PLANT SUCCESSION IN AN IRREGULARLY FIRED GRASSLAND AREA—DOMA PEAKS REGION, PAPUA

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INTRODUCTION

Location of study area

New Guinea is an island of extremely diverse vegetation types all of which are affected to some extent by an indigenous people who operate either a system of shifting agriculture or are nomadic in habit. In both cases they invariably leave a trail of fired vegetation in their wake. The purpose of this article is to present a quantitative assessment of the degree to which irregular firing affects the pattern of succession of some specific associations in a low montane grassland not subject to agricultural pressures. The assessment is based on detailed records taken from a representative location.

No intensive data have been published about such areas in Papua, New Guinea. Ecological studies in a broad sense have been carried out in inhabited grassland areas by Havel (1960), Robbins (1960, 1961a, b), van Royen (1963) and Walker (1966).

Although the study area was reasonably representative of the species complex of most of the locality, numerous minor associations occur in the grassland which are not mentioned in this paper. All or most of these associations are dominated to some extent by Cyperaceae or *Gleichenia* spp.

The general region was the Doma Peaks in the southern Highlands of Papua close to the New Guinea border at lat. 5°55′ S by long. 143°10′ E (Fig. 1). The study area was at an altitude of 2590 m (8500 ft) in a grassland valley in Tari Gap a few miles south-east of Tari. Field observations were made during an expedition to the Doma Peaks in June 1966 with a botanical team from the Rijksherbarium, Leiden, Holland, and the Department of Forests of Papua and New Guinea.

Environmental conditions

The important environmental influences operating in these fired grasslands are as follows.

Topography

The grassland is in an uninhabited undulating valley floor of about 1420 ha (3500 ac), running roughly east–west at an average altitude of 2590 m (8500 ft), and is closely surrounded by several mountain peaks 3050 m (10 000 ft) to 3660 m (12 000 ft) high. Throughout the valley there is a patchwork of light moss forest outliers which are encompassed by extensive grassland communities. The valley is dissected by a few small creeks some of which originate in dense cyperaceous swamps. Generally the grassland is wet underfoot for the greater part of the year.

Soil

The uppermost soil is normally a wet peat varying in thickness from 5 to 15 cm (2–6 in.). Occasionally a raised layer of drained peat overlies a wet A^1 soil horizon to a depth of several inches, and then plants which require slightly better drainage exist in microassociations.

The underlying A and B horizons show a gradual transition downward from a dense, black clay loam about 15 cm (6 in.) next to a 25 cm (10 in.), heavy, brown clay with increasing gleying. The 'parent' horizon is a deep, blue-grey to yellow-brown, impervious, plastic clay probably derived from volcanic ash deposits in the late Tertiary.

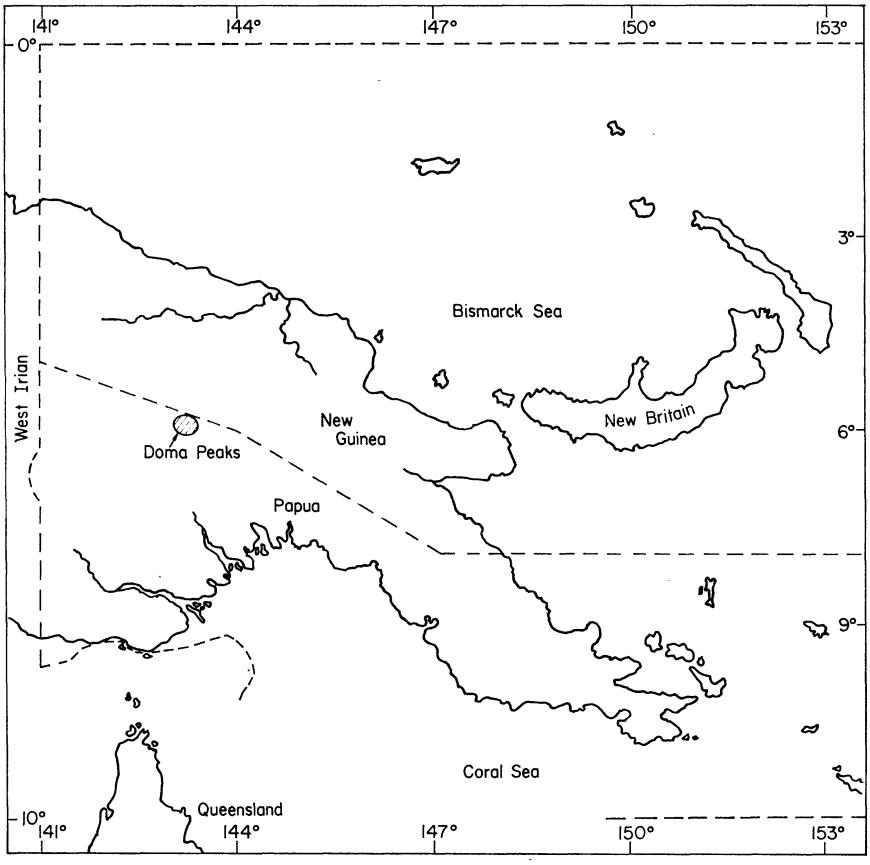


FIG. 1. Map of the Territory of Papua and New Guinea showing location of Doma Peaks.

Random soil profiles taken in the grassland and in the forest varied little. The clay substratum is probably overlain by a high water table for the greater part of the year and the resulting boggy surface conditions vary little from slope to ridge top. Free water occurs commonly in small shallow 'turf sinks' along the low ridges and near old tracks.

Climate

No local meteorological data are available. The wet season predominates early in the year and rainfall would probably exceed 5080 mm (200 in.). During the expedition (May–August) spells of several days of continual wet weather alternated with short fine spells

with clear mornings, the remnant mist layers dispersing by 09.00 hours. Mist enveloped the grassland usually by 16.00 hours and often remained over the valley during the night. Cloud cover was extremely variable. Precipitation was chiefly fine drizzle starting usually at 13.30 hours accompanied by mist. Heavy showers were infrequent. The mean minimum temperature was 5·6° C (42° F) at 04.00 hours, the minima often being less than those at nearby camps at higher altitudes. The mean maximum valley temperatures at midday were about 21° C (70° F).

Wind direction was very variable and seemed to depend on proximity of nearby mountain slopes. Wind varied in force, becoming gusty during the early evening showers.

Fauna

There are no large terrestrial herbivores in the area. Domestic pigs often accompany their owners across the valley and apparently have a considerable impact on the species composition of the vegetation in the vicinity of walking tracks. They probably cause the 'turf sinks' along low ridges. Numerous members of Phalangidae abound in the forest and there are several small, nocturnal, ground-foraging marsupials and rodents. Bird life is abundant in the forest and quail occur in the grassland. Frogs (Microhylidae) are numerous in both forest and tussock grassland.

Grassland species composition

The grassland is relatively poor in plant species and the botanical collections probably included at least 90% of the species present, and certainly 95% of the species flowering in the area at the time. There was a complete absence of legumes both in the grassland and in the surrounding forest zone. This is not uncommon in such areas of New Guinea. The majority of grass species were in flower so that comprehensive collecting was facilitated and some major grassland associations could be recognized readily.

The grassland structure can be related to the topography and overlying fire patterns. Broadly the communities may be grouped into ridge, slope and gully communities, forest/grassland transition and cyperaceous bogs.

Ridge communities

Structurally these are akin to the west tussock grassland of Beard (1955) and are characterized mainly by grasses, *Miscanthus floridulus*, *Imperata cylindrica* var. *major*, *Danthonia archboldii* and *Hierochloe redolens*, usually associated with Cyperaceae, *Gleichenia* spp. and minor herbs. Occasional 'raised bog' conditions occur locally.

Slope communities

These are mainly low, flat, herbaceous bog characterized by some low grasses, *Deyeuxia sclerophylla*, *Isachne myosotis*, and herbs, *Potentilla*, *Ranunculus* and *Tetramolopium* spp. Other common herbs are *Drosera*, *Utricularia*, *Xyris*, *Eriocaulon*, *Gentiana* and *Plantago* spp. with occasional composites, *Lactuca* and *Blumea* spp. Ericaceous shrubs occur together with the ubiquitous Cyperaceae and *Gleichenia*. Ferns and club mosses (*Davallia* and *Lycopodium* spp.) are numerous, and moss hummocks, although absent on slopes with sparse vegetation, are numerous elsewhere.

Gully communities

These vary considerably due to local differences in drainage patterns, e.g. dissected creek banks and bog edges. Continual firing inhibits any significant shrub formation and

here the usual dominant is a *Cyathea* sp. (Phot. 1) surrounded by a mixture of grasses, *Miscanthus floridulus*, *Imperata cylindrica*, *Echinopogon* sp., *Eulalia leptostachys*, *Brachypodium sylvaticum* and *Isachne arfakensis*. *Blumea*, *Ranunculus* and *Potentilla* spp. also occur with Cyperaceae and *Gleichenia* on narrow transitions between localized bog flats and grass communities along creek banks.

Cyperaceous swamp

These are often circular swamps up to several acres in extent, dominated by *Juncus* sp. and *Machaerina rubiginosa*. Occasionally hummocks occur with *Hypericum habbemense* and some ferns. Such swamps are rarely landlocked but are commonly drained by small streams.

Grassland/forest transition

The grassland along transition areas is usually dominated by high *Miscanthus floridulus* interspersed with *Hierochloe redolens*. Here the stunted 'meadow' form of *Gleichenia* does not occur but a climbing form is present to a limited extent. Moss hummocks are large and act as a buffer mechanism against fire along the forest edge. A brief study of the floristics and physiognomy of these hummocks and the parts they play as fire barriers will be submitted in a later paper.

The over-riding factor in the successional dynamics of these communities is fire and most of the grassland is in a continual state of flux due to irregular firing.

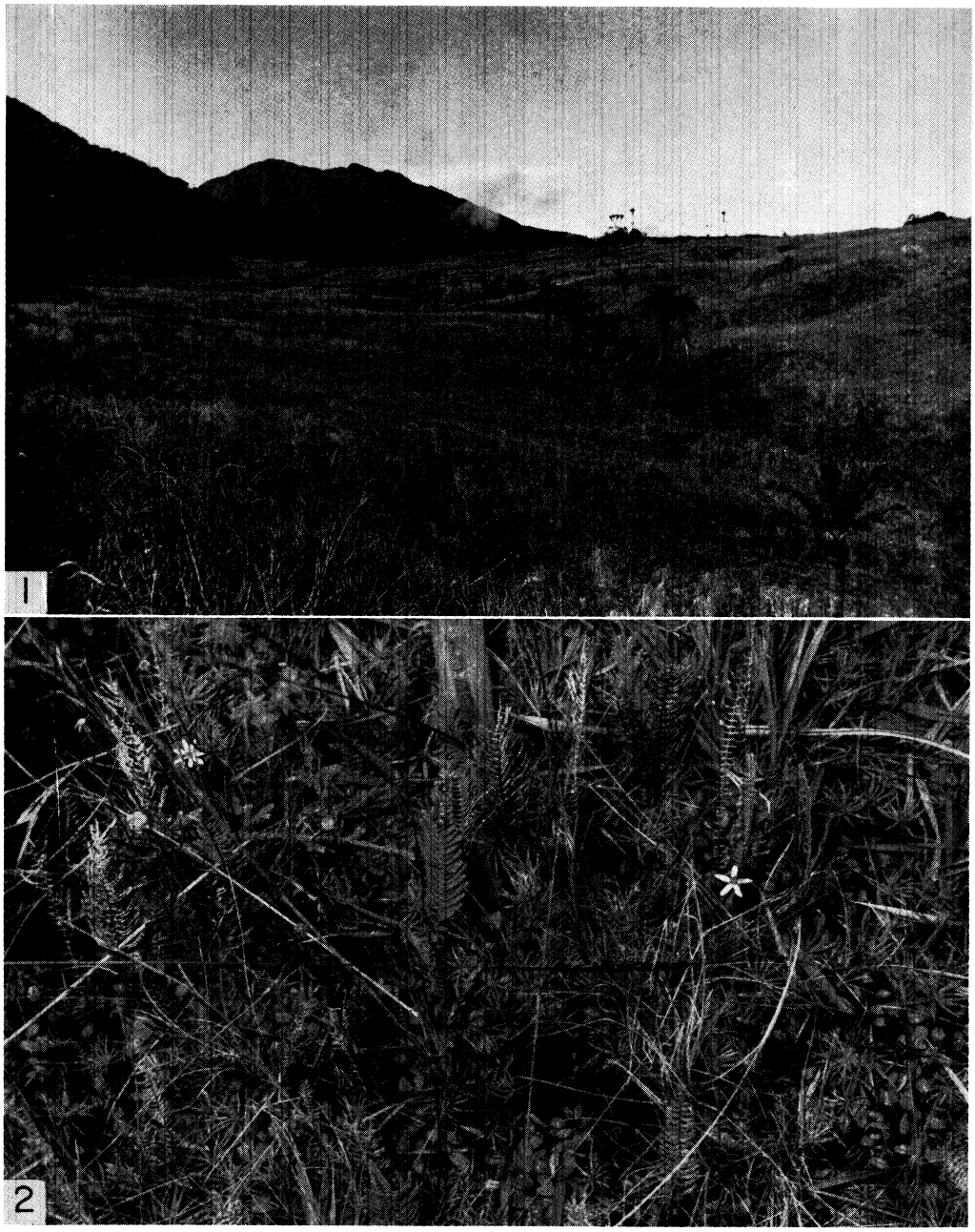
Firing patterns

Fires are started by itinerant native people usually hunting and travelling between villages on either side of the Doma Peaks complex. The pattern of firing is irregular both in duration, time of year and the extent and configuration of boundaries. The result is a complete arrangement of communities in which there are recognizable associations in recently fired zones contiguous with younger and radically different 'stable' associations in non-recently fired zones. 'Recently' is defined as having been fired within the last 3 months. It is extremely difficult to obtain accurate data from local people on firing dates beyond 3 months.

Factors limiting the extent of fires are as variable as they are numerous. Fickle wind currents in the valley can either fan or extinguish a fire within minutes. Mist and rain both play important roles as fire extinguishers and act as an effective damper on fires lit in the afternoon. Mist frequency seems important in determining the degree of vulnerability of grassland species to fire, but the most important factor appears to be the extent of surface water. The latter affects the species composition of the vegetation and produces varying degrees of vulnerability to fire so that ecological tension zones are created along surface moisture gradients.

METHODS

When a preliminary survey and a comprehensive botanical collection of the grassland area had been made, an area for detailed study was marked out. This included a mixture of ridge and slope conditions and contained a recently fired zone contiguous with a remnant non-recently fired stable grass/fern association grading into flat herbaceous bog. The recently fired area was believed to be about $2\frac{1}{2}$–3 months old.



PHOT. 1. Typical fired grassland in area studied showing gallery forest and fire-resistant communities of tree fern (*Cyathea* sp.).

PHOT. 2. Densely appressed vegetation in non-recently fired zone showing association of *Tetramolopium procumbens* (narrow-leafed rosette) and an unidentified *Ranunculus* sp. (in flower). Common fern is *Gleichenia microphylla*, broad-leafed grass is *Deyeuxia sclerophylla*. Other species include narrow-leafed grass *Hierochloe redolens*, *Eriocaulon hookerianum* and *Potentilla foersteriana*.

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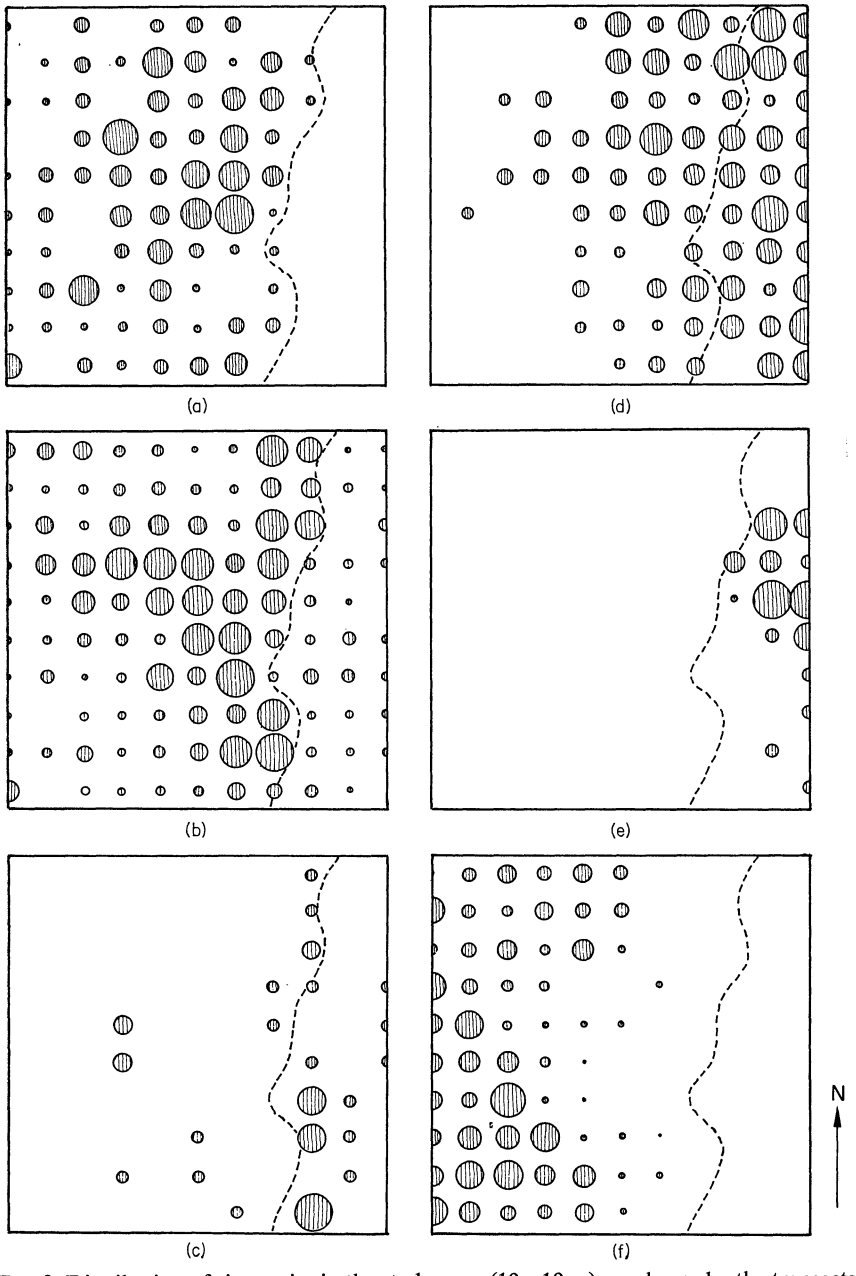

FIG. 2. Distribution of six species in the study area (10 × 10 m) as shown by the transects 100 × 3 cm, 1 m apart running from north to south. Zone to the right of the dotted line indicates 'recently fired' and to the left 'non-recently fired'. Area under *Tetramolopium procumbens* indicates non-fired bog. (a) *Eriocaulon hookerianum*; (b) *Gleichenia* spp.; (c) *Lobelia angulata*; (d) *Machaerina rubiginosa*; (e) *Isachne myosotis*; (f) *Tetramolopium procumbens*.

The study area was 10 × 10 m (32·8 × 32·8 ft) square and had a dense vegetation cover. Thin 'belt' transects 10 m × 3 cm (32·8 ft × 1·18 in.) wide were spaced 1 m apart running north–south across the square roughly parallel to the fire line. A complete count was made of all plants with their central axes lying within this 3 cm (1·18 in.) strip. Vegetative shoots propagated by runners, e.g. *Gleichenia*, were recorded as individual plants.

Each transect was divided into 1 m strips so each transect was a line of contiguous 100 × 3 cm (39·37 × 1·18 in.) quadrats.

The number of individuals of all species present was counted in each quadrat.

In order to show differences in abundance of plants diagrammatically the maximum count obtained for a quadrat in the square for any one species was given the scale value equal to 0·5 m (19·68 in.) radius, and on a plan of the area a circle was inscribed at the centre of that quadrat at the appropriate position on the transect. All other counts for this species could then be conveniently drawn to scale on the plan without overlapping (see Fig. 2 for example of use).

With such close gridding this method gives an immediate visual appraisal of overall species distribution and has nothing to do with degree of cover although this may be indicated indirectly. An immediate visual comparison of the distribution of each species is thus possible and permits an evaluation of the status of each species in the succession towards sub-climax conditions.

Two soil profiles were recorded in the plot, each under different drainage conditions.

Terminology is derived from several sources. 'Associations' are referred to under the system used by Beadle & Costin (1952). Degrees of abundance are those suggested by Braun-Blanquet (1927). 'Sub-climax' is a term of convenience applied here to the mature pyric grasslands under investigation and is used in preference to 'deflected sere' or 'disclimax' of some authors, e.g. Robbins (1961b).

RESULTS

Species composition in a non-recently fired zone

The major associations cannot be discussed adequately by giving one or two co-dominants. Visually the major association appeared to be dominated by *Gleichenia* spp., and the then partially flowering grass *Hierochloe redolens*. However density counts revealed a large predominance of the less conspicuous *Machaerina rubiginosa*, *Rhynchospora rugosa* and non-flowering *Miscanthus floridulus*, together with a lower growing, appressed mat of *Eriocaulon hookerianum* markedly associated with dense *Gleichenia*. By comparison some other grassland localities showed *Gleichenia* to be the dominant species with associated *Gaultheria mundula*. *G. mundula* did not occur on the sample plot and its presence in other areas was usually associated with a complete absence of *Machaerina* and *Eriocaulon* spp.

Gleichenia–Machaerina *association*

This is the prominent 'sub-climax' association on low ridges and the better-drained slopes in the grassland area. The vegetation is usually under 1 m tall and most of the grasses in the association are somewhat suppressed under *Gleichenia* and at the time when the records were being made these grasses were not flowering but in the adjacent recently fired zone two grasses of the same species were, without exception, all in flower.

These were *Miscanthus floridulus* and *Isachne globosa*. The grass species *Deyeuxia sclerophylla* (generally non-flowering under *Gleichenia*) tended to flower more in herbaceous bog conditions. *Hierochloe redolens* had just completed flowering in *Gleichenia* association whereas clumps were in flower in the recently fired area. Other plant species common to this association are in order of importance: *Rhynchospora rugosa*, *Eriocaulon hookerianum*, *Blumea lacera*, *Fimbristylis* sp., *Hypericum habbemense*, *Hydrocotyle sibthorpioides*, *Dianella* sp., *Lycopodium* sp. and mosses.

Tetramolopium–Ranunculus *association*

These two elements commonly dominate the moister slopes in the grassland. Local apparently anaerobic soil conditions probably favour the establishment of this low, appressed and rather matted bog herbage (Phot. 2). Fires seldom reach these associations and *Gleichenia* occurs spasmodically in a much reduced form. The grass *Deyeuxia sclerophylla* is common to both this and the *Gleichenia–Machaerina* association. An important species associated with *Tetramolopium–Ranunculus*, is *Potentilla foersteriana*. Other species occurring in this association are *Xanthomyrtus* sp., *Eriocaulon hookerianum*, *Hypericum habbemense* and occasional *Miscanthus floridulus*.

Haloragis–Gentiana *sub-association*

Regarded as a sub-association of *Tetramalopium–Ranunculus*, it has associated also with it *Utricularia* sp. Due to the small size of the plants involved the sub-association is difficult to detect without making counts. Conditions are generally more boggy than in the rest of the parent association, and often small local depressions with free water are visible.

Species composition in a recently fired zone

Vegetation composition in recently fired zones is in a continual state of rapid change. At the time of counting, flowering grasses and Cyperaceae were the dominant groups.

The recently fired area in the plot studied was dominated largely by fire-resistant species accompanied by rapidly invading non-aggressive pioneer species (see Fig. 4). The then-flowering dominant grass *Miscanthus floridulus* was the tallest (1 m (40 in.)) accompanied by the much smaller pioneer grass *Isachne globosa*. Fire-resistant Cyperaceae (*Machaerina rubiginosa* and *Rhynchospora rugosa*) were prominent species together with the pioneer *Fimbristylis* sp. *Hierochloe redolens* seems to be fire-susceptible as only two large clumps survived. Although *Gleichenia* is susceptible to fire initially it regenerates quickly by both sexual and vegetative means. An important though quite small (3 cm (1 in.) high) grass was *Isachne myosotis* which was in flower. Other species in this area of the plot were *Xanthomyrtus* sp., *Viola* cf. *arcuata*, *Hypericum habbemense*, *Blumea lacera* and *Deyeuxia sclerophylla* (see Fig. 3).

Transition species

Transitions occur between the recently fired and non-recently fired zones and between the *Gleichenia*–Cyperaceae and *Tetramolopium–Ranunculus* associations. Quantitative results in these cases are of dubious value for some species in view of the few counts available. Two of the more definite transitional species are *Lobelia angulata* and *Hypericum*

habbemense. Both show a higher density along the recently and non-recently fired transition and occur to a limited extent in the *Gleichenia–Tetramolopium* transition.

Other species of suspected transitional preference are *Styphelia* sp., *Vaccinium* and

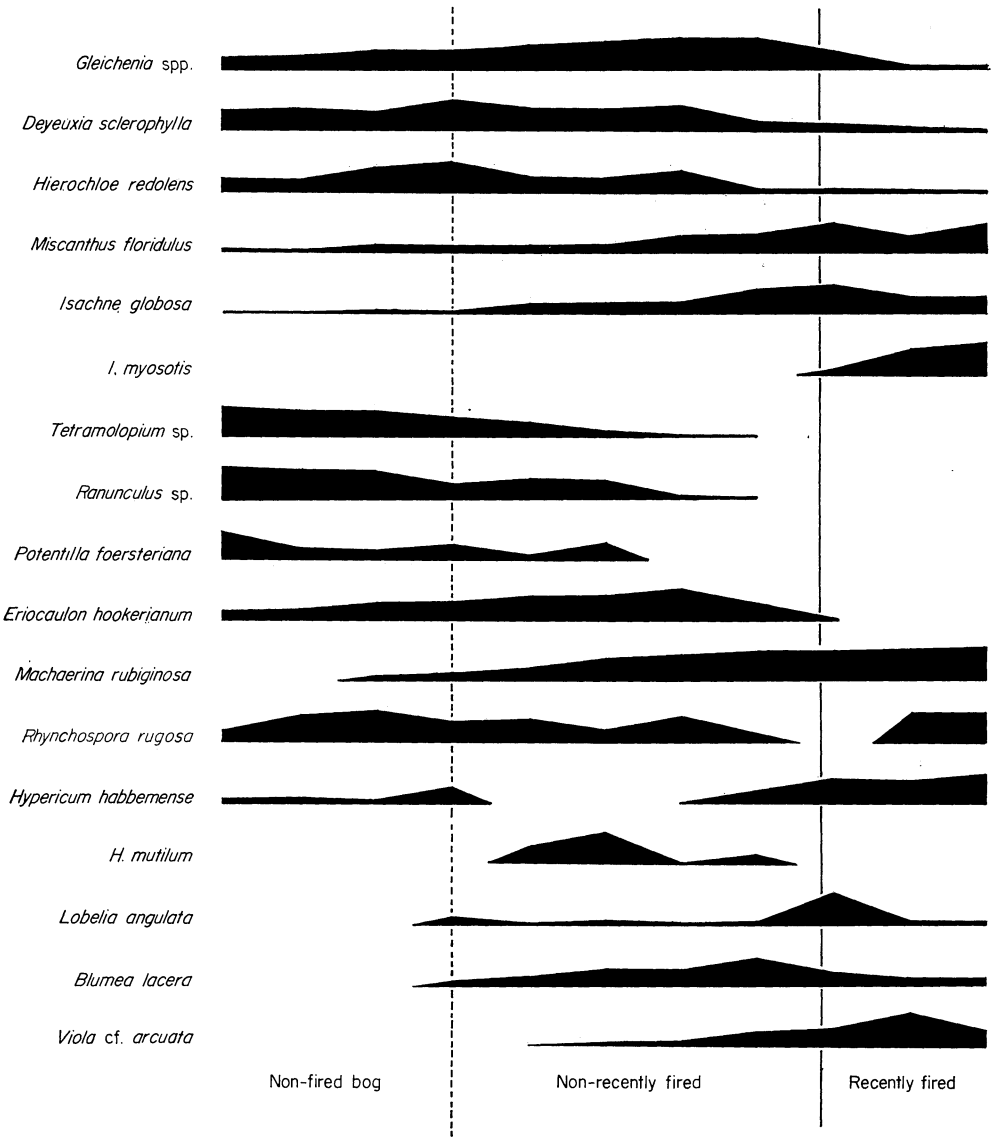

FIG. 3. Density profile of 10 × 10 m plot showing relative distribution of some species. Vertical line is mean fire line. Dotted line is mean of non-fired bog/non-recently fired transition.

Rhododendron species, *Viola* cf. *arcuata*, *Hydrocotyle sibthorpioides* and *Xanthomyrtus* sp. In addition *Hypericum habbemense* and *Lycopodium* spp. are found between the recently and non-recently fired associations while *Pilea johniana* occurs in both transitions.

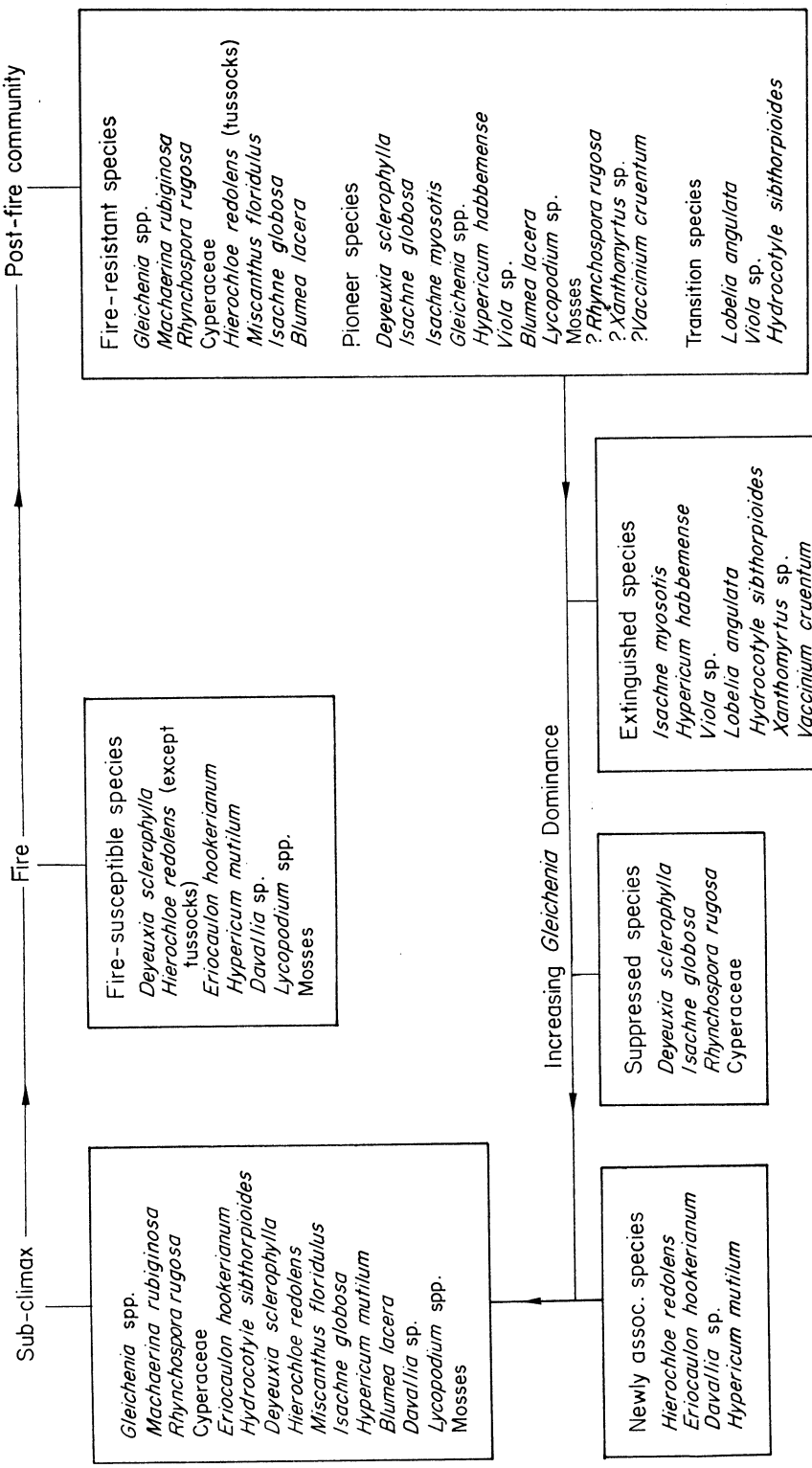

FIG. 4. Succession in *Gleichenia–Machaerina rubiginosa* association.

Plant succession through a recently fired zone to a non-recently fired sub-climax

The probable succession in the plot is shown in Fig. 4. From a study of other sub-climax areas in the grassland it is assumed that, prior to firing, the vegetation of the recently fired zone was similar in plant species composition to the non-recently fired, and some climatic factor had operated to prevent further firing.

The distribution diagram (Fig. 2) enables the pattern of succession of the more common species to be distinguished in the progression towards the more stabilized community. The status of a particular species in the line of succession can be obtained by comparison between degree of presence in the recently and non-recently fired zones (Fig. 2). The ingress of some later secondary species can be portrayed by comparing the density of these species in the recently fired zone with that under the sub-climax association, e.g. *Eriocaulon hookerianum* and *Hypericum mutilum* (Fig. 3).

DISCUSSION

The role of Gleichenia

The plant genus having the greatest impact on succession towards the grassland sub-climax communities is *Gleichenia*. This fern is initially susceptible to fire but has remarkable powers of regeneration apparently both sexually and vegetatively. It is very aggressive with a diversity of form and a wide range of environmental tolerance. It is a common dominant in sub-alpine grassland at 3350 m (11 000 ft) on nearby Mt Kerewa and, though absent from pure cyperaceous bog, occurs in most grassland communities. On the grassland it is always indicative of a fire-induced sere. The effect of *Gleichenia* on the species complex in the plot is discussed under the following headings.

Gramineae

Superficially the grassland appears to be dominated by grass species, but such dominance normally exists only within the relatively short interval between fire and the ensuing *Gleichenia* invasion. Usually the grasses mature and flower in this interim period, particularly *Miscanthus floridulus* and *Imperata cylindrica* var. *major*. The grass genus *Isachne* is represented by *I. globosa* which flowers following regeneration after fire, remaining suppressed and non-flowering under *Gleichenia*. *Isachne myosotis* which is a minute species occurs only as a pioneer (Fig. 2). This species rapidly achieves anthesis in the first stages of post-fire-community recovery, and sets seed before it is engulfed and extinguished by *Gleichenia* and other aggressives. Seed from *Isachne myosotis* may remain dormant until the next firing.

A grass common to both *Gleichenia–Machaerina* and *Tetramolopium–Ranunculus* associations is *Deyeuxia sclerophylla* which tends to flower in more open conditions. It seems to be a slow pioneer in the recently fired section (Fig. 3). Since its flowering appears to be suppressed within the *Gleichenia*-dominated association, it may, like *Isachne* and *Miscanthus* spp., attain its flowering peak prior to the *Gleichenia* takeover.

Hierochloe redolens occurs sparsely in the regenerating community but is common in mature *Gleichenia* stands. As noted previously this species is largely removed by fire, although mature clumps exhibit some fire resistance. *Hierochloe redolens* regains stability under conditions of *Gleichenia* domination where it flowers sporadically. Probably the lag in germination following fire is much greater than in other grass species present or

alternatively, germinating conditions may be optimal only under the dense cover afforded by *Gleichenia.*

Cyperaceae

Members of Cyperaceae are of almost equal importance to *Gleichenia* in the composition of sub-climax swards. This family is probably the best represented in the whole grassland area under most conditions. It is well suited to the predominating bog condition and several species exhibit great resistance to fire, notably *Machaerina rubiginosa* and *Rhynchospora rugosa.*

Machaerina rubiginosa occurs usually as fire-resistant tussocks and is markedly associated with *Gleichenia* (Figs. 2 and 3). Its degree of fire resistance compared with that of *Gleichenia* is visibly demonstrated in Fig. 2. This resistance to fire probably partially balances the comparatively slow regenerative rate as seen in the plot. In other grassland areas it is interesting to note a complete absence of *Machaerina rubiginosa* in *Gleichenia–Gaultheria* associations where *Imperata cylindrica* var. *major* is the chief pioneer associate. This may occur because of an apparently higher water deficit in *Imperata* associations.

Rhynchospora rugosa is a sedge somewhat reduced by fire but with strong regenerative properties and, like *Fimbristylis* sp., is later suppressed by *Gleichenia,* and is absent under very dense *Gleichenia* growth.

Herbs

Several species of plants appear to have preferences for the transition zone as well as existing outside it. These are *Lobelia angulata, Viola* cf. *arcuata, Hypericum habbemense* and *Blumea lacera.* These species attain maximum density in the transition and all are susceptible to fire.

Several successional pathways seem to be involved in the establishment of transition zone species. The woody *Styphelia suaveolens, Vaccinium cruentum* and *Rhododendron commonae* are absent in the recently fired zone and in herbaceous bog and are suppressed under *Gleichenia.* They appear to achieve their best establishment at the transition between sub-climax *Gleichenia* associations and stable herbaceous bog. This has important implications in thicket formation. *Hypericum habbemense* may also become established in this way but, as it is present in the recently fired zone and absent under stable *Gleichenia,* its presence along the *Gleichenia–Tetramolopium* transition could be regarded as a remnant from previous fire cycles. Another similar kind of niche establishment involves the invasion or highest development in the transition zone of a species existing under *Gleichenia,* e.g. *Blumea lacera* (Fig. 3). Another pathway similarly involves the optimal development in the transition of a species such as *Viola* cf. *arcuata* established in the recently fired zone (Fig. 3).

Perhaps the plants with the narrowest ecological niches are the small herbs *V.* cf. *arcuata, Hydrocotyle sibthorpioides* and *Lobelia angulata.* These are small semi-prostrate herbs usually associated with newly fired ground and even tend to proliferate along the transition of the recently fired strip with stable *Gleichenia–Machaerina.* These are transients (Fig. 4).

In the plot the genus *Hypericum* exhibited a remarkable ecological divergence between two species *H. habbemense* and *H. mutilum* (Fig. 3). Following fire *H. habbemense,* an erect robust herb 30 cm (12 in. high), established itself rapidly as a pioneer species. It also occurs to a lesser extent in the tension zone between *Tetramolopium procumbens*

and *Gleichenia*. Under sub-climax *Gleichenia* this species is apparently completely replaced by the much smaller semi-prostrate *Hypericum mutilum* (Fig. 3).

The role of woody transition plants in the formation of grassland thickets

Under stable sub-climax conditions in *Gleichenia*-dominated associations, *Xanthomyrtus* sp. is suppressed and usually non-flowering. In *Tetramolopium*/*Gleichenia* transitions it is reduced to a low sporadically flowering, semi-prostrate herb. In grassland/forest transitions and in outlier thickets the same species grows as a compact woody shrub and forms a sizeable clump up to 2·4 m (8 ft) high where it flowers profusely. Fruit-set seems adequate to produce viable seed, which is probably fire-resistant or fire-stimulated, as seedlings were noted in newly fired areas. *Xanthomyrtus* probably remains in this state in irregularly fired areas and under favourable long-term conditions becomes the basis of pioneering thicket formations. This species was associated with moss hummocks in woody thickets comprised of *Olearia*, *Glochidion*, *Rhododendron*, *Dacrydium*, *Vaccinium* and *Dimorphanthera* species.

Woody species of *Rhododendron*, *Vaccinium*, *Xanthomyrtus* and *Haloragis* are common to young thickets and otherwise occur in open grassland, mainly along the transition between stable *Gleichenia* associations and stable, low, herbaceous bog. The latter is rarely affected by fire. From firing experiments on the grassland it seems such plants can withstand only moderate grass fires and this partly accounts for the restriction of this woody group to the non-fired bog/fired *Gleichenia* transitions.

Woody transition plants play an important role in the formation of grassland thickets under long-term, favourable conditions. A nucleus of these species was found to be maintained in certain recognizable niches of the grassland complex, such as the ones above. Probably these grassland thickets are themselves precursors and site nuclei for mature forest regeneration.

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SUMMARY

The effects of irregular burning of vegetation by man are discussed in relation to succession in a non-agricultural montane grassland in Papua. Comprehensive quantitative floristic observations were carried out in a densely vegetated area up to the stage of a stable sub-climax *Gleichenia* association. Under repeated but irregular firing, a homogeneous mixture of *G. linearis* var. *montana* and *G. microphylla* var. *vulcanica* dominate the sub-climax composition. Grass species attain their maximum growth and flowering peaks between firing and the *Gleichenia* subclimax. Other grass species and some herbs mature and die within this period. Some Cyperaceae are important constituents of the succession

and exhibit high fire resistance. The succession of plant species from about $2\frac{1}{2}$ months after burning to the sub-climax is shown by means of close, regular line transects within a sample area.

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APPENDIX

List of species recorded with transect totals

Lobelia angulata Forst.	(Campanulaceae)	38
Blumea lacera (Burm.f.) DC. var. *lacera*	(Compositae)	51
Tetramolopium procumbens	(Compositae)	825
Drosera peltata J. C. Sm.	(Droseraceae)	1
Styphelia suaveo ens (Hook. f.) Warb.	(Epacridaceae)	19
Rhododendron commonae Foerster	(Ericaceae)	4
Vaccinium cruentum Sleumer	(Ericaceae)	24
Gentiana ettingshausenii F.V.M. } Mixture	(Gentianaceae)	17
G. piundensis van Royen }		
Hypericum habbemense A. C. Smith	(Guttiferae)	38
H. mutilum L.	(Guttiferae)	19
Haloragis halconensis Merr.	(Haloragidaceae)	30
H. micrantha (Thunb.) R. Br.	(Haloragidaceae)	12
Utricularia sp. unidentified	(Lentibulariaceae)	11
Xanthomyrtus sp. unidentified (species (e) Vink 17156)	(Myrtaceae)	199
Plantago aundensis van Royen	(Plantaginaceae)	11
Ranunculus sp. unidentified	(Ranunculaceae)	668
Potentilla foersteriana Laut.	(Rosaceae)	21
Hydrocotyle sibthorpioides Lamk.	(Umbelliferae)	20
Pilea johniana Stapf	(Urticaceae)	0
Viola cf. *arcuata*	(Violaceae)	36
Machaerina rubiginosa (Spreng.) Koyama	(Cyperaceae)	164
Rhynchospora rugosa (Vahl) Gale	(Cyperaceae)	215
Cyperaceae, small unidentifiable immature plants		31
Eriocaulon hookerianum Stapf	(Eriocaulaceae)	252
Deyeuxia sclerophylla Stapf	(Gramineae)	374+two clumps
Hierochloe redolens (Vahl) R. & S.	(Gramineae)	59+ eighteen clumps
Isachne globosa (Thunb.) Kuntze	(Gramineae)	136
I. myosotis Nees		84
Miscanthus floridulus (Labill.) Warb. ex Laut. & K. Schum.	(Gramineae)	95+nine clumps
Dianella ensifolia L.	(Liliaceae)	1
Bulbophyllum sp. unidentifiable	(Orchidaceae)	1
Malaxis sp. unidentifiable	(Orchidaceae)	15
Spiranthes sp. unidentifiable	(Orchidaceae)	1
Xyris papuana van Royen	(Xyridaceae)	5
Davallia sp. (sterile)	(Davalliaceae)	4
Gleichenia spp. (mixture of *G. linearis* var. *montana* Holtt., and *G. microphylla* var. *vulcanica* Holtt.)	(Gleicheniaceae)	638
Lycopodium sp. (1)	(Lycopodiaceae)	26
Lycopodium sp. (2)	(Lycopodiaceae)	15
Mosses abundant (rated as 6 on Domin scale)		

Total count 4189 individuals.

Other species mentioned

Gaultheria mundula F.v.M.	(Ericaceae)
Brachypodium sylvaticum (Huds.) Beauv.	(Gramineae)
Danthonia archboldii Hitch.	(Gramineae)
Eulalia leptostachys (Pilger) Howard	(Gramineae)
Imperata cylindrica (L.) Beauv. var. *major* (Nees) Hubbard	(Gramineae)
Isachne arfakensis Ohwi	(Gramineae)