	.	.	.	.
Myosotis australis	Hcaesp	.	3	.	.	.	.
Potentilla sp.	Hcaesp	.	.	.	3	.	.
Stellaria sp.	Hcaesp	+	.	.	.	.	.
Oreomyrrhis pumila	Hcaesp	.	.	.	.	2	.
Gentiana sp.	Hcaesp	.	.	.	.	1	.
Oxalis magellanica	Hcaesp	.	1	.	.	.	.
Cotula wilhelminensis	Hrept	.	.	.	.	2	.
Hedyotis trichoclada	Hrept	.	+	.	.	.	.
Trigonotis sp.	Hrept	.	.	.	.	.	1
Gnaphalium breviscapum	Hrept	.	.	.	.	1	.
Trigonotis culminicola	Hrept	.	.	.	.	2	.
Cotula wilhelminensis	Hrept	.	.	.	.	.	1
Pilea johniana	Hrept	.	.	.	.	+	2
Gnaphalium sp.	Hrept	.	.	.	2	.	.
Trigonotis papuana	Hrept	2	.	.	.	.	.
Viola arcuata	Hrept	.	+	.	.	.	.
Keysseria radicans	Hrept	.	.	.	3	.	.
Plantago aundensis	Hros	.	.	.	4	.	2
Plantago depauperata	Hros	.	.	.	.	+	.
Ranunculus pseudolowii	Hsem	.	1	.	.	.	.
Lactuca laevigata var.laevigata	Hsem	.	2	.	2	.	.
Lactuca.laevigata var.pusilla	Hsem	.	.	.	.	2	.
Potentilla foersteriana var.foerst ?	Hsem	.	.	.	.	.	2
Geranium balgooyi	Hsem	.	2	.	.	.	.
Geranium.monticola	Hsem	.	.	.	.	2	2
Erigeron sumatrensis	Tscap	.	2	.	.	.	.
Senecio brassii	Tscap	.	2	.	2	.	.
MOSSES AND HEPATICS:							
Sphagnum spp.	BrChsph	8	.	.	.	.	.
unidentified taxa	BrChpulv	.	.	.	3	4	7

APPENDIX IV: Table 3 : Phytosociological records

VEGETATION UNIT		*Coprosma brassii - Styphelia suaveolens* heath				Dwarf shrub heath on shallow soils				Subalpine bog heath		
RELEVE N°		**75**	**81**	**82**	**71**	**20**	**31**	**52**	**53**	**7**	**14**	**16**
ALTITUDE (m)		3730	3460	3450	3520	3630	3690	3790	3790	3640	3630	3650
NUMBER OF SPECIES		13	29	15	23	21	17	21	22	13	17	13
TOTAL COVER (%)		80	-	80	80	50	70	70	80	70	75	70
DECLIVITY (%)		10	35	10	20	20	10	10	15	-	-	-
EXPOSURE		S	W	-	E	W	W	N	N	-	-	-
SOIL PROFILE (N°)		-	81	-	-	-	31	-	-	7	14	-
SPECIES	**LIFE FORM**	**COVER AND ABUNDANCE**										
TREES AND SHRUBS:												
Cyathea tomentosissima	MiPros	.	1	.	2	.	.	.	.	.	.	.
Rapanea cacuminum	MiPscap	.	1	.	.	.	.	.	.	.	.	.
Rhododendron gaultheriifolium	NPcaesp	.	.	5	3	.	2	.	.	.	.	.
Xanthomyrtus compacta	NPcaesp	.	2	.	.	.	.	.	.	.	.	.
Coprosma brassii	NPcaesp	2	1	.	3	.	.	.	.	.	.	.
Rhododendron correoides	NPcaesp	2	3	.	.	.	.	.	.	.	.	.
Drimys piperita	NPcaesp	.	1	.	2	.	.	.	.	.	.	.
Rhododendron g.var.expositum	Chfrut	.	.	.	.	4	.	4	2	.	.	.
Rhododendron versteegii	Chfrut	.	3	4	4	.	.	3	.	.	.	2
Styphelia suaveolens	Chfrut	7	6	4	.	2	3	2	3	3	2	4
Rhododendron saxifragoides	gChfpulv	3	.	.	4	.	.	.	.	5	.	.
Xanthomyrtus comp. (creeping)	Chfrutrept	.	.	.	.	.	1	.	.	.	.	.
Vaccinium cf.sororium	Chfrutrept	.	.	5	.	.	.	.	.	.	.	.
Vaccinium oranjense	Chfrutrept	.	5	.	3	.	.	.	.	.	.	.
Coprosma archboldiana	Chfrutrept	.	4	.	.	.	.	.	.	.	.	.
Vaccinium coelorum	Chfrutrept	2	.	.	.	.	.	.	.	.	.	.

RELEVE N°		75	81	82	71	20	31	52	53	7	14	16
Trochocarpa dekockii	Chfrutrept	.	5	.	4	2	+	3	3	1	2	3
Eurya brassii (creeping)	Chfrutrept	.	.	2	3	.	.	.	.	1	.	.
Vaccinium sp.(cf.decumbens)	Chfrutrept	.	.	.	.	.	.	.	.	1	.	4
Myrmecodia lamii(terrestre)	Chsucc	.	.	+	.	.	.	.	.	.	.	.
Parahebe ciliata	Chsuff	.	3	.	.	.	.	.	.	.	.	.
Drapetes ericoides	Chsuff	.	.	.	.	1	.	2	2	.	.	.
Tetramolopium kl.f.lanceolatum	Chsuff	.	.	.	.	.	.	4	.	.	.	.
Tetramolopium prostratum	Chsuff	.	+	.	.	.	.	.	.	.	.	.
Tetramolopium kl.f.klossii	Chsuff	2	.	6	3	4	4	.	5	+	5	4
Rubus lorentzianus	PLsuff	.	.	.	2	.	.	.	.	.	.	.
FERNS:												
Ctenopteris cf.fusca	ChEherb	.	2	.	.	.	.	.	.	.	.	.
Hymenophyllum sp.	ChEherb	.	+	.	.	.	.	.	.	.	.	.
Equisetum ramosissimum	Grhiz	.	3	.	.	.	.	.	.	.	.	.
Plagiogyria sp.	Grhiz	.	.	.	2	.	.	.	.	.	.	.
Lycopodium carolinianum	Hrept	.	.	.	2	.	2	.	.	.	3	.
GRASSES:												
Deschampsia klossii	Chherb	2	.	.	2	.	.	.	.	.	.	1
Danthonia oreoboloides	fChhpulv	.	.	.	.	2	1	3	2	.	2	.
Agrostis rig.var.remota	Hcaesp	2	3	3	2	2	4	3	4	1	3	2
Anthoxanthum h.var.angustum	Hcaesp	2	.	.	2	+	.	.	.	+	.	+
Deyeuxia pusilla	Hcaesp	.	.	.	.	3	.	.	3	.	.	.
Poa lamii	Hcaesp	5	.	.	5	.	.	.	.	7	5	4
Festuca parvipaleata	Hcaesp	.	2	.	.	.	.	.	.	.	.	.
Poa hentyi	Hcaesp	.	.	.	.	+	.	.	.	.	.	.
Festuca? jansenii	Hcaesp	.	2	.	.	.	.	.	.	.	.	.
Festuca crispato-pilosa	Hcaesp	.	.	.	.	.	.	3	.	.	.	.

RELEVE N°		75	81	82	71	20	31	52	53	7	14	16
OTHER MONOCOTS.:												
Ghania javanica	Chherb	1	.	2	3	2	.	.	.	.	3	2
Eriocaulon pulvinatum	fChhpulv	.	.	.	.	.	.	.	2	.	.	
Eriocaulon alpinum	fChhpulv	.	.	.	.	2	.	.	.	.	.	.
Centrolepis philippinensis	fChhpulv	.	.	.	.	.	1	.	1	.	4	.
Astelia alpina	fChhpulv	.	3	2	4	2	.	2	2	.	3	.
Schoenus maschalinus	fChhpulv	.	3	.	.	.	.	.	.	.	.	.
Oreobolus pumilio	fChhpulv	1	.	4	2	4	5	4	4	3	4	.
Carex brevic.var.montivaga	Hcaesp	.	.	.	.	.	.	.	.	.	2	
Carex gaudichaudiana	Hcaesp	.	3	3	.	.	.	.	.	.	.	1
Carex brachyathera	Hcaesp	.	3	.	.	.	.	.	.	.	.	.
Uncinia compacta var.alpina	Hcaesp	.	.	.	.	.	.	2	2	.	.	.
Carex sp.	Hcaesp	.	.	.	.	.	2	.	.	.	.	.
Carex brevic.var.perciliata	Hcaesp	.	.	.	.	2	.	.	.	+	.	.
Carex bilateralis	Hcaesp	.	2	.	.	.	.	.	.	.	.	.
Carpha alpina	Hcaesp	.	.	.	.	.	.	.	4	.	.	.
DICOT.HERBS:												
Epilobium sp.	Chsuff	.	2	.	.	.	.	.	.	.	.	.
Acaena anserinifolia	Chsuff	.	.	.	1	.	.	.	.	.	.	.
Euphrasia versteegii	Chsuff	.	.	.	.	.	.	2	1	.	.	.
Potentilla brassii	fChhpulv	.	.	.	.	2	3	1	2	.	.	.
Potentilla parvula	Hcaesp	.	2	.	.	.	.	.	.	.	.	.
Gentiana cf.ettinghausenii	Hcaesp	.	1	.	2	.	.	.	1	.	.	.
Gentiana sp.	Hcaesp	.	.	1	.	.	+	1	.	2	+	+
Potentilla sp.	Hcaesp	.	.	1	.	.	.	.	.	.	.	.
Gonocarpus micranthus	Hrept	.	.	.	.	.	3	.	.	.	2	.
Pilea johniana	Hrept	.	.	.	.	1	.	1	.	.	.	.
Plantago depauperata	Hros	.	.	.	.	1	3	4	3	.	1	.

RELEVE N°		75	81	82	71	20	31	52	53	7	14	16
Plantago aundensis	Hros	.	2	.	.	.	.	.	.	.	.	.
Lactuca laevigata var.pusilla	Hsem	.	.	.	.	1	.	2	2	.	+	.
Abrotanella papuana	Hsem	.	.	.	.	.	+	.	1	.	1	.
Potentilla foerst.var.foerst.?	Hsem	.	.	.	.	.	.	2	.	2	.	.
MOSSES AND HEPATICS:												
Sphagnum sp.	BrChsph	7	7	6	7	.	.	.	.	.	.	.
unidentified taxa	BrChpulv	.	.	.	.	1	3	4	2	.	.	.
LICHENS:												
Thamnolia vermicularia	LiCh	.	.	.	.	.	.	.	.	.	.	3
BLUE ALGAE:												
Stigonema panniforme	PhycH	.	.	.	.	3	.	6	6	.	.	.

APPENDIX IV: Table 4: Phytosociological records

VEGETATION UNIT		*Deschampsia klossii* tussock grassland						*Gahnia javanica* tussock sedgeland			Subalpine short grassland				
RELEVE N°		**74**	**10**	**18**	**23**	**55**	**34**	**37**	**38**	**66**	**6**	**15**	**33**	**61**	**76**
ALTITUDE (m)		3730	3640	3550	3650	3780	3650	3100	3100	3650	3640	3640	3790	3750	3730
NUMBER OF SPECIES		15	14	10	14	14	20	21	18	16	18	16	14	23	17
TOTAL COVER %		80	80	100	100	100	70	100	100	70	80	80	80	-	70
DECLIVITY (°)		-	-	-	-	-	-	-	-	30	-	25	10	15	25
EXPOSURE		-	-	-	-	-	-	-	-	N-E	-	S-E	S-W	W	S
SOIL PROFILE N°		-	-	-	-	-	-	37	-	-	-	-	33	-	-
SPECIES	LIFE FORMS	COVER AND ABUNDANCE													
SHRUBS:															
Coprosma sp. (juv.)	NPcaesp	.	.	.	.	+	.	.	.	.	.	.	.	.	.
Drimys piperita	NPcaesp	.	.	.	.	.	.	3	2	.	.	.	.	.	.
Coprosma novoguineensis	NPcaesp	.	.	.	.	.	4	.	.	.	.	.	.	.	.
Rhododendron gaultherif.	NPcaesp	.	.	1	.	.	.	3	.	.	.	.	.	.	.
Vaccinium sp. (sterile)	Chfrut	.	.	.	.	.	.	.	3	.	.	.	.	.	.
Rhododendron versteegii	Chfrut	2	.	.	.	.	.	3	.	.	.	.	+	1	.
Styphelia suaveolens	Chfrut	2	2	.	.	1	5	4	3	2	1	2	2	3	2
Vaccinium coelorum	Chfrutrept	2	.	.	.	.	.	.	.	.	.	.	.	.	.
Xanthomyrtus comp. (creeping)	Chfrutrept	.	.	.	.	.	.	7	.	.	.	.	.	.	.
Vaccinium oranjense	Chfrutrept	.	.	.	.	.	1	.	.	.	.	.	.	.	.
Vaccinium sp. (cf. decumbens)	Chfrutrept	.	3	.	.	.	.	.	.	.	.	.	+	.	.
Trochocarpa dekockii	Chfrutrept	.	.	.	.	.	.	3	.	2	+	.	.	.	2
Rhododendron saxifragoides	gChfpulv	4	.	.	.	5	.	2	+	.	.	.	.	.	.
Tetramolopium k.f. klossii	Chsuff	.	.	.	.	.	.	3	3	6	4	3	6	4	4
Drapetes ericoides	Chsuff	.	.	.	.	.	.	.	.	.	1	1	.	.	.
FERNS:															
Humata pusilla	Chherb	.	.	.	.	.	.	.	1	.	.	.	.	.	.

RELEVE N°		74	10	18	23	55	34	37	38	66	6	15	33	61	76
Schizea fistulosa	Grhiz	.	.	.	.	.	.	1	.	.	.	.	.	.	.
Blechnum nudius	Grhiz	.	.	.	.	.	+	.	.	.	.	.	.	.	.
Lycopodium carolinianum	Hrept	.	.	.	.	.	.	2	.	1	.	.	1	2	.
GRASSES:															
Deschampsia klossii	Chherb	5	7	4	9	7	7	.	.	.	.	.	.	2	.
Danthonia oreoboloides	fChhpulv	.	.	.	.	3	.	.	.	2	3	3	.	2	2
Poa pilata	Hcaesp	.	2	.	.	.	.	.	.	.	.	.	.	.	.
Danthonia vestita	Hcaesp	.	.	.	1	.	.	.	.	.	.	.	.	.	.
Deyeuxia sten. var. chaseana	Hcaesp	.	.	+	2	.	5	.	.	.	.	.	.	.	.
Anthox. redol. var. longif.	Hcaesp	.	.	1	2	.	.	.	.	.	.	.	.	.	.
Festuca ? jansenii	Hcaesp	.	.	.	2	.	1	.	.	.	.	.	.	.	.
Agrostis rig. var. remota	Hcaesp	2	3	7	.	1	.	4	5	3	.	+	3	3	2
Festuca cripato-pilosa	Hcaesp	.	.	.	+	.	.	.	.	.	.	+	.	2	.
Poa lamii	Hcaesp	5	.	.	.	.	.	.	.	.	.	.	.	.	3
Anthox. horsf. var. angustum	Hcaesp	1	+	2	.	.	.	.	.	.	.	.	.	.	.
Deyeuxia pusilla ?	Hcaesp	.	+	.	.	.	2	.	.	.	1	2	.	.	.
Anthox. redol. var. redolens	Hcaesp	.	.	.	.	2	5	.	.	.	.	.	.	.	.
Deyeuxia brassii	Hcaesp	.	.	.	.	2	.	.	.	.	.	.	.	2	.
OTHER MONOCOTS.:															
Gahnia javanica	Chherb	.	.	.	.	.	.	5	1	5	.	3	.	.	.
Pterostylis (sect. Dendrobium)	Chherb	.	.	.	.	.	.	.	+	.	.	.	.	.	.
Astelia alpina	fChhpulv	.	.	.	.	3	4	.	.	.	+	.	.	3	3
Centrolepis fascicularis	fChhpulv	.	.	.	.	.	.	1	.	.	.	.	.	.	.
Centrolepis philippinensis	fChhpulv	1	.	.	.	.	.	.	.	.	1	4	.	.	2
Eriocaulon alpinum	fChhpulv	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Eriocaulon pulvinatum	fChhpulv	.	.	.	.	.	.	.	.	.	.	.	.	2	.
Oreobolus pumilo	fChhpulv	3	3	.	.	.	.	5	2	4	4	2	4	3	4
Carex gaudichaudiana	Hcaesp	.	.	.	.	.	.	.	.	.	.	2	.	.	.
Carex brevic. var. perciliata	Hcaesp	.	.	.	.	.	.	.	.	.	2	.	3	.	.
Carpha alpina	Hcaesp	.	.	.	+	.	.	.	.	4	6	7	4	4	6

RELEVE N°		74	10	18	23	55	34	37	38	66	6	15	33	61	76
Luzula papuana	Hcaesp	.	.	.	.	.	+	.	.	.	.	.	.	.	.
Machaerina teretifolia	Hcaesp	.	.	.	.	.	.	+	1	.	.	.	.	.	.
Scirpus subcapitatum	Hcaesp	.	.	.	.	.	.	.	4	.	.	.	.	.	.
Uncinia comp.var.alpina	Hcaesp	.	.	.	.	.	.	.	.	.	.	.	.	2	.
DIDOT.HERBS:															
Trachymene papillosa	Chherb	.	.	.	.	.	.	.	1	.	.	.	.	.	.
Keysseria wollastonii	Chsuff	.	.	.	.	.	.	.	.	.	+	.	.	.	.
Euphrasia versteegii	Chsuff	.	.	.	.	.	.	.	.	1	.	.	+	2	2
Epilobium hooglandii	Chsuff	.	.	.	.	.	5	.	.	.	.	.	.	.	.
Epilobium sp.	Chsuff	.	.	2	.	.	.	.	.	.	.	.	.	.	.
Oreomyrrhis buwaldiana	gChsufpulv	.	.	.	.	.	.	.	.	.	1	.	.	.	.
Potentilla brassii var. brassii	fChhpulv	3	2	.	.	2	.	.	.	1	3	3	3	3	4
Potentilla habbemana	Hcaesp	.	.	+	.	.	.	.	.	.	.	.	.	.	.
Oreomyrrhis pumila	Hcaesp	.	.	.	+	.	+	.	.	.	.	.	.	.	.
Gentiana macgregorii	Hcaesp	.	.	.	.	.	.	2	.	.	.	.	+	.	.
Gentiana sp.	Hcaesp	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Potentilla brassii var. simplex	Hcaesp	.	.	.	.	.	.	.	.	.	1	.	.	.	.
Gentiana cf. ettinghausenii	Hcaesp	2	.	.	.	+	.	2	1	2	.	.	.	.	.
Potentilla hooglandii	Hcaesp	.	.	.	1	.	3	.	.	.	.	.	.	.	.
Cotula wilhelminensis	Hrept	.	.	.	.	.	.	.	.	.	.	.	2	.	.
Trigonotis sp.	Hrept	.	.	.	.	.		.	.	.	.	.	.	.	.
Gonocarpus micranthus	Hrept	.	.	.	.	.	.	.	.	2	.	.	.	1	.
Keysseria radicans	Hrept	.	.	.	.	.	2	.	.	.	.	.	.	.	.
Gnaphalium breviscapum	Hrept	.	.	.	.	.	3	.	.	.	.	2	.	.	.
Pilea johniana	Hrept	2	1	.	1	.	.	.	.	.	+	.	.	2	1
Plantago aundensis	Hros	.	.	.	2	2	4	.	.	.	.	.	.	3	.
Plantago depauperata	Hros	.	.	.	.	.	.	.	.	2	2	+	.	2	1
Lactuca laevig. var.pygmaea	Hsem	.	.	.	.	.	2	.	2	.	.	.	.	.	.
Lactuca laev.var.pusilla	Hsem	2	1	.	.	.	.	2	1	2	.	.	3	3	.
Ranunculus habbemensis	Hsem	.	.	.	.	.	.	.	3	.	.	.	.	.	.
Abrotanella papuana	Hsem	.	.	.	.	.	.	.	.	.	.	.	.	2	2

RELEVE N°		74	10	18	23	55	34	37	38	66	6	15	33	61	76
Geranium monticola	Hsem	.	.	+	1	.	.	.	.	.	.	.	.	.	.
Ischnea ela.f.elachoglossa	Hsem	.	.	.	.	.	.	3	.	.	.	.	.	.	.
Drosera peltata	Hsem	.	.	.	.	.	.	3	.	.	.	.	.	.	.
Ranunculus perindutus	Hsem	.	.	1	.	.	.	.	.	.	.	.	.	.	.
Ranunculus angustipetalus	Hsem	.	1	.	.	.	.	.	.	.	.	.	.	.	.
Ranunculus spp.	Hsem	.	1	.	.	+	4	.	.	.	1	.	.	.	.
Potentilla f.var.foerst.?	Hsem	.	.	.	.	.	3	2	1	.	.	.	.	.	.
Ischnea elacho.f.nana	Hsem	.	.	.	1	.	.	.	.	.	.	.	.	.	.
Ranunculus amerophylloides	Hsem	.	.	.	.	.	.	.	.	.	.	.	.	.	3
Senecio brassii	Tscap	.	.	.	2	.	.	.	.	.	.	.	.	.	.
MOSSES AND HEPATICS:															
unidentified taxa	BrChpulv	.	.	.	.	.	.	.	.	4	.	3	.	4	.
Sphagnum sp.	BrChsph	7	.	.	.	5	.	.	.	.	.	.	.	.	.

APPENDIX IV: Table 5: Phytosociological records

VEGETATION UNIT:		Hard cushion bog			Astelia alpina bog								Gleichenia vulcanica bog			
RELEVE N°		8	9	83	11	13	17	35	56	69	77	86	12	67	68	84
ALTITUDE (m)		3630	3630	3430	3650	3680	3640	3650	3800	3550	3640	3400	3650	3600	3550	3430
NUMBER OF SPECIES		19	8	20	17	17	15	20	13	8	14	19	10	10	15	26
TOTAL COVER (%)		100	100	100	90	100	80	100	100	100	100	100	90	100	100	100
DECLIVITY (°)		-	-	-	5	20	10	5	-	10	15	-	-	-	10	20
EXPOSURE		-	-	-	-	S	-	-	-	W	E	-	-	-	W	N-W
SOIL PROFILE N°		-	-	-	11	13	17	-	-	-	-	86	12	-	-	84
SPECIES	LIFE FORM	ABUNDANCE DOMINANCE														
SHRUBS:																
Eurya brassi	NPcaesp	.	.	.	.	3	.	.	.	.	.	.	.	.	.	.
Coprosma novoguineensis	NPcaesp	.	.	.	.	2	.	.	4	.	.	.	.	.	.	.
Coprosma brassii	NPcaesp	.	.	.	.	.	.	2	.	1	2	1	.	.	.	.
Styphelia suaveolens	Chfrut	+	.	1	3	1	1	.	5	2	.	2	1	.	.	.
Rhododendron versteegii	Chfrut	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.
Trochocarpa dekockii	Chfrutrept	.	.	.	.	2	.	.	.	.	.	.	4	.	.	.
Vaccinium coelorum	Chfrutrept	.	.	1	.	.	.	.	.	.	.	2	.	.	.	.
Xanthomyrtus comp.(creeping)	Chfrutrept	.	.	1	.	.	.	.	.	.	.	.	.	.	3	4
Rhododendron saxifragoides	gChfpulv	.	.	.	.	.	.	4	4	.	.	2	.	.	.	.
Tetramolopium kl.f.klossii	Chsuff	+	.	1	3	.	2	.	4	.	.	3	2	.	1	.
Drapetes ericoides	Chsuff	+	.	.	.	.	1	.	.	.	.	.	.	.	.	.
FERNS:																
Humata pusilla	ChEherb	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.
Gleichenia vulcanica	Grhiz	.	.	2	.	.	.	.	.	3	.	.	8	8	7	8
Schizea fistulosa	Grhiz	.	.	2	.	.	.	.	.	.	.	.	.	.	.	2

RELEVE N°		8	9	83	11	13	17	35	56	69	77	86	12	67	68	84
GRASSES:																
Deschampsia klossii	Chherb	.	.	.	1	3	.	4	3	.	.	3	.	.	.	.
Poa crassicaulis	fChhpulv	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
Danthonia oreoboloides	fChhpulv	5	.	4	4	.	3	2	.	.	.	3	.	2	1	.
Deyeuxia brassii	Hcaesp	.	.	.	.	.	.	.	3	.	3	.	.	2	1	2
Poa pilata	Hcaesp	.	5	.	.	.	.	.	.	.	.	.	.	.	.	.
Festuca crispato-pilosa	Hcaesp	.	.	.	.	2	.	3	.	.	6	.	.	.	.	.
Agrostis rig. var. remota	Hcaesp	2	2	2	1	2	5	3	2	.	3	2	1	.	2	2
Anthox. red. var. longifolium	Hcaesp	.	.	.	.	.	.	.	.	.	3	.	.	.	.	.
Anthox. horsf. var. angustum	Hcaesp	.	.	.	.	.	+	.	.	2	.	.	.	.	.	.
Deyeuxia steno. var. chaseana	Hcaesp	.	.	.	.	.	.	2	.	.	.	1	.	.	.	.
Poa lamii	Hcaesp	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.
Festuca? jauseni	Hcaesp	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
Dichelachne rara ssp. rara	Hcaesp	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.
Deyeuxia pusilla ?	Hcaesp	1	.	.	.	.	.	.	.	.	.	.	:	.	.	.
OTHER MONOCOTS.:																
Gahnia javanica	Chherb	.	.	.	.	.	.	2	.	.	.	.	2	3	.	.
Schoenus maschalinus	fChhpulv	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3
Centrolepis philippinensis	fChhpulv	5	7	7	.	.	2	.	.	.	.	.	.	3	.	3
Astelia alpina	fChhpulv	.	.	2	3	7	6	8	6	6	4	8	.	4	5	3
Eriocaulon alpinum	fChhpulv	4	7	2	.	.	.	.	.	.	.	.	.	.	.	2
Oreobolus pumilio	fChhpulv	5	3	3	3	.	3	2	.	.	.	.	3	.	2	3
Centrolepis fascicularis	fChhpulv	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
Eriocaulon pulvinatum	fChhpulv	6	7	.	.	.	.	.	.	.	.	.	.	.	.	3
Carex bilateralis	Hcaesp	.	.	.	.	+	.	.	.	.	.	3	.	.	.	.
Carex cf. celebica	Hcaesp	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.
Carex gaudichaudiana	Hcaesp	1	3	.	.	.	2	.	.	.	2	.	.	.	.	.

RELEVE N°		8	9	83	11	13	17	35	56	69	77	86	12	67	68	84
Carpha alpina	Hcaesp	1	.	2	4	.	.	2	.	.	.	.	5	3	4	1
Schoenus nitens	Hcaesp	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Scirpus subcapitatum	Hcaesp	.	.	.	.	4	.	.	.	7	.	.	.	.	2	.
Uncinia compacta var.alpina	Hcaesp	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.
Uncinia compacta var.compacta	Hcaesp	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.
Uncinia riparia	Hcaesp	.	.	.	.	.	.	.	3	.	.	.	.	.	.	.
DICOT.HERBS:																
Euphrasia cf.culminicola	Chsuff	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.
Euphrasia versteegii	Chsuff	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Potentilla brassii var.brassii	fChhpulv	.	.	7	7	.	2	.	.	.	.	.	.	.	.	.
Gentiana cf.ettighausenii	Hcaesp	.	.	.	.	.	.	.	.	.	.	.	.	2	+	.
Gentiana sp.	Hcaesp	+	.	.	+	.	+	.	.	.	1	1	+	.	.	1
Myosotis australis	Hcaesp	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Oreomyrrhis papuana	Hcaesp	.	.	.	.	.	.	.	+	.	1	2	.	.	.	.
Potentilla hooglandii	Hcaesp	.	.	.	.	.	.	3	.	.	.	3	.	.	.	1
Potentilla parvula	Hcaesp	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.
Potentilla sp.	Hcaesp	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
Potentilla brassii var.simplex	Hcaesp	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cotula wilhelminensis	Hrept	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.
Gnaphalium breviscapum	Hrept	.	.	3	.	.	3	.	.	.	1	.	.	.	.	3
Gonocarpus micranthus	Hrept	.	.	1	.	.	.	.	.	.	.	.	.	.	.	1
Hedyotis trichoclada	Hrept	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.
Hydrocotyle sibthorpioides	Hrept	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.
Keysseria radicans	Hrept	.	.	.	.	.	.	.	.	.	2	2	.	.	.	.
Pilea johniana	Hrept	.	.	.	.	2	.	2	.	.	1	.	.	2	2	.
Keysseria p.f.pinguiculiformis.	Hros	.	.	2	.	.	.	.	.	.	.	.	.	.	.	1
Plantago aundensis	Hros	.	.	.	1	1	.	4	.	.	2	1	.	.	.	2
Plantago depauperata	Hros	.	.	3	2	.	3	.	.	.	.	.	.	.	.	2
Drosera peltata	Hsem	.	.	3	.	.	.	.	.	.	.	.	.	.	.	.

RELEVE N°		8	9	83	11	13	17	35	56	69	77	86	12	67	68	84
Geranium monticola	Hsem	.	.	.	.	.	.	2	.	.	.	2	.	.	.	.
Geranium wilhelminae	Hsem	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.
Ischnea elacho.f.nana	Hsem	+	.	.	1	.	.	.	.	.	.	.	.	.	.	.
Lactuca l.var.laevigata	Hsem	.	.	.	.	.	.	.	.	+	.	.	.	.	1	.
Lactuca l.var.pusilla	Hsem	1	.	.	1	1	.	.	.	.	.	.	.	.	.	2
Potentilla f.var.foerst.?	Hsem	.	.	.	.	.	.	2	3	.	2	.	.	.	.	.
Ranunculus amerophylloides	Hsem	.	.	.	.	2	.	.	.	.	.	.	.	.	1	.
Ranunculus sp.	Hsem	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.
MOSSES AND HEPATICS:											.					
unidentified taxa	BrChpulv	1	3	5	.	.	2	.	.	.	.	.	2	6	.	2
Sphagnum sp.	BrChsph	.	.	.	.	.	.	.	5	6	.	.	.	.	.	.

APPENDIX IV: Table 6: phytosociological records

VEGETATION UNIT:		Short grass bog			Carex spp. open fen and related vegetation				Carpha alpina fen
RELEVE N°		**5**	**70**	**72**	**19**	**73**	**79**	**80**	**54**
ALTITUDE (m)		3640	3500	3480	3550	3560	3450	3470	3780
NUMBER OF SPECIES		16	14	16	15	19	14	22	14
TOTAL COVER (%)		95	60	60	100	90	100	70	95
DECLIVITY (°)		10	-	-	10	-	-	40	-
EXPOSURE		-	-	-	E	-	-	W	-
SOIL PROFILE N°		5	-	-	-	-	79	-	-
SPECIES	**LIFE FORM**	**COVER AND ABUNDANCE**							
SHRUBS:									
Styphelia suaveolens	Chfrut	3	.	2	.	1	.	3	.
Trochocarpa dekockii	Chfrutrept	.	.	.	2	.	.	.	.
Vaccinium coelorum	Chfrutrept	.	.	2	.	.	.	5	.
Vaccinium cf.sororium	Chfrutrept							1	
Xanthomyrtus comp.(creeping)	Chfrutrept	.	.	.	.	.	.	3	.
Rhododendron saxifragoides	gChfpulv	.	.	+	.	.	.	.	.
Coprosma archboldiana	fChfpulv	.	.	.	.	.	.	4	.
Tetramolopium kl.f.klossii	Chsuff	5	5	1	.	3	.	4	1
Parahebe ciliata	Chsuff	.	.	.	.	.	.	3	.
FERNS:									
Lycopodium carolinianum	Hrept	.	4	.	.	.	.	.	.
Equisetum ramosissimum	Grhiz	.	.	.	.	.	.	7	.
GRASSES:									
Deschampsia klossii	Chherb	.	2	.	2	.	.	+	.
Danthonia oreoboloides	fChhpulv	.	4	3	.	4	.	.	.
Festuca crispato-pilosa	Hcaesp	.	.	.	4	.	5	.	.
Agrostis rig.var.remota	Hcaesp	1	3	1	.	1	.	2	2
Anthox.horsf.var.angustum	Hcaesp	.	.	.	.	.	3	.	.
Poa lamii	Hcaesp	.	.	3	.	.	.	.	.
Poa wisselii	Hcaesp	.	.	.	.	.	.	1	.
Agrostis avenacea	Hcaesp	.	.	.	.	.	2	.	.
Festuca? janseni	Hcaesp	.	.	.	.	.	6	3	.
Deyeuxia pusilla ?	Hcaesp	2	.	.	.	.	.	.	.
OTHER MONOCOTS.:									
Schoenus maschalinus	fChhpulv	.	.	.	.	.	.	5	.
Centrolepis philippinensis	fChhpulv	.	2	.	.	.	.	.	5
Astelia alpina	fChhpulv	2	.	.	.	.	.	.	2
Eriocaulon alpinum	fChhpulv	1	.	.	.	.	..	.	.
Oreobolus pumilio	fChhpulv	3	5	7	.	6	.	.	2
Gaimardia setacea	fChhpulv	.	.	2	.	.	.	.	2

RELEVE N°		5	70	72	19	73	79	80	54
Eriocaulon tubiflorum	fChhpulv	.	.	2	.	.	.	.	.
Eriocaulon pulvinatum	fChhpulv	.	.	.	.	2	.	.	2
Carex brevic.var.montivaga	Hcaesp	.	.	4	.	.	.	.	.
Carpha alpina	Hcaesp	3	.	.	.	3	.	.	8
Carex bilateralis	Hcaesp	.	.	.	.	.	6	1	.
Carex gaudichaudiana	Hcaesp	.	2	.	.	4	.	.	.
Luzula papuana	Hcaesp	.	.	.	.	.	2	.	.
Uncinia compacta var.alpina	Hcaesp	.	.	.	.	.	.	.	3
Carex cf.celebica	Hcaesp	.	.	.	7	.	.	.	.
Scirpus fluitans	HydHcaesp	.	.	.	.	.	.	.	3
Carex brachyathera	Hcaesp	.	.	.	.	.	.	3	.
DICOTYLEDONS:									
Epilobium sp.	Chsuff	.	.	.	1	.	.	3	.
Euphrasia cf.culminicola	Chsuff	+	.	.	.	.	.	.	.
Euphrasia versteegii	Chsuff	.	.	.	.	1	.	2	.
Potentilla brassii var.brassii	fChhpulv	7	.	.	2	2	.	.	1
Gentiana cf.ettighausenii	Hcaesp	.	.	1	.	2	.	.	1
Gentiana sp.	Hcaesp	+	2	.	.	.	.	.	.
Myosotis australis	Hcaesp	.	.	.	.	.	3	.	.
Potentilla parvula	Hcaesp	.	.	.	2	.	.	.	.
Gnaphalium breviscapum	Hrept	.	.	.	.	.	.	2	2
Gonocarpus micranthus	Hrept	.	2	2	.	1	.	.	.
Hydrocotyle sibthorpioides	Hrept	.	.	.	.	.	.	2	.
Keysseria radicans	Hrept	.	.	.	2	.	.	.	.
Pilea johniana	Hrept	+	.	.	.	1	2	.	.
Keysseria ping.f.ping.	Hros	+	.	.	.	.	.	.	.
Plantago aundensis	Hros	.	.	.	4	.	4	2	.
Plantago depauperata	Hros	1	.	.	3	2	.	.	.
Trachymene novoguineensis	Hros	.	.	.	.	1	.	.	1
Abrotanella papuana	Hsem	.	3	2	.	2	.	.	.
Drosera peltata	Hsem	.	.	.	.	+	.	.	.
Geranium monticola	Hsem	.	.	.	1	.	.	.	.
Geranium wilhelminae	Hsem	.	.	.	.	.	3	.	.
Ischnea elacho.f.nana	Hsem	.	.	.	2	.	.	.	.
Lactuca laevigata var.pusilla	Hsem	.	3	1	1	2	.	.	.
Ranunculus amerophylloides	Hsem	.	.	.	5	.	.	.	.
Ranunculus angustipetalus	Hsem	.	3	3	.	.	.	.	.
Ranunculus pseudolowii	Hsem	.	.	.	.	.	3	.	.
Ranunculus sp.	Hsem	2	.	.	.	.	.	.	.
Triplostegia glandulifera	Hsem	.	.	.	+	.	3	3	.
Senecio brassii	Tscap	.	.	.	.	.	3	.	.
MOSSES AND HEPATICS:									
unidentified taxa	BrChpulv	1	4	.	.	5	5	6	.

APPENDIX IV: Table 7 : Phytosociological records

VEGETATION UNIT		*Gleichenia bolanica* shrublands	*Stigonema panniforme* community
RELEVE N°		21	51
ALTITUDE (m)		3640	3790
NUMBER OF SPECIES		21	13
TOTAL COVER (%)		-	60
DECLIVITY (°)		50	10
EXPOSURE		E	N
SPECIES	**LIFE FORM**	**COVER AND ABUNDANCE**	
SHRUBS:			
Coprosma novoguineensis	NPcaesp	2	.
Rhododendron gault.var.exp.	Chfrut	.	1
Styphelia suaveolens	Chfrut	.	.
Xanthomyrtus comp. (creeping)	Chfrutrept	3	.
Vaccinium decumbens	Chfrutrept	2	.
Vaccinium cf.sororium	Chfrutrept	.	.
Vaccinium coelorum	Chfrutrept	.	.
Eurya brassii (rampant)	Chfrutrept	2	.
Trochocarpa decockii	Chfrutrept	2	3
Coprosma archboldiana	fChfpulv	.	.
Tetramolopium kl.f.klossii	Chsuff	2	2
Parahebe ciliata	Chsuff	.	.
FERNS:			
Lycopodium carolinianum	Hrept	1	.
Gleichenia bolanica	Grhiz	7	.
Gleichenia vulcanica	Grhiz	4	.
Equisetum ramosissimum	Grhiz	.	.
GRASSES:			
Deschampsia klossii	Chherb	.	.
Danthonia oreoboloides	fChhpulv	1	3
Agrostis rig.var.remota	Hcaesp	.	2
Festuca? jansenii	Hcaesp	.	.
Poa wisselii	Hcaesp	.	.
OTHER MONOCOTS.:			
Gahnia javanica	Chherb	2	.
Schoenus maschalinus	fChhpulv	.	.
Oreobolus pumilio	fChhpulv	1	2
Astelia alpina	fChhpulv	3	

RELEVE N°		21	51
Mediocalcar sp.	Hcaesp	1	.
Carex brevic.var.perciliata	Hcaesp	+	.
Octarrhena sp.	Hcaesp	+	.
Carex gaudichaudiana	Hcaesp	.	1
Carex brachyathera	Hcaesp	.	.
Carex bilateralis	Hcaesp	.	.
DICOT.HERBS:			
Potentilla brassii var.brassii	fChhpulv	1	.
Euphrasia versteegii	Chsuff	+	.
Epilobium sp.	Chsuff	.	.
Euphrasia humifusa	Hcaesp	.	1
Gentiana sp.	Hcaesp	+	.
Gnaphalium breviscapum	Hrept	.	.
Pilea johniana	Hrept	1	1
Hydrocotyle sibthorpioides	Hrept	.	.
Triplostegia glandulifera	Hros	.	.
Plantago aundensis	Hros	.	.
Plantago depauperata	Hros	1	2
Lactuca laev.var.pusilla	Hsem	.	1
MOSSES AND HEPATICS:			
unidentified taxa	BrChpulv	.	1
ALGAE:			
Stigonema panniforme	PhycH	.	7

APPENDIX IV: TABLE 8 Phytosociological records

VEGETATION UNIT		Alpine Dwarf Shrub Heath					Alpine Short grass bog	*Uncinia riparia* sedge-land	*Rhacomitrium* heath and related veg.		Alpine scree community		
RELEVE N°		**28**	**47**	**48**	**50**	**2**	**57**	**58**	**1**	**44**	**3**	**43**	**45**
ALTITUDE (m)		4000	4100	4080	4050	3930	3990	4000	4200	4230	4150	4200	4210
NUMBER OF SPECIES		31	20	18	19	19	15	12	11	14	13	13	11
TOTAL COVER (%)		70	90	90	60	70	100	100	30	60	40	80	50
DECLIVITY (°)		45	45	35	35	30	-	-	50	-	45	30	45
EXPOSURE		N-E	E	E	N	N	-	-	N	-	N	S	S
SOIL PROFILE n°		28	.	-	-	2	-	-	-	-	-	-	-
SPECIES	**LIFE FORM**	**COVER AND ABUNDANCE**											
SHRUBS:													
Coprosma novoguineensis	NPcaesp	3	.	.	.	.	.	.	.	.	.	.	.
Styphelia suaveolens	Chfrut	3	7	6	4	2	2	.	.	.	.	.	.
Rhododendron versteegii	Chfrut	4	.	.	.	.	.	.	.	.	.	.	.
Rhododendron pusillum	Chfrut	5	.	.	.	.	.	.	.	.	.	.	.
Vaccinium oranjense	Chfrutrept	2	.	.	.	.	.	.	.	.	.	.	.
Trochocarpa dekockii	Chfrutrept	4	.	.	3	3	.	.	.	.	.	.	.
Drapetes ericoides	Chsuff	.	.	5	.	.	.	.	.	.	.	.	.
Tetramolopium fasciculatum	Chsuff	.	.	.	4	.	.	.	.	.	.	.	.
Tetramolopium prostratum	Chsuff	2	.	.	.	.	.	.	1	.	.	.	.
Parahebe ciliata	Chsuff	.	1	2	.	.	.	.	.	3	.	3	.
Tertramol. piloso-villosum	Chsuff	.	.	.	.	.	.	.	1	.	1	.	.
Tetramolopium kl.f.lanceol.	Chsuff	.	3	.	.	.	.	.	.	.	.	.	.
Tetramolopium kl.f.klossii	Chsuff	.	2	.	3	6	.	.	.	.	.	.	.
FERNS:													
Grammitis frigida	ChEherb	2	.	.	.	.	.	.	.	.	.	.	.
Hymenophyllum ooides	ChEherb	.	.	.	1	.	.	.	.	.	.	.	.

RELEVE N°		28	47	48	50	2	57	58	1	44	3	43	45
Pteris mon.-wilheminensis	Grhiz	.	.	.	.	.	.	.	1	.	.	.	.
GRASSES:													
Deschampsia klossii	Chherb	.	2	2	.	.	.	3	1	2	4	2	1
Poa crassicaulis	fChhpulv	.	3	2	.	.	.	.	.	.	.	.	.
Poa clavigera	fChhpulv	.	.	.	.	.	.	.	6	.	1	4	.
Danthonia oreoboloides	fChhpulv	2	.	.	2	1	.	.	.	.	.	.	.
Festuca? jansenii	Hcaesp	.	4	.	.	.	.	.	.	.	.	.	.
Festuca parvipaleata	Hcaesp	.	.	.	.	.	.	2	.	.	.	.	.
Poa hentyi	Hcaesp	3	.	4	.	3	.	.	.	.	.	.	.
Deyeuxia sten. var. cluscana	Hcaesp	2	.	.	.	.	.	.	.	.	.	.	.
Anthox. horsfieldii var. angustum	Hcaesp	1	.	.	.	.	.	.	.	.	.	.	.
Poa sp.4	Hcaesp	+	.	.	.	.	.	.	.	.	.	.	5
Festuca crispato-pilosa	Hcaesp	.	.	.	.	.	3	.	.	.	.	.	.
Deyeuxia brassii	Hcaesp	.	.	.	.	2	.	.	.	.	.	.	.
Poa nivicola	Hcaesp	.	.	.	.	.	.	.	.	1	.	.	1
Poa papuana	Hcaesp	1	4	.	4	.	.	.	.	.	.	.	.
Poa sp. (cf. papuana ?)	Hcaesp	.	.	.	.	.	.	.	.	5	.	.	.
Anthox. red. var. redolens	Hcaesp	.	4	.	.	.	.	.	.	.	.	.	.
Agrostis rigid. var. remota	Hcaesp	2	.	.	3	2	.	2	.	.	.	.	.
Poa lunata	Hcaesp	.	2	.	.	.	.	.	.	.	.	.	.
OTHER MONOCOTS.:													
Centrolepis philippinensis	fChhpulv	2	2	.	2	1	5	.	.	.	.	.	.
Astelia alpina	fChhpulv	3	4	4	3	4	2	.	.	.	.	.	.
Oreobolus pumilio	fChhpulv	2	.	.	.	.	.	.	.	.	.	.	.
Schoenus maschalinus	fChhpulv	+	.	.	.	.	.	.	.	.	.	.	.
Eriocaulon alpinum	fChhpulv	2	.	.	.	.	.	.	.	.	.	.	.
Carex brev. var. perciliata	Hcaesp	+	.	.	.	2	.	.	.	.	.	.	.
Carpha alpina	Hcaesp	2	.	.	.	3	.	.	.	.	.	.	.

RELEVE N°		28	47	48	50	2	57	58	1	44	3	43	45
Carex brachyathera	Hcaesp	1	.	.	.	.	.	.	.	.	.	.	.
Uncinia compacta var.alpina	Hcaesp	.	3	2	2	.	3	.	.	.	.	.	.
Uncinia riparia	Hcaesp	.	.	.	.	.	.	7	.	.	.	.	.
DICOT.HERBS:													
Lepidium minutiflorum	gChsufpulv	.	3	4	.	.	.	.	.	.	.	.	.
Oreomyrrhis buwaldiana	gChsufpulv	.	.	.	.	.	.	.	4	.	.	.	.
Potentilla irianensis	gChsufpulv	.	.	.	.	.	.	2	.	.	.	.	.
Ranunculus bellus	fChhpulv	.	.	.	.	.	5	.	.	.	.	.	.
Potentilla brassii var.brassii	fChhpulv	1	.	.	.	.	4	2	.	.	.	.	.
Euphrasia versteegii	Chsuff	.	.	.	.	.	1	.	.	.	.	.	.
Euphrasia cf.culminicola	Chsuff	.	.	.	.	1	.	.	.	.	.	.	.
Keysseria wollastonii	Chsuff	.	.	.	.	.	.	.	.	2	1	2	.
Epilobium detznerianum	Chsuff	.	.	.	.	.	.	.	3	.	1	.	3
Cerastium papuanum ssp.keysseri	Hcaesp	.	.	.	.	.	.	.	2	2	+	3	2
Gentiana sp.	Hcaesp	.	.	.	.	.	1	.	.	.	.	.	.
Oreomyrrhis pumila	Hcaesp	+	.	3	2	.	.	.	.	3	+	3	5
Oreomyrrhis papuana	Hcaesp	+	.	3	.	.	.	.	.	.	.	.	.
Euphrasia sp.	Hcaesp	+	.	.	.	.	.	.	.	.	.	.	.
Gentiana cf.nerteriifolia	Hcaesp	.	.	.	.	1	.	.	.	.	.	.	.
Myosotis australis	Hcaesp	.	.	.	.	.	.	.	1	1	.	2	2
Gentiana cf.ettingshausenii	Hcaesp	.	2	3	2	.	.	.	.	.	.	.	.
Pilea johniana	Hrept	.	.	1	2	1	1	.	4	2	1	1	.
Sagina papuana	Hrept	.	.	3	.	.	.	.	.	3	.	4	2
Gnaphalium brassii	Hrept	.	.	.	.	.	.	.	.	.	1	.	.
Sagina belonophylla	Hrept	.	.	.	.	.	.	.	3	3	1	.	.

RELEVE N°		28	47	48	50	2	57	58	1	44	3	43	45
Trigonotis sp.	Hrept	.	2	.	.	.	.	.	.	.	.	.	.
Gnaphalium breviscapum	Hrept	2	.	2	.	.	.	.	.	.	.	.	2
Plantago aundensis	Hros	.	2	1	.	.	.	2	.	.	.	.	.
Plantago depauperata	Hros	4	.	.	2	1	.	.	.	.	.	.	.
Abrotanella papuana	Hros	.	.	.	.	1	.	.	.	.	.	.	.
Keysseria pinguicula f.nana	Hros	.	.	.	.	1	4	1	.	.	.	.	.
Lactuca laevigata var.pusilla	Hsem	2	.	.	3	2	.	.	.	.	.	.	.
Ranunculus pseudolowii	Hsem	.	.	.	.	.	.	1	.	.	.	.	.
Potentilla foersteriana	Hsem	.	4	3	3	1	.	.	.	5	.	4	.
Potentilla parvula	Hsem	.	.	.	.	.	3	.	.	.	.	.	.
Geranium lacustre	Hsem	.	.	.	.	.	2	1	.	.	.	.	.
Ranunculus consimilis	Hsem	.	.	.	.	.	.	.	.	.	1	.	.
Lactuca laevigata var.pygmaea	Hsem	+	.	.	.	.	.	.	.	.	.	.	.
Geranium monticola	Hsem	.	3	.	.	.	.	.	.	.	1	4	2
Ischnea elachoglossa f.nana	Hsem	.	.	.	.	.	3	2	.	3	.	3	2
MOSSES AND HEPATICS:													
unidentified taxa	BrChpulv	.	3	4	2	.	5	7	.	6	5	7	7

APPENDIX IV: Table 9: Phytosociological records

VEGETATION UNIT		Alpine tussock grassland								*Astelia alpina* alpine herbfield			
RELEVE N°		**4**	**25**	**26**	**27**	**63**	**46**	**49**	**64**	**59**	**24**	**62**	**65**
ALTITUDE (m)		4150	4000	4000	4000	4100	4150	4090	4000	4000	4100	3960	4000
NUMBER OF SPECIES		11	19	8	19	23	11	17	20	22	14	18	18
TOTAL COVER (%)		95	100	100	100	100	70	100	100	90	90	100	100
DECLIVITY (°)		45	15	45	45	45	35	45	30	25	35	25	5
EXPOSURE		N	S-W	N	N	N	N	N	N	W	S	N-W	-
SOIL PROFILE N°		4	-	26	-	-	-	-	-	-	24	-	-
SPECIES	**LIFE FORM**	**COVER AND ABUNDANCE**											
SHRUBS:													
Coprosma novoguineensis	Npcaesp	.	2	.	.	+	.	.	2	3	.	.	2
Styphelia suaveolens	Chfrut	1	.	.	.	3	.	4	2	4	6	.	5
Rhododendron versteegii	Chfrut	.	.	.	.	.	.	.	.	2	.	.	.
Vaccinium coelorum	Chfrutrept	.	.	.	.	.	.	.	.	3	.	3	.
Trochocarpa dekockii	Chfrutrept	.	.	.	.	.	.	.	.	4	.	3	.
Tetramolopium k.f.klossii	Chsuff	.	.	.	.	.	.	.	.	3	.	6	
Tetramolopium k.f.lanceol.	Chsuff	.	.	.	.	.	3	.	.	.	.	.	
Parahebe ciliata	Chsuff	.	+	.	2	2	2	2	2	.	.	.	.
GRASSES:													
Deschampsia klossii	Chherb	6	6	9	7	8	.	4	3	2	2	.	.
Danthonia oreoboloides	fChhpulv	.	2	.	.	.	.	.	.	2	.	3	3
Poa clavigera	fChhpulv	3	.	.	.	2	.	.	.	.	.	.	.
Poa crassicaulis	fChhpulv	.	.	.	2	.	.	4	.	.	.	.	.
Poa inconspicua	fChhpulv	.	.	3	.	.	.	.	.	.	.	.	.
Agrostis rigidula var.remota	Hcaesp	.	.	.	3	.	.	.	.	.	.	1	.

RELEVE N°		4	25	26	27	63	46	49	64	59	24	62	65
Anthox.redolens var.longifolium	Hcaesp	.	4	2	2	2	.	7	.	.	.	.	.
Anthoxanthum r.var.redolens	Hcaesp	.	.	.	.	.	.	.	4	.	.	.	.
Deyeuxia brassii	Hcaesp	.	3	.	5	.	.	.	2	.	4	.	3
Deyeuxia pusilla ?	Hcaesp	.	.	1	2	.	.	.	.	2	.	2	3
Festuca? jansenii	Hcaesp	.	.	.	.	.	.	.	3	.	.	.	3
Poa hentyi	Hcaesp	.	.	.	.	.	.	.	.	.	+	.	.
Poa keysseri var.keysseri	Hcaesp	.	3	2	.	.	.	.	.	.	.	.	
Poa nivicola	Hcaesp	+	2	.	.	2	5	.	.	3	.	.	.
Poa papuana	Hcaesp	.	2	.	.	.	.	4	.	.	2	.	
Poa sp.3	Hcaesp	.	.	.	.	2	.	.	.	.	.	.	.
OTHER MONOCOTS.:													
Astelia alpina	fChhpulv	.	.	.	4	3	.	3	.	7	6	6	8
Centrolepis philippinensis	fChhpulv	.	.	.	.	.	.	.	.	2	.	2	2
Oreobolus pumilio	fChhpulv	.	.	.	.	.	.	.	.	.	.	4	.
Schoenus maschalinus	fChhpulv	.	.	.	.	.	.	.	.	.	.	1	.
Carex brachyathera	Hcaesp	.	.	.	.	.	.	.	5	.	.	.	.
Carex brevic.var.perciliata	Hcaesp	.	.	.	.	.	.	.	.	.	2	.	.
Carex gaudichaudiana	Hcaesp	.	.	.	.	1	.	.	.	.	.	.	.
Carex sp.	Hcaesp	.	.	.	.	.	.	.	.	2	.	.	.
Carpha alpina	Hcaesp	.	.	.	+	.	.	.	.	2	.	.	.
Luzula papuana	Hcaesp	.	.	.	.	1	.	.	1	.	.	.	.
Schoenus setiformis	Hcaesp	.	.	.	.	.	.	.	.	.	.	.	2
Uncinia compacta var.compacta	Hcaesp	.	.	.	.	.	.	.	2	.	.	.	2
Uncinia compacta var.alpina	Hcaesp	.	.	.	.	.	.	.	.	.	.	2	.
DICOT.HERBS:													
Potentilla hooglandii	gChsufpulv	.	.	2	3	3	.	.	2	.	.	.	.
Papuzilla minutiflora	gChsufpulv	.	3	.	2	2	4	.	.	.	.	.	.
Oreomyrrhis buwaldiana	gChsufpulv	.	1	.	.	.	4	.	.	.	.	.	.

RELEVE N°		4	25	26	27	63	46	49	64	59	24	62	65
Potentilla foersteriana var. foerst.	gChsufpulv	.	.	.	1	.	.	2	2	2	.	2	2
Potentilla irianensis	gChsufpulv	2											
Potentilla mangenii	gChsufpulv	.	.	.	.	.	.	2	.	.	.	.	.
Potentilla brassii var. brassii	fChhpulv	.	.	.	.	.	.	.	.	.	4	.	2
Sagina belonophylla	fChhpulv	2	.	.	.	.	.	.	.	.	.	.	.
Euphrasia cf. culminicola	Chsuff	.	.	.	.	.	.	.	.	.	.	.	.
Keysseria wollastonii	Chsuff	+	.	.	.	.	.	.	.	.	.	.	.
Epilobium detznerianum	Chsuff	.	.	.	.	2	.	.	.	.	.	.	.
Myosotis australis	Hcaesp	.	.	.	.	2	3	.	1	.	.	.	.
Gentiana cf. ettingshausenii	Hcaesp	.	.	.	.	.	.	2	.	.	.	2	.
Gentiana sp.	Hcaesp	.	.	+	.	.	.	.	.	1	+	.	.
Veronica archboldii	Hcaesp	.	2	1	1	.	.	.	.	.	+	.	.
Gentiana alpinipalustris	Hcaesp	.	+	.	.	.	.	.	.	.	.	.	.
Gentiana cf. nerteriifolia	Hcaesp	.	.	.	.	.	.	.	.	.	.	.	.
Euphrasia humifusa	Hcaesp	.	.	.	1	2	.	2	.	.	.	.	.
Oreomyrrhis papuana	Hcaesp	.	.	.	.	.	.	3	.	.	.	.	.
Oreomyrrhis pumila	Hcaesp	.	.	.	.	2	.	.	2	2	.	1	2
Cotula wilhelminensis	Hrept	.	.	.	.	.	.	2	1	3	.	.	.
Trigonotis culminicola	Hrept	.	2	.	.	.	.	.	.	.	+	.	.
Gnaphalium breviscapum	Hrept	.	.	.	.	2	.	2	2	.	.	.	.
Trigonotis sp.	Hrept	.	.	.	.	1	.	3	2	.	.	.	.
Pilea johniana	Hrept	1	2	.	.	1	3	2	.	2	2	2	1
Keysseria radicans	Hrept	.	.	.	.	.	.	.	.	.	.	.	3
Gnaphalium brassii	Hrept	.	.	.	1	.	.	.	.	.	.	.	.
Cerastium pap. ssp. keysseri	Hrept	1	2	.	.	.	4	+	.	.	.	.	.
Hydrocotyle sibthorpioides	Hrept	.	1	.	.	.	.	.	.	.	.	.	.
Sagina papuana	Hrept	.	.	.	2	2	4	.	.	.	.	.	.

RELEVE N°		4	25	26	27	63	46	49	64	59	24	62	65
Plantago aundensis	Hros	.	.	.	.	.	.	.	1	.	.	.	.
Keysseria pinguiculiformis f.nana	Hros	.	.	.	1	.	.	.	.	1	.	.	.
Plantago depauperata	Hros	.	.	.	2	.	.	.	.	.	.	2	2
Geranium monticola	Hsem	4	+	.	.	2	3	.	1	.	+	.	.
Geranium wilhelminae	Hsem	.	.	.	.	.	.	.	3	.	.	.	.
Ranunculus consimilis	Hsem	.	.	.	2	.	.	.	.	.	.	.	.
Ischnea elach.f.nana	Hsem	.	.	.	.	1	.	.	.	.	.	.	.
Abrotanella papuana	Hsem	.	.	.	.	.	.	.	.	.	.	2	+
Ranunculus amerophyloides	Hsem	.	.	.	.	.	.	.	.	.	.	.	2
Lactuca laevigata var.pusilla	Hsem	.	+	.	.	.	.	.	.	2	.	.	.
MOSSES AND HEPATICS:													
unidentified taxa	BrChpulv	4	.	.	.	.	6	.	.	5	3	3	.

Appendix V : Distribution table of genera

J : Mt Jaya W : Mt Wilhelm K : Mt Kinabalu/Borr

T : Mt Trikora OS : Owen-Stanley Range

(underlined = genera with lowland species)

	Type	J	T	W	OS	K
GYMNOSPERMS:						
Cupressaceae:						
Libocedrus	6	*	*	*	*	
Podocarpaceae:						
Dacrycarpus	4a	*	*	*	*	*
Phyllocladus	8a		*		*	*
Podocarpus	1	*	*	*	*	*
ANGIOSPERMS/MONOCOTYLEDONS:						
Centrolepidaceae:						
Centrolepis	7	*	*	*	*	*
Gaimardia	9		*	*	*	
Cyperaceae:						
Carex	1	*	*	*	*	*
Carpha	9	*	*	*	*	
Gahnia	8a	*	*		*	
Machaerina	9	*	*			*
Oreobolus	9	*	*	*	*	*
Schoenus	9	*	*	*	*	*
Scirpus	1	*	*	*	*	*
Uncinia	9	*	*	*	*	*
Eriocaulaceae:						
Eriocaulon	1	*	*	*	*	
Poaceae:						
Agrostis	1a	*	*	*	*	*
Anthoxanthum	2a	*	*	*	*	*
Brachypodium	2a	*	*	*	*	
Bromus	1a	*	*	*		*
Cortaderia	9		*	*	*	
Danthonia	1a	*	*	*	*	*
Deschampsia	1a	*	*	*	*	*
Deyeuxia	2a	*	*	*	*	
Dichelachne	8a		*	*	*	
Festuca	1a	*	*	*	*	

	Type	J	T	W	OS	K
Imperata	1		*			
Isachne	1		*			
Microlaena	3		*		*	
Miscanthus	3			*		
Phalaris	1a			*		
Poa	1a	*	*	*	*	*
Trisetum	2a		*			*
Iridaceae:						
Patersonia	7a				*	
Sisyrinchium	9	*	*	*	*	
Juncaceae:						
Juncus	1a		*			
Luzula	1a		*	*	*	
Liliaceae:						
Aletris	2a					*
Astelia	9	*	*	*	*	
Orchidaceae:						
Bulbophyllum	1		*	*		*
Calanthe	1		*	*		
Ceratostylis	3		*	*		
Chitonanthera	6a	*		*		
Coelogyne	4		*			*
Corybas	8a			*		
Dendrobium	3	*	*	*	*	
Dendrochylum	4a					*
Epiblastus	6			*		
Eria	4					*
Giulianettia	1a		*	*		
Glomera	6	*	*			
Glossorhyncha	6	*	*	*	*	
Habenaria	1		*			*
Ischnocentrum	6a			*		
Liparis	1			*		
Mediocalcar	6	*	*	*	*	
Microtatorchis	6		*	*	*	
Octarrhena	8a		*	*		
Pedilochilus	6	*	*	*	*	
Peristylus	4a			*		
Phreatia	3		*	*	*	
Platanthera	1		*			
Pterostylis	7	*	*	*		

	Type	J	T	W	OS	K
Spathoglottis	4			*		
Spiranthes	1	*				
Thelymitra	7			*		
Sphenostemonaceae:						
Sphenostemon	8a			*		
Zingiberaceae:						
Alpinia	3			*		
Riedelia	5			*		
ANGIOSPERMS / DICOTYLEDONS:						
Actinidiaceae:						
Saurauia	1	*	*	*		
Apiaceae:						
Hydrocotyle	1	*	*		*	*
Oreomyrrhis	9	*	*	*	*	*
Trachymene	7	*	*	*	*	*
Apocinaceae:						
Alyxia	1		*			
Parsonsia	3		*			
Araliaceae:						
Harmsiopanax	5			*	*	
Schefflera	1	*	*	*		*
Asteraceae:						
Abrotanella	9		*	*	*	
Anaphalis	2a	*	*	*	*	
Arrhenechtites	9	*	*	*		
Bedfordia	7a		*			
Brachycome	8a				*	
Cotula	1a	*	*	*	*	
Dichrocephala	4a			*		
Erigeron	1		*	*		
Gnaphalium	1a	*	*	*	*	
Ischnea	4a	*	*	*	*	
Keysseria	6	*	*	*	*	
Lactuca	4a	*	*	*	*	*
Lagenophora	9		*	*	*	
Myriactis	4a		*	*	*	*
Olearia	8a	*	*	*	*	
Piora	6a				*	
Rhamphogyne	6a		*			
Senecio	1a	*	*	*	*	

	Type	J	T	W	OS	K
Sonchus	1			*		
Tetramolopium	8	*	*	*	*	
Aquifoliaceae:						
Ilex	1			*		*
Balanophoraceae:						
Balanophora	3					*
Bignoniaceae:						
Tecomanthe			*			
Boraginaceae:						
Cynoglossum	1			*		
Myosotis	1a	*	*	*	*	
Trigonotis	4a	*	*	*	*	*
Brassicaceae:						
Cardamine	1a	*	*	*	*	
Lepidium	6a	*	*		*	
Callitrichaceae:						
Callitriche	1a		*	*	*	
Campanulaceae:						
Lobelia	1	*	*	*	*	*
Peracarpa	4a				*	
Pratia	1				*	
Wahlenbergia	9		*	*	*	
Caryophyllaceae:						
Cerastium	2a	*	*	*	*	
Sagina	2a	*	*	*	*	
Scleranthus	1a	*			*	
Stellaria	1a			*		
Celastraceae:						
Celastrus	1			*		
Perrottetia	2			*		
Chloranthaceae:						
Ascarina	8		*	*		
Clusiaceae:						
Hypericum	1	*	*	*	*	
Coriariaceae:						
Coriaria	1a			*		
Cunoniaceae:						
Acsmithia						
Caldcluvia	9			*		
Dapniphyllaceae:						
Daphniphyllum	4a		*	*	*	*

	Type	J	T	W	OS	K
Dipsacaceae:						
Triplostegia	4a	*	*	*	*	
Droseraceae:						
Drosera	1		*			
Elaeocarpaceae:						
Elaeocarpus	3		*	*	*	
Sericolea	6a	*	*	*		
Epacridaceae:						
Decatoca	6a				*	
Styphelia	8a	*	*	*	*	*
Trochocarpa	7	*	*	*	*	*
Ericaceae:						
Agapetes	4			*	*	
Dimorphanthera	6	*	*	*	*	
Diplycosia	5	*	*			*
Gaultheria	1a	*	*	*	*	*
Rhododendron	2a	*	*	*	*	*
Vaccinium	2a	*	*	*	*	*
Euphorbiaceae:						
Homalanthus	8a			*		
Macaranga	3			*		
Fagaceae:						
Lithocarpus	4					*
Nothofagus	9		*	*		
Gentianaceae:						
Gentiana	1a	*	*	*	*	*
Swertia	2a				*	
Geraniaceae:						
Geranium	1a	*	*	*	*	
Gesneriaceae:						
Aeschinanthus	4a			*		
Cyrtandra	5			*		*
Dichrotrichon	5					*
Haloragaceae:						
Gonocarpus	7	*	*	*	*	*
Gunnera	9			*		
Myriophyllum	1				*	
Lauraceae:						
Actinodaphne	5					*
Endiandra	4a		*			
Litsea	4a		*			

	Type	J	T	W	OS	K
Linaceae:						
Linum	?			*		
Loganiaceae:						
Fagraea	4			*		
Loranthaceae:						
Amyema	8a		*	*	*	*
Lepidaria	5					*
Monimiaceae:						
Palmeria	7a			*		
Moraceae:						
Streblus	3			*		
Myricaceae:						
Myrica	2a					*
Myrsinaceae:						
Embelia	3					*
Maesa	3			*		
Rapanea	1	*	*	*	*	*
Myrtaceae:						
Decaspermum	3	*	*	*		
Leptospermum	8a					*
Xanthomyrtus	6	*	*	*		*
Syzygium	3					*
Nepenthaceae:						
Nepenthes	3					*
Oleacaceae:						
Jasminum	3			*		
Onagraceae:						
Epilobium	1a	*	*	*	*	
Oxalidaceae:						
Oxalis	1a	*	*	*	*	
Piperaceae:						
Piper	1		*	*		
Pittosporaceae:						
Pittosporum	3	*	*	*	*	
Plantaginaceae:						
Plantago	1a	*	*	*	*	
Polygonaceae:						
Muehlenbeckia	9		*	*	*	
Polygonum	1		*	*	*	
Portulacaceae:						
Montia	1a		*		*	

	Type	J	T	W	OS	K
Potamogetonaceae:						
Potamogeton	1		*			
Ranunculaceae:						
Ranunculus	1a	*	*	*	*	*
Thalictrum	2a	*	*			
Rhamnaceae:						
Alphitonia	8a			*		
Rhamnus	1			*		
Rosaceae:						
Acaena	9	*	*	*	*	
Photinia	2a					*
Potentilla	1a	*	*	*	*	*
Prunus	1		*	*	*	
Rubus	1	*	*	*	*	*
Rubiaceae:						
Amaracarpus	6			*	*	
Coprosma	8a	*	*	*	*	*
Galium	1a	*	*	*	*	
Hedyotis	3	*	*	*	*	*
Hydnophytum	6		*			
Myrmecodia	5	*	*			
Nertera	9	*	*	*	*	*
Psychotria	1		*	*		
Timonius	3	*	*	*		
Rutaceae:						
Acronychia	8a		*	*		
Evodia			*			
Evodiella	7a			*		
Melicope	3		*	*	*	
Tetractomia	5		*			
Santalaceae:						
Cladomyza	5	*	*	*	*	
Sapindaceae:						
Dodonaea	7			*		
Saxifragaceae:						
Astilbe	2a		*			
Carpodetus	8	*	*	*	*	
Polyosma	4			*	*	*
Quintinia	8a	*	*	*	*	
Scrophulariaceae:						
Detzneria	6a			*		

	Type	J	T	W	OS	K
Euphrasia	1a	*	*	*	*	*
Mazus	?			*		
Parahebe	9	*	*	*	*	
Veronica	2a	*	*	*	*	
Symplocaceae:						
Symplocos	1	*	*	*	*	*
Theaceae:						
Adinandra	4a					*
Eurya	4	*	*	*	*	*
Schima	4a					*
Ternstroemia	1					*
Thymeleaceae:						
Drapetes	9	*	*	*	*	*
Urticaceae:						
Cypholophus	5		*			
Elatostema	1	*		*		*
Lecanthus	4a			*		
Parietaria	1a	*	*			
Pilea	1	*	*	*	*	*
Pipturus	3			*		
Urtica	1a		*			
Violaceae:						
Viola	1a	*	*	*	*	
Winteraceae:						
Drimys	9	*	*	*		*
Zygogynum	8			*		

Les TRAVAUX SCIENTIFIQUES DU MUSÉE NATIONAL D'HISTOIRE NATURELLE DE LUXEMBOURG paraissent à intervalles non réguliers.

Liste des numéros parus à cette date:

I Atlas provisoire des Insectes du Grand-Duché de Luxembourg. Lepidoptera, 1re partie (Rhopalocera, Hesperiidae).
Marc MEYER et Alphonse PELLES, 1981.

II Nouvelles études paléontologiques et biostratigraphiques sur les Ammonites du Grand-Duché de Luxembourg et de la région Lorraine attentante. Pierre L. MAUBEUGE, 1984.

III Revision of the recent western Europe species of genus Potamocypris (Crustacea, Ostracoda). Part 1: Species with short swimming setae on the second antennae. Claude MEISCH, 1984.

IV Hétéroptères du Grand-Duché de Luxembourg
1. Psallus (Hylopsallus) pseudoplatani n. sp. (Miridae, Phylinae) et espèces apparentées. Léopold REICHLING, 1984.
2. Quelques espèces peu connues, rares ou inattendues.
Léopold REICHLING, 1985.

V La bryoflore du Grand-Duché de Luxembourg: taxons nouveaux, rares ou méconnus.
Ph. DE ZUTTERE, J. WERNER et R. SCHUMACKER, 1985.

VI Revision of the recent western Europe species of genus Poatmocypris (Crustacea, Ostracoda). Part 2: Species with long swimming setae on the second antennae. Claude MEISCH, 1985.

VII Les Bryozoaires du Grand-Duché de Luxembourg et des régions limitrophes. Gaby GEIMER et Jos. MASSARD, 1986.

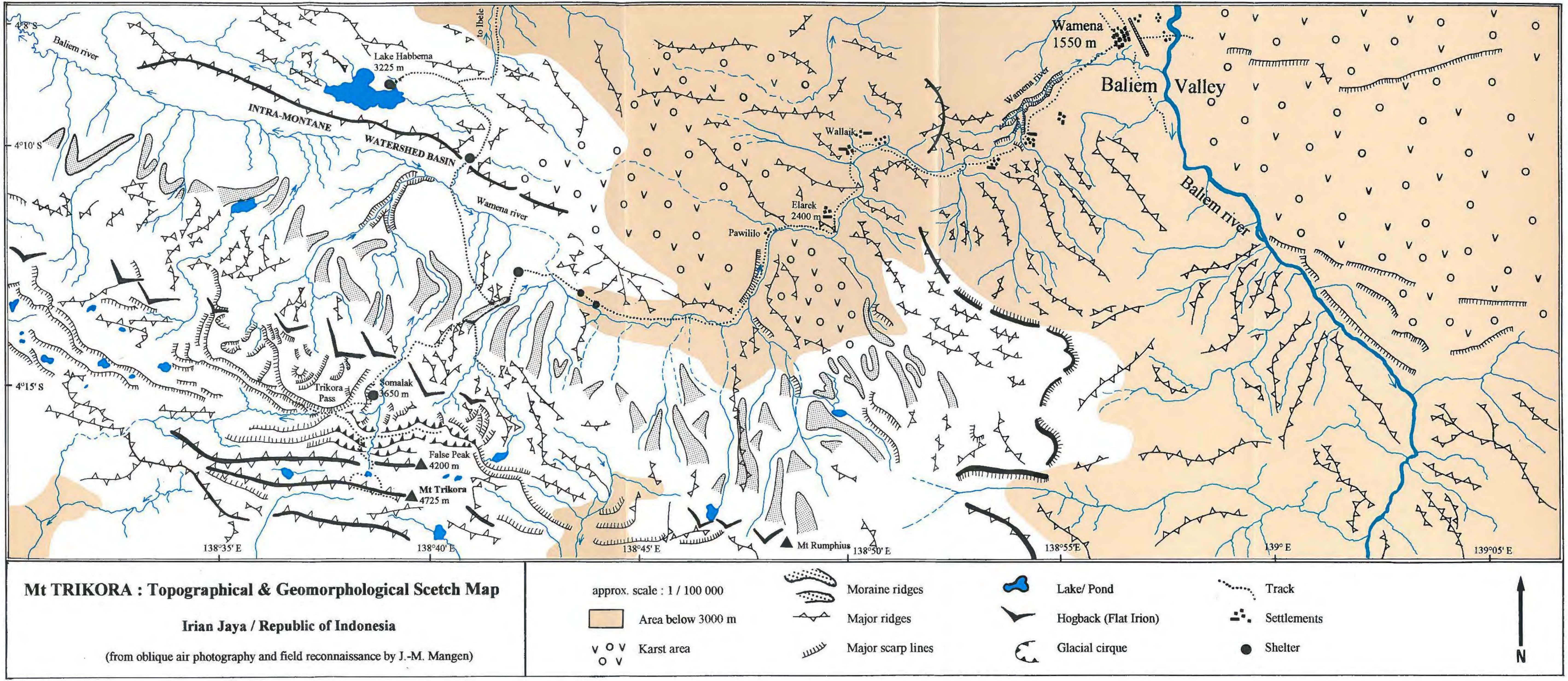
VIII Répartition et écologie des macrolichens épiphytiques dans le Grand-Duché de Luxembourg. Elisabeth WAGNER-SCHABER, 1987.

IX La limite nord-orientale de l'aire de Conopodium majus (Gouan) Loret en Europe occidentale. Régine FABRI, 1987.

X Epifaune et endofaune de Liogryphaea arcuata (Lamarck).
Armand HARY, 1987.

Ces numéros peuvent être obtenus à l'adresse suivante:

Musée national d'histoire naturelle, Bibliothèque-Echanges, Marché-aux-Poissons, L-2345 LUXEMBOURG



Mt TRIKORA : Topographical & Geomorphological Scetch Map

Irian Jaya / Republic of Indonesia

(from oblique air photography and field reconnaissance by J.-M. Mangen)