STRUCTURE AND FLORISTICS OF A MONTANE GRASSLAND/FOREST TRANSITION, DOMA PEAKS REGION, PAPUA

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I. SUMMARY

A comprehensive study of structure and floristics in a typical montane (2700 m) grassland/forest transition in Papua-New Guinea was made using a destructive technique involving complete removal of all woody species below 10 m, in a single belt transect. By this means the distribution of all tracheophytes in a dense transitional system was accurately determined, providing evidence that the transition was advancing over open grassland. Use is made of profile and plan drawings.

The transition is described as a discrete community in terms of juvenile, mature, and senescent phases. A distinct group of transition species is recognized. The distributions of life-forms and a symbiotic relationship between moss-hummocks and transition species are discussed, and the role of fire in transition dynamics is briefly considered.

2. INTRODUCTION

No quantitative published data appear to be currently available on grassland/forest transitions in Papua-New Guinea. Until recently (Fosberg, 1968; Hills and Randall, 1968) very little attention had been given to the concept of such transitions in the tropics as being discrete communities or ecosystems.

Generally there have been two viewpoints on the structural and floristic arrangement of grassland/forest ecotones. One is that they may possess certain floristic elements which differ from either grassland or forest communities while still possessing some characteristics of both (Odum, 1959). The other is that they are merely vegetational overlaps of both grassland and forest ecosystems. In addition to Odum (loc. cit.), others including Garfitt (1966) have referred to the 'edge-effect' associated with transitions and many plant and animal ecologists agree on transitions being somewhat exceptional in their high species density. In an evolutionary sense, Wilson (1959) has postulated that such marginal habitats formed a bridge for the development of certain Melanesian ant species groups derived from Asia. In the light of such high biological interest it is thus remarkable that transitions have not been explored more thoroughly.

Hills and Randall (1968) in an editorial comment on a symposium dealing with the ecology of the forest/savanna boundary made the observation that most contributors to the symposium dwelt either on the grassland or the forest to the exclusion of the boundary situation. This paper is designed to contribute at least some quantitative data if only from a single transect, in an attempt to define a little more clearly the actual position of the transition as a third and quite distinct community.

The importance of the development of the transition is underlined when it is considered that, as a separate although contiguous community, its dynamic status (depending on fire frequency) will have a measurable effect on the advance or retreat of either grassland or forest. It needs little in the way of statistics to outline the current situation regarding shifting agriculture and the resultant expansion of both grassland and woody savannas in the tropical world. If more attention can be focussed on an ecological study of the transitions concerned in different tropical areas, it is certain that a much clearer picture of both grassland and forest genesis will be obtained.

3. TERMINOLOGY

The term *transition* is used rather than *ecotone*, *boundary* or *margin* because it infers a movement from one state to another and more correctly expresses the dynamic situation.

The difficulty entailed in effectively defining structure apart from physiognomy is noted here and has been observed elsewhere, notably by Fosberg (1967) and Webb c.s. (1969), the latter choosing not to separate them at all for use in numerical analysis of complex rainforest communities.

In the present investigation basic vegetation classification including structure follows Beadle and Costin (1953) with the exception that rainforest nomenclature follows the physiognomic classification laid down by Webb (1959). More detailed physiognomic description of life-forms is derived from the classification of Raunkiaer (1934) as enlarged and revised by Ellenberg and Mueller-Dombois (1967), although problems have arisen here in locating a satisfactory term for the layered 'stoloniferous' woody phanerophytes abundant in the Ibiwara transition.

4. LOCATION

The area studied was in the Ibiwara Valley in the Doma Peaks region at about 2700 m (Kalkman & Vink, 1970). The grass/forest mosaic was at various stages of equilibrium with local patterns of topography and fire frequency. Location of a sharp grassland/forest transition was difficult due to the range of seral stages in the area.

5. METHODS

Methods were designed to give maximum data for structure and floristics only.

Following an intensive botanical collection of local grassland/forest transitions a typical site was selected. A belt transect 45 m long × 10 m wide was laid out covering extremes from a mature grassland situation through the transition to 'mature' structured montane forest; the profiles and plan maps in the present paper cover only 350 of the 450 sq.m. This transect was then divided into 5 m × 5 m contiguous quadrats (see fig. 2). Within the transect a complete count of spermatophyte and pteridophyte species was then made. Observations and collections (largely indeterminate) were made of conspicuous bryophyte species, e.g. in moss-hummocks. In addition to a species count, the position and dimension of each woody individual was fixed, plotted to scale on a map and shown both in a plan view of the transect, and if taller than 1 m, as a profile view along one side of the transect to a depth of 5 m (see figs 1 and 2). Notes were made of seedling establishment. Open grassland species were mapped in recognisable associations and included small woody genera, e.g. *Gaultheria* and *Styphelia*.

In the forest interior, floor species, largely soft-tissued *Zingiberaceae* and *Urticaceae*, were mapped separately (see figs 3 and 4). To show the somewhat remarkable layering habit of many transition species surface root systems were also mapped (see fig. 5).

Measurement of all plants was rendered difficult, initially, by the extreme tangle ot transition species, particularly the *Ericaceae*. As a result a destructive method was used in which each plant under 10 m was removed from the transect after being counted. Through such a tedious, destructive, and positively effective method the transect from the woody transition point inwards eventually assumed the aspect of a closely cropped 'lawn' (see photos 7 and 8).

Botanical collections of sterile material in the transect were subsequently identified by comparison with flowering material from the Ibiwara locality (see Appendix), and later identified at the Rijksherbarium Leiden. A better than 75 % good identification to species level was obtained.

6. ENVIRONMENTAL FACTORS

a. Climate

Macroclimate data from Ibiwara are extremely scant (Gillison, 1969; Kalkman & Vink, 1970). No data for microclimatic conditions were recorded. Generally, atmospheric turbulence appeared to be greatly reduced in the forest as a result of protection by the transition 'barrier' and the forest canopy. Consequently, important implications arise here in terms of fire resistance. Relative humidity in all vegetation investigated was probably in excess of 95 % overnight when mist was usually present. In other, lower montane areas of New Guinea, e.g. about 2000 m, Gillison (unpublished data) found that humidity in the grassland mat fell off rapidly after 0700 hours, often down to 40 % on a sunny day, with a corresponding lag of about two hours in both transition and oak *(Castanopsis acuminatissima)* forest. In the Ibiwara transect we found enclosed micro-communities within transition moss-hummocks (see fig. 1) in which the plants were in a continually humid state (probably greater than 95 % R.H.) throughout a 24 hour period. On exposure to midday ambient shade conditions such communities withered rapidly. It is certain that relative to the rest of the transect, light and temperature values were considerably depressed within moss-hummock communities.

Aspect appeared to influence the development of transitions in the Ibiwara locality, and vegetation appeared to be more xeric in transitions exposed to the afternoon sun than in those with an eastern aspect such as the one under investigation.

b. Topography

The transect was generally even with a less than five degree slope from forest down to grassland and with a common slope of less than three degrees at right angles to the transect. No topographic discontinuity was evident along the transition.

c. Edaphic features

The soils in the Ibiwara zone were probably derived from Pleistocene ash deposits (Perry c.s., 1965). Profiles to a depth of 80 cm showed relatively similar features in grassland, transition, and forest, with a peaty surface horizon of 20—30 cm in the grassland overlying a yellow-grey plastic clay. The peaty layer increased in depth to almost 50 cm in transition and forest, probably due to increased litter fall and absence of fire.

Free water occurred at about 40 cm in grassland and transition, becoming deeper in the forest. The majority of root systems were developed above the clay horizon. In the 'core' grassland situation in the Ibiwara area gley horizons were common (Gillison, 1969).

d. Site History

No firm data are available for any precise determination of site history. Comparison in 1966 with aerial photographs taken over the period 1959—61 showed very little vegetational change.

Saunders (1965) includes the grassland area studied within a category of 'derived grassland following forest removal and natural grasslands of the intramontane basins and alpine areas'. The main historical factor is undoubtedly man. From the frequent although irregular firing which had been maintained (probably in excess of 50 years) by villagers passing through the Tari Gap, it appears almost certain that the Ibiwara area was once under montane forest and had developed since into the mixed grassland/forest mosaic.

Hunting tracks were usually present within the forest margin and the collection of *Pandanus* fruit was common along grassland/forest transitions where *Pandanus* largely occurred. The higher incidence of fauna occurring along the transition also attracted hunters. Evidence for the fluctuation of the transition was everywhere abundant and is dealt with in a separate section of this paper.

7. VEGETATION

a. Grassland, structure and floristics

The grassland varied locally but the formation could be regarded as wet tussock grassland with a high incidence of *Cyperaceae*. In general, high fire frequency had produced a short mixed grassland subclimax consisting variously of the grasses *Arundinella furva, Imperata cylindrica, Danthonia archboldii, Miscanthus floridulus, Eulalia leptostachys, Dichelachne novoguineensis, Brachypodium sylvaticum, Isachne arfakensis, Isachne spec.*, and *Agrostis avenacea.*

Generally this sward was dominated by clumps of *Danthonia archboldii* interspersed with numerous Cyperaceous co-dominants, *Machaerina rubiginosa* and *Rhynchospora rugosa.* Other unidentifiable *Cyperaceae* were common. A mixture of *Gleichenia erecta* and *Gleichenia vulcanica* occurred locally in small clumps. Scattered herbs were *Gentiana ettingshausenii* and *G. piundensis, Potentilla foersteriana* var. *ima*, and *Haloragis halconensis.* Woody species were *Rhododendron commonae, Xanthomyrtus (e), Styphelia suaveolens*, and *Gaultheria mundula.*

A conspicuous feature of the grassland section of the transect was the local scattering of hummocks consisting mainly of *Sphagnum sp.* which increased in size and frequency towards the transition (see fig. 1 and photo 4). Flora associated with these moss-hummocks appeared to change depending on hummock size. Hummocks greater than 30 cm commonly possessed a cover of prostrate *Xanthomyrtus (e)*, and were penetrated by *Miscanthus floridulus* and *Machaerina rubiginosa.* A species of *Selliguea* existed on the periphery with its rhizomes well ramified within the hummock. In addition, *Gleichenia spp., Haloragis halconensis, Gaultheria mundula*, and *Styphelia suaveolens* occurred in the same peripheral zone.

The impression gained from the association was that *Sphagnum* hummocks, once they reached a height greater than about 30 cm, provided a fire protected situation allowing vegetative as well as sexual regeneration of various vascular plants. The circumstance became more complex with much larger hummocks in the transition.

Fire resistance of the dominant grass species *Danthonia archboldii* appeared reasonably high. The formation of clumps of this grass under frequent firing undoubtely offered some protection to its root system. Under local bog conditions in more open grassland it developed conspicuous blackened 'trunks' up to 15 cm thick and 50 cm high. Other than *D. archboldii* most of the grass species apart from scattered rhizomatous *Imperata cylindrica* var. *major* and possibly *Miscanthus floridulus* seemed to exist as therophytes. In an investigation of an open grassland plot (Gillison, 1969) it was found that the genus *Isachne (I. arfakensis, I myosotis,* and *I. spec.)* invaded as an early pioneer following fire and achieved anthesis in two to three weeks. The Cyperaceous species *Machaerina rubiginosa* also exhibited high fire resistance as did other *Cyperaceae* including *Rhynchospora rugosa.* The ferns *Gleichenia spp.* and *Selliguea spec.* were similarly resistant to fire.

Most other vascular species were either typical geophytes, e.g. *Potentilla foersteriana* var. *ima*, or else fire resistant chamaephytes, e.g. *Styphelia suaveolens, Gaultheria mundula, Rhododendron commonae,* and the prostrate *Xanthomyrtus (e).* Under decreasing fire-frequency outside the transect area the latter assumed erect shrub-like proportions. Regenerative characteristics of most species in the grassland section of the transect showed high adaptation to fire with a conspicuous production of small and easily dispersed propagules. In addition, vegetative regeneration was a definite characteristic of the same zone.

b. Forest

The transect was extended into the forest until a significant section representing reasonably mature montane rain forest was obtained. The forest of a notophyll/microphyll type was characterized by a low floor stratum varying in height to about 3 m, occupied by shrubs (mainly species of *Piper, Drimys, Levieria* and *Palmeria, Wikstroemia androsaemifolia* and *Streblus urophyllus* var. *urophyllus*). In addition the tree-ferns *Cyathea rigens* and *Dicksonia hieronymi* were common, as were some herbs (species of *Alpinia, Cyrtandra (b),* and *Procris*). It is of particular note that above the 3 m point there was usually either a gap until the mature forest canopy was reached at about 10 m or else there was locally mixed, vertically contiguous foliage consisting of lianas, tree-ferns, and woody phanerophytes. Throughout the forest and within the transect no evidence existed to delineate distinct strata other than floor and canopy. Climbing and scrambling plants included *Schefflera, Piper, Cyrtandra* (*a*), and *Lycopodium* species, but were dominated by *Dimorphanthera cornuta* var. *cornuta* and *D. collinsii* var. *collinsii*. Epiphytic mosses and lichens were observed. Tree species of *Rosaceae, Lauraceae,* and *Saxifragaceae* were common canopy elements throughout the montane forest and in the transect were represented by *Prunus grisea* var. *grisea, P. pullei, Litsea exsudens,* and *Quintinia (a).* Senescent *Pandanus* also occurred.

Regeneration of woody forest species appeared to be almost entirely by seed. *Drimys piperita ('coriacea')* was observed to propagate by a 'stoloniferous' method which probably occurred as a result of suckering from a fallen plant (photo 5). Some floor plants, e.g. *Alpinia spp.* and *Rubus archboldianus*, were capable of vegetative as well as sexual propagation, while others such as *Procris* were apparently only sexually regenerative.

It was assumed that apart from some lianas, e.g. *Dimorphanthera* species and possibly the rhizomatous *Alpinia spp.*, fire resistance of all other forest species was relatively low.

c. The transition

Because grassland/forest transitions continually change location due to varying environmental factors such as fire and drainage it is difficult to define spatial limits. On the grassland aspect in particular a close examination along the transition usually revealed a continuum of a few species which were found scattered even in the 'core' regions of open grassland.

Generally speaking in New Guinea there is a recognisable group of transition species (fig. 6), members of which do not usually occur in open grassland and are rarely found under mature forest conditions. That species group may be used to apply reasonably close floristic limits to define the transition community, and it may be left to the observer, and the particular state of the transition at that time, to decide how much importance must be given to overlaps. The 'intactness' of the transition will be a reflection of the grassland status in terms of its development under a given fire frequency. High fire frequency will lead to a sharply defined transition whereas the reverse will lead to an expansion of the transition with resultant poorer definition.

In New Guinea most grassland/forest transitions may be described in terms of three phases. These phases are contiguous within the transition community and are termed *juvenile*, *mature*, and *senescent*. Provided the transition represents a fluctuating condition and not a state of initial grassland invasion into mature forest, the latter phase will be present (Gillison, unpublished data).

The Ibiwara transition represented a fluctuating condition then under forest advance, and is described accordingly.

1. Juvenile transition

Juvenile transition is usually an overlap site with grassland species, and contains a mixture of transitional plants under 100 cm high often together with seedlings of mature transition species.

At Ibiwara a feature of the juvenile transition was the development of a moss-hummock 'barrier' which consisted of a broken line of hummocks up to 1 m high and up to 3 m across the base, made up largely of *Sphagnum* and to a lesser degree of other unidentifiable bryophytes. The exposed grassland side of the hummocks was steep whereas the protected side sloped gradually towards the mature transition (see fig. 1). Within the humid interior of the hummock was a ramified rhizome system of a *Selliguea* species together with small 'caves' containing other ferns *(Hymenophyllaceae)*. Rhizomes of *Miscanthus floridulus* and shoots of *Machaerina rubiginosa* were also present as were the protected root systems of *Xanthomyrtus (e)*, *Coprosma novoguineensis*, *Syzygium cf. adelphicum* and *Haloragis halconensis*. Ferns *(Gleichenia spp.)* and Ericads were present to a limited degree. Also within the hummocks were suckering stems of *Rapanea (a)* (arising from mature transitions) together with root stocks of *Vaccinium cruentum* (photo 4) and *Rhododendron commonae*. A noteworthy occurrence was the presence of germinating *Pandanus* seedlings near the hummock surface (see photo 4).

Behind the hummocks were 1—3 m tall woody phanerophytes *Glochidion (a)*, *Daphniphyllum gracile*, *Olearia rufa*, *Coprosma novoguineensis*, *Pittosporum pullifolium*, the liana *Jasminum spec.*, the stoloniferous herb *Dianella ensifolia*, and seedlings of *Rapanea (a)* and *Vaccinium cruentum*. The majority of species were fast growing with a high rate of seed dispersal and were restricted to a somewhat exposed situation.

2. Mature transition

The mature transition phase contained a range of life-forms from reptant 'stoloniferous' woody phanerophytes to both erect woody and rosulate phanerophytes and lianas. Mosses and fruticose lichens (thallo-chamaephytes) were present.

The two most conspicuous life-form groups were the rosulate *Pandanus* and the tremendous tangle of creeping *Ericaceae*. This root/stem tangle (photo 6) was carefully mapped (see fig. 5) and it was found that the exposed foliage clumps in most cases originated from a leafless horizontal branching system often rooted at distances up to about 10 metres in towards the forest. Stems of some species, e.g. *Vaccinium cruentum*, *Rhododendron beyerinckianum*, and *Dimorphanthera cornuta* var. *cornuta*, had produced roots at various points and in some cases towards the senescent zone, old rotting stems and root butts still connected to viable recently layered stems, were evident.

Tree species were *Timonius belensis*, *Pittosporum pullifolium*, *Syzygium cf. adelphicum*, and *Pandanus spec.*

3. Senescent transition

This contained dying or etiolated plants of species also found in the mature transition. Apart from an occasional unidentifiable dead treelet, typical units were *Pandanus*, *Jasminum*, *Rapanea*, and *Piper* species, *Daphniphyllum gracile*, *Vaccinium cruentum*, *Rhododendron beyerinckianum*, and *Dimorphanthera cornuta* var. *cornuta*. Dead or dying root-stocks of these species were characteristic of the local status. In addition, there was evidence of superposition of species, e.g. *Pandanus* roots enveloping old *Rapanea* bases. Further in the forest where canopy holes occurred, senescents maintained a tenuous hold.

8. DISCUSSION

The evidence based on structure and backed up by floristic data points to a discrete community established between the adjacent montane forest and grassland communities. The degree of separation was somewhat diffuse in small areas on either side of the transition where small overlaps occurred with ubiquitous species e.g. some grassland chamaephytes and thallo-chamaephytes, and within the forest there were some scattered relict transition species. Provided these species are recognised in their correct perspective it is not difficult to view the transition as a separate entity.

Physiologically, the species regarded here as characterising the transition reached greatest vigour in the mature transition and were then most active in their dispersal of propagules.

As the transition is therefore a separate unit, and as it is certain that under varying fire frequency there will be rapid changes in location of the transition, it is assumed to retain its identity the transition must exhibit a high degree of mobility.

In the Ibiwara transition the degree of mobilization had reached an amazing peak of efficiency. The vegetative propagation by natural layering exhibited particularly by the numerous *Ericaceae* revealed the forest was unmistakably in a state of advance over the grassland as shown by the presence of old root-stocks and decaying stems still attached to the live plant and located well towards the forest.

It is interesting to note that the above method of propagation is ideally geared to ensure survival of the plant should a sudden reverse occur due to an intense fire. Here the line of 'retreat' is facilitated by three factors: firstly there is the fire resistance of Ericaceous species, followed secondly by rapid foliar regeneration, and thirdly the last line of retreat, stepwise to layer points along the stem (photo 2).

Another perhaps unique point in the Ibiwara transition was the apparent symbiotic relationship of the moss-hummocks with woody transition species. In the juvenile transition zone, a layering *Rapanea* species had formed a base for the growth of a hummock about 1 m high. Apart from the protection from fire offered by the moss-hummock to small woody species rooted within it, *Pandanus* seedlings were observed to germinate in the hummock surface layers. The seedlings under these conditions had produced a robust adventitious root system supported by the moss (photo 1). Several advantages were achieved by such a system. One was the escape from rodents (*Pandanus* seedlings were rarely seen to be established in any number on the open forest floor), secondly the *Pandanus* was afforded a good degree of protection from fire, and thirdly a rapid increase in height of the plant was gained over local competitors.

The possibility that such a critical system could have evolved at first seemed unlikely until an inspection in senescent transition showed the adventitious roots of two mature *Pandanus* trees established over the remains of old layered *Rapanea* bases.

Successful development leading to the establishment of thickets containing transition species in some open grassland areas with low fire frequency was investigated at Ibiwara (Gillison, 1969). Under these conditions ecological tension zones occurred along moisture gradients which, under low fire frequency, allowed nuclei of woody plants to develop. Under prolonged conditions of fire absence it is likely that such thickets would coalesce with the advancing grassland/forest transition leading ultimately to a complete forest cover.

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SPECIES PRESENT IN IBIWARA GRASSLAND/FOREST TRANSITION

No.	Family	Name 1)	Compared Specimen 2)
1.	Pter.	*Gleichenia erecta* 3)	K. 4635
2.	Pter.	*Gleichenia vulcanica* 4)	K. 4640
3.	Gram.	*Arundinella furva* 5)	NGF 25090
4.	Gram.	*Danthonia archboldii* 6)	K. 4769
5.	Gram.	*Miscanthus floridulus*	—
6.	Myrt.	*Xanthomyrtus* (*e*)	NGF 25150
7.	Gram.	*Isachne spec.* 7)	NGF 25094
8.	Gent.	*Gentiana ettingshausenii*	K. 4619
		and *G. piundensis*	K. 4621
9.	Gram.	*Brachypodium sylvaticum*	—
10.	Pter.	*Pteridium aquilinum*	K. 4947
11.	Pter.	*Selliguea spec.*	V. 17007
12.	Lil.	*Dianella ensifolia*	NGF 28280
13.	Pand.	*Pandanus spec.*	—
14.	Rub.	*Coprosma novoguineensis*	K. 4614
15.	Eric.	*Diplycosia rupicola*	NGF 25185
16.	Ros.	*Rubus archboldianus*	V. 17515
17.	Halor.	*Haloragis halconensis*	V. 16969
18.	Myrs.	*Rapanea* (*a*)	V. 16990
19.	Pitt.	*Pittosporum pullifolium*	K. 4616
20.	Eric.	*Vaccinium cruentum*	NGF 25186
21.	Euph.	*Glochidion* (*a*)	V. 17096
22.	Myrt.	*Syzygium cf. adelphicum*	V. 16992
23.	Comp.	*Olearia rufa*	NGF 25130
24.	Daphn.	*Daphniphyllum gracile*	NGF 25133
25.	Pip.	*Piper* (*a*)	NGF 25137
26.	Eric.	*Rhododendron beyerinckianum*	V. 16973
27.	Eric.	*Dimorphanthera cornuta* var. *cornuta*	K. 4952
28.	Mor.	*Streblus urophyllus*	NGF 25159
29.	Rub.	*Timonius belensis*	NGF 25119
30.	Ros.	*Prunus pullei*	NGF 25156
31.	—	Unknown	
32.	Eric.	*Dimorphanthera collinsii* var. *collinsii*	K. 4902
33.	Ros.	*Prunus grisea* var. *grisea*	K. 4627
34.	Myrs.	*Rapanea* (*b*)	V. 16972
35.	Laur.	*Litsea exsudens*	K. 4899
36.	—	Dead treelet	
37.		*Dicksonia hieronymi*	K. 4654
38.	Monim.	*Kibara* (*a*)	V. 17232
39.	Thymel.	*Wikstroemia androsaemifolia*	V. 17195
40.	Pter.	*Cyathea rigens*	K. 4885
41.	—	Unknown	
42.	—	Unknown	
43.	Monim.	*Levieria parvifolia*	K. 5160
44.	Wint.	*Drimys piperita* ('*coriacea*')	—
45.	Euph.	*Breynia cernua*	NGF 25197

1) For indications between brackets see Appendix in Kalkman & Vink 1970.

2) K: Kalkman; NGF: Gillison or Frodin; V: Vink.

3-7) In Gillison 1969 listed as: *3*) *Gleichenia linearis* var. *montana*; *4*) *Gleichenia microphylla* var. *vulcanica*; *5*) *Deyeuxia sclerophylla*; *6*) *Hierochloe redolens*; *7*) *Isachne globosa*.

No.	Family	Name 1)	Compared Specimen 2)
46.	Oleac.	*Jasminum spec.*	K. 4613
47.	—	Unknown	
48.	Aral.	*Schefflera (e)*	V. 16975
49.	Aral.	*Schefflera (a)*	V. 16960
50.	Euph.	*Claoxylon (b)*	V. 17509
51.	Elaeoc.	*Elaeocarpus (b)*	NGF 28123
52.	Sax.	*Quintinia (a)*	NGF 25122
53.	Pter.	*Dryopteris spec.*	—
54.	Monim.	*Palmeria (a)*	V. 17209
55.	Myrs.	*Rapanea spec.*	—
56.	Rut.	*Acronychia (a)*	NGF 25121
57.	Euph.	*Omalanthus (a)*	NGF 25120
58.	Apoc.	*Alyxia spec.*	NGF 25143
59.	Gesn.	*Aeschynanthus (a)*	NGF 25184
60.	Elaeoc.	*Sericolea (b)*	NGF 25118
61.	Rub.	*? Psychotria spec.*	—
62.	—	Unknown	
63.	—	Unknown	
64.	Podoc.	*Podocarpus bracteatus*	NGF 25178
65.	Eric.	*Rhododendron commonae*	V. 16958
66.	Epacri.	*Styphelia suaveolens*	K. 4670
67.	Eric.	*Gaultheria mundula* var *? mundula*	
68.	—	Unknown	
69.	Zing.	*Alpinia (a)* and *Alpinia (b)*	K. 4712 NGF 28314
70.	Pter.	*Blechnum (a)*	K. 4641
71.	Orch.	*Calanthe spec.*	K. 4884
72.	Gram.	*Imperata cylindrica* var. *major*	—
73.	Bryoph.	*Sphagnum spec.*	—
74.	Gent.	*Swertia papuana*	K. 4609
75.	Cyp.	*Rhynchospora rugosa*	NGF 25105
76.	Cyp.	*Machaerina rubiginosa*	NGF 25168
77.	Ros.	*Potentilla foersteriana* var. *ima*	K. 4925
78.	Lycop.	*Lycopodium (d)*	K. 4883
79.	Urt.	*Procris*	K. 4705
80.	Gesn.	*Cyrtandra (a)* and *Cyrtandra (b)*	V. 16912 V. 17493
81.	Gram.	*Isachne arfakensis*	NGF 25098
82.	Gram.	*Agrostis avenacea*	K. 4875
83.	Gram.	*Dichelachne novoguineensis*	NGF 25103
84.	Gram.	*Eulalia leptostachys*	NGF 25102
85.	Cyp.	indet.	—
86.	Cyp.	indet.	—
87.	Cyp.	indet.	—

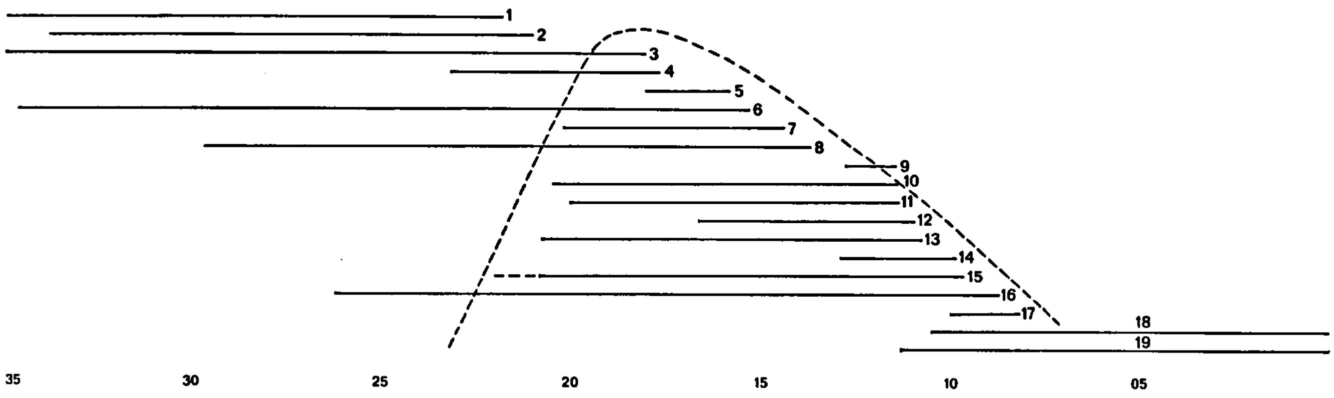

Figure 6. Distribution of light demanding species in the transect. Dotted line indicates grouping of transition species. 1. *Litsea exsudens*; 2. *Dimorphanthera collinsii* var. *collinsii*; 3. *Timonius belensis*; 4. *Prunus pullei*; 5. *Glochidion* spec.; 6. *Dimorphanthera cornuta* var. *cornuta*; 7. *Rhododendron beijerinckianum*; 8. *Piper* (*a*); 9. *Olearia rufa*; 10. *Syzygium cf. adelphicum*; 11. *Daphniphyllum gracile*; 13. *Pittosporum pullifolium*; 14. *Diplycosia rupicola*; 15. *Rapanea* (*a*); 16. *Pandanus* spec.; 17. *Coprosma novoguineensis*; 18. *Xanthomyrtus* (*a*); 19. mosses and grassland herbage. Ordinate: metres.

Photo 1. Moss-hummock removed to show developing *Pandanus* specimen.

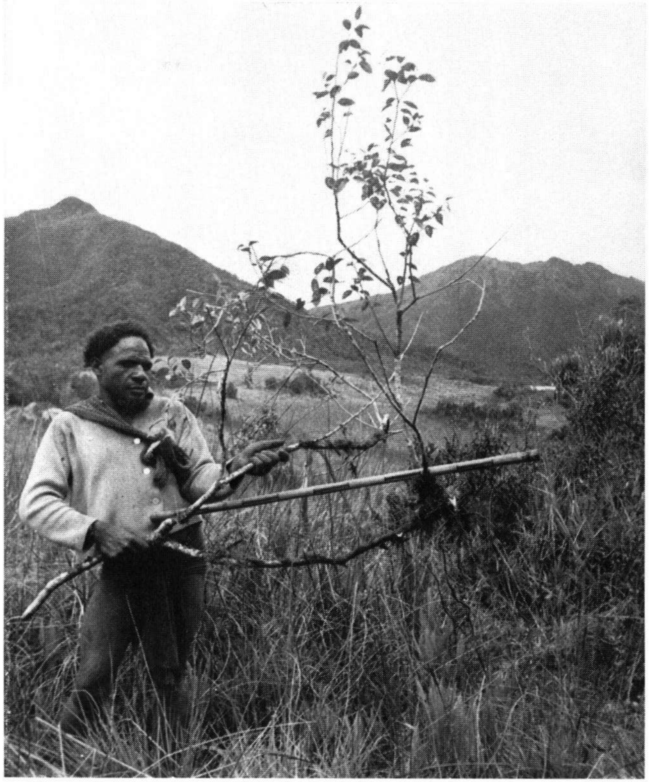

Photo 2. Showing layering feature in *Vaccinium cruentum* from transition.

Photo 3. Face of grassland/forest transition on the front of the transect (all photos by the author).

Photo 4. Cut-away section of exposed moss-hummock, viewed from forest side. Note seedling of *Pandanus* at bottom left. Measuring stick with 10 cm divisions.

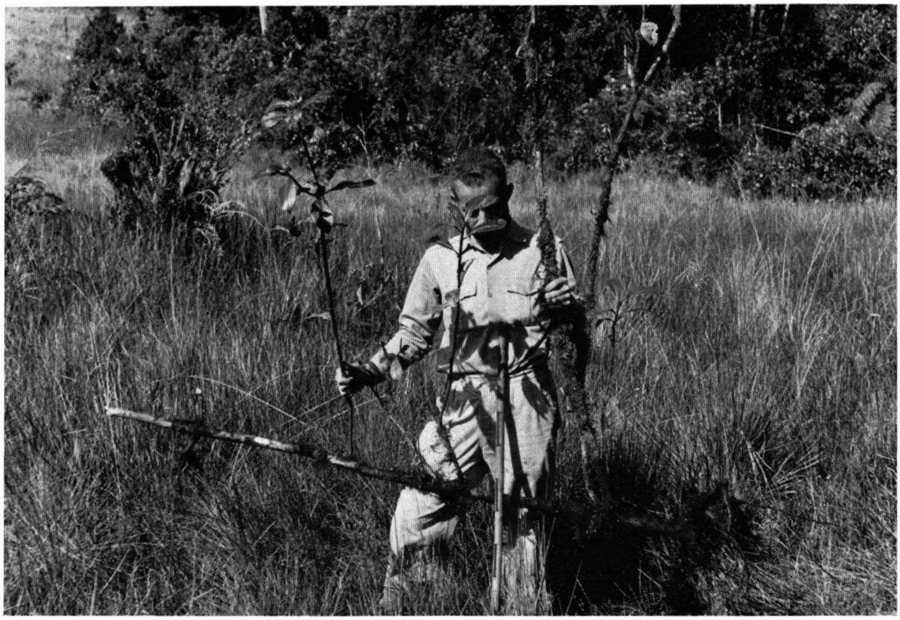

Photo 5. Showing layering from a fallen plant of *Drimys piperita* '*coriacea*' from the forest.

Photo 6. Showing tangled stem/root mass of mature transition — looking out towards grassland.

Photo 7. Transition face showing complete removal of transition community following destructive technique. Note escaped *Pandanus* specimen, same as photo's 1 and 3.

Photo 8. Razed appearance of transition following removal of all specimens under 10 m. Note sticks indicatingqua drats.