Observations on *Themeda australis–Eucalyptus* Savannah in Papua

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SAVANNAHS, vegetation types with a ground cover dominated by grasses and an open tree storey, are extensive in the coastal lowlands of the Central District, Territory of Papua (Fig. 1). These lowlands were included in a regional survey carried out in 1962 by a team of the Division of Land Research and Regional Survey, CSIRO.

This paper describes the vegetation of savannah near Jackson's Airport, about 12 km east of Port Moresby. Emphasis is laid on correlation with edaphic conditions. The field work, in cooperation with the geomorphologist and the pedologist of the team, was done in July and August 1963.

The following data pertinent to this area are extracted from the survey report (Mabbutt et al., 1965).

The climate is monsoonal: strong southeasterly winds prevail during the dry season from May till October, in which monthly rainfall averages 30 mm, and light variable winds during the rest of the year with monthly rainfalls averaging 160 mm. Table 1 gives more detailed information about rainfall, together with data on temperature and evaporation.

The landscape, made up of strike ridges and vales, is underlain by fairly steeply dipping rocks of Tertiary age. Cherty shale, marl, and limestone form the rounded ridges; the vales have been cut in less resistant tuff. Relief is in the order of 100 m. Lithosols and regosols are found on the ridges, brown clay soils and texture-contrast soils on the higher parts of the flatter land, and dark clay soils and alluvial soils near and along drainage lines. The vegetation is savannah, predominantly of the *Themeda australis–Eucalyptus* type, with tall grass vegetation and forest along permanent streams.

Fires are common throughout the dry season, at the end of which most of the ground cover has been burnt. Regrowth starts after some rain has fallen. Areas burnt early in the dry season can have a fair cover at the end of it and are liable to burn off again. At the time of our investigation, notwithstanding high rainfall in June, the dry season was already well advanced and fire had destroyed the ground vegetation of a part of the area under investigation.

Wild life in the area is very scarce and its influence on the vegetation is negligible. Grazing by cattle is restricted to a few fenced properties.

Two transects were selected for observations: transect 1 was located 3 km south of Jackson's Airport near the Rigo Road; transect 2 about 1.5 km northeast of the airport. Levels were taken along each transect and at selected situations pits were dug, varying in depth between 1.0 and 2.5 m.

TOPOGRAPHIC AND SOILS DESCRIPTION OF THE TRANSECTS

Each transect comprised a fairly straight, smooth hill slope attaining 22° to 30° and with minor rock outcrop, passing into a shallowly dissected foot slope mainly between 0°30′ and 5° and up to 1200 m long, and ended at a small strike stream, which on transect 1 has a narrow bordering flood-plain.

Much runoff is as sheet flow: slope wash on hill slopes results in small terracettes, and on foot slopes leaves a fairly abundant lag gravel (Mabbutt and Scott, 1966).

Each transect had a similar sequence of soils (Scott, unpublished data). The hills are occupied by red regosols, which are deeply developed at the lower slope of site 2. On the adjacent foot slopes texture-contrast soils are found, whilst black clay soils occupy the remainder of the flatter country, forming a

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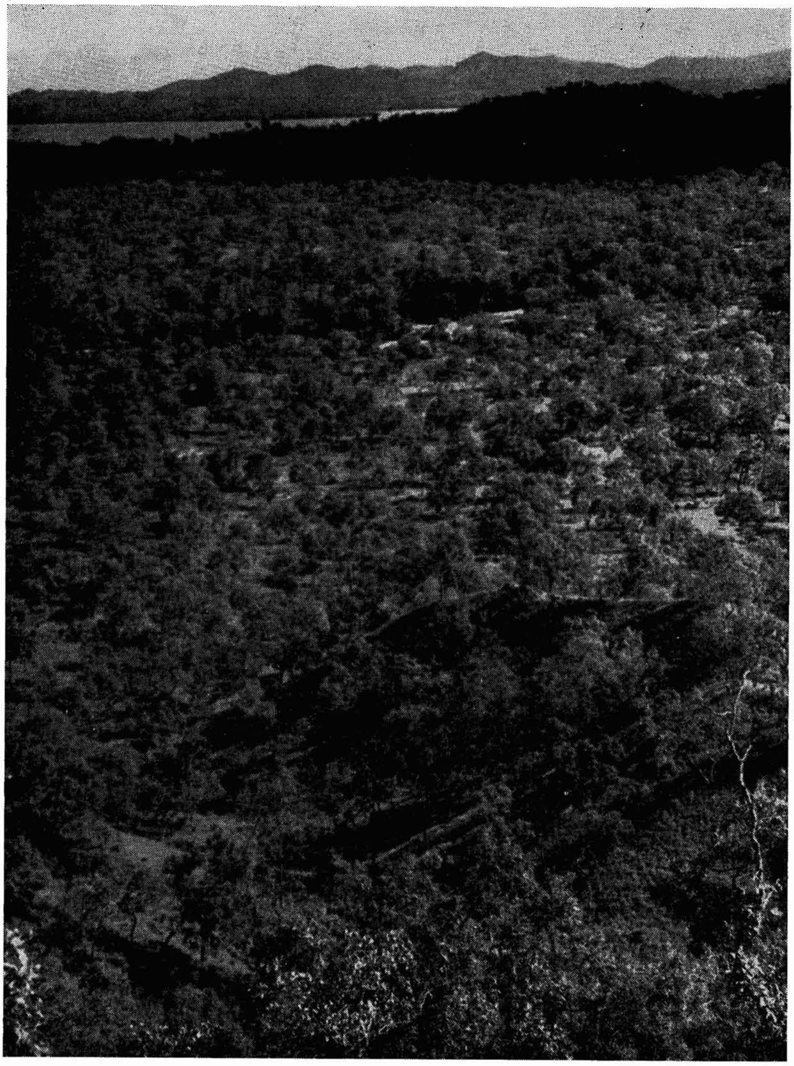

FIG. 1. View from the crest of a strike ridge over the savannah country just east of, but similar to, that in which the transects were laid out. The foothill in the foreground rises fairly abruptly from the foot slopes, which end against a forested narrow flood-plain. In the farther distance is another strike ridge shadowed by clouds and backed by Bootless Inlet.

belt of 50 m width parallel with the creek at transect 1, but extending over 300 m from the gully at transect 2. The soil of the flood-plain is an organic black clay.

THE VEGETATION

The *Themeda australis–Eucalyptus* savannah has a tree stratum of one or more of the *Eucalyptus* species *E. alba*, *E. confertiflora*, and *E. papuana*, and some scattered *Albizia procera;* and a grass cover dominated by *Themeda australis*, with *Heteropogon contortus* and *Sehima nervosum* commonly associated, the latter especially on stonier soils. A shrub layer is only locally developed; *Albizia procera* and *Cycas media* are the more important species. This type of savannah occurs on both transects, except for a fringe of forest and tall grass on the narrow flood-plain.

The Trees

DISTRIBUTION PATTERNS (Fig. 2): *Eucalyptus alba* occurred over the whole transect 1; its height ranged from 9 to 16 m. On the black clay and adjacent texture-contrast soils it was accompanied or predominated by *E. confertiflora,* of about the same height. Relative proportions of *E. alba* and *E. confertiflora* varied between 6:4 and 2:8. On the rest of the texture-contrast soils and the regosols *E. alba* was joined by *E. papuana,* varying in height between 10 and 20 m and mostly remaining subordinate. Relative proportions varied between 9:1 and 5:5. Somewhere in the central part of the texture-contrast soils, over a distance of about 50 m, an overlap in the area of *E. confertiflora* and of *E. papuana* occurred (Fig. 3). On the transition to the organic black clay soils some specimens of *E. papuana* also occurred.

E. papuana occurred over the whole transect 2, with heights ranging from 10 to 18 m on the flat country and from 17 to 22 m on the slopes and along the gully. *E. alba,* 9–13 m high, was concentrated on the texture-contrast soils, but some trees occurred along the gully and one single tree was growing on the slope. On the texture-contrast soils the relative proportions of *E. alba* and *E. papuana* varied between 8:2 and 5:5. Not a single specimen of *E. confertiflora* was seen.

The density is in the order of 150 trees per hectare. A more exact determination of density was abandoned because of signs of wartime disturbance such as local cutting of trees, trees that were pushed over, and patches of rather dense eucalypt regrowth. Moreover, it is unlikely that this would have contributed very much to an explanation of the described distribution pattern. Observations of the 1962 survey show that this rather haphazard pattern is a general feature. More detailed regional investigations may reveal the causal factors.

ROOT SYSTEMS: Root systems were studied in 11 pits, which had been dug at the foot of the trunks, by removing as much soil from the roots as was possible without undue time-consuming effort. They usually appeared to consist of a small taproot and about five main horizontal roots branching from the base of the

TABLE 1

MEAN MONTHLY TEMPERATURE, RAINFALL, AND EVAPORATION AT JACKSON'S AIRPORT, PORT MORESBY

	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	ANNUAL
Mean max. temp. (°C)*	31.9	31.4	31.3	30.8	29.9	29.1	28.0	27.8	28.7	30.0	31.2	32.0	30.3
Mean temp. (°C)*	28.2	28.0	28.0	27.5	27.0	26.1	25.3	25.3	25.9	26.9	27.7	28.3	27.0
Mean min. temp. (°C)*	24.5	24.4	24.3	23.0	23.9	23.2	22.8	22.7	23.2	23.7	24.3	24.7	23.8
Mean rainfall (mm)*	146	219	144	222	38	15	10	23	65	23	81	159	1139
Rainfall in 1963 (mm)**	322	179	297	75	36	313	40	10					
Mean evaporation (mm)*	161	126	140	119	134	115	141	165	164	210	192	180	1836

* Data from Fitzpatrick (1965).
** Data from monthly statistical summaries of Bureau of Meteorology, Melbourne (for the 8 months preceding this investigation).

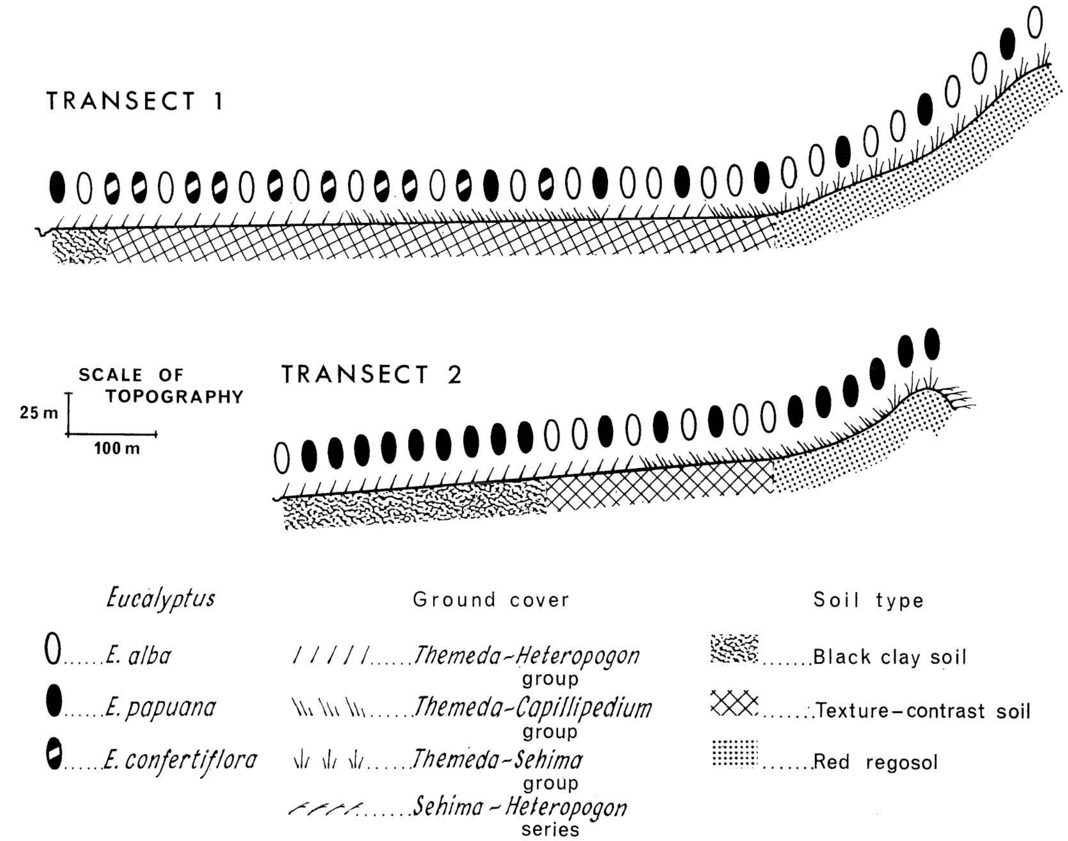

FIG. 2. Diagram of the transects, showing the distribution and mutual proportions of the *Eucalyptus* species, and the distribution of the ground cover groups and of the soil types.

trunk. The horizontal roots of *E. papuana* are often oval in section with the long axis vertical, and divide at or near the base in several horizontal roots above each other (Fig. 4).

Horizontal roots run for distances up to about 25 m more or less parallel with the surface, often not deeper than 0.2 m, only very gradually tapering. Near the base vertical roots branch off from horizontal roots, and are particularly common in some specimens of *E. alba.* In some cases these roots run down vertically more than 1.5 m, but more often they gradually bend away obliquely, and may even bend up and penetrate the topsoil again, where they continue horizontally.

The way in which the main roots of *E. alba* branch off from the base of the trunk is different from that of *E. papuana* and *E. confertiflora,* where they gradually emerge from the base. In the case of *E. alba* the trunk is usually a little swollen, but sometimes is considerably so. With a trunk diameter of 24 cm, the diameter of the base may vary between 30 and 45 cm. Just below the surface the base is constricted, under which constriction the main roots branch off.

The taproot, if present, may reach a depth of 1.3 m but is usually shorter. It branches off under acute-angle, thick roots, which show the same features as described above for the vertical roots. One specimen of *E. alba* was found which lacked the cluster of horizontal roots but which had a very stout taproot.

Tree roots with diameters of 1 cm or less, whose origin could not be traced, were found scattered at depths of 1.3 m, and rootlets with diameters commonly less than 1 mm were still found at a depth of 2 m (bottom of the deepest pits). Rootlets of 1 or 2 mm diameter were seen branching off from the main roots; they have a slightly thickened base.

The conclusion is reached that the *Eucalyptus* species studied have root systems with major roots strongly developed in horizontal directions, rather close to the ground level, and smaller roots penetrating to depths of 2 m and over.

The Shrubs

Except for young specimens of the eucalypts, *Albizia procera* was the only shrub encountered over the whole length of both transects. It was, however, more common on the flatter parts. Mostly varying in height between 1.5 and 3.5 m, some reached a height of 8 m and thus penetrated into the tree layer. The shrubs grow in clusters and consist mostly of little-branched shoots, which were generally shedding leaves at the time of the investigation. Examination of the surface soil and removal of the superficial soil layers revealed that the shoots are linked by a network of creeping woody rootstocks, often as thick as the base of the shoots (Fig. 5). From the rootstock branch off vertical and oblique roots, which branching does not seem to have any correlation with the places

FIG. 3. The overlapping distribution area on transect 1 of *Eucalyptus confertiflora* (with flaky bark) and *E. papuana* (tree with light trunk and slender foliage at right). The tree at the left (with damaged bark) is *E. alba.* In the foreground several branches of *Albizia procera* shrubs; in the background an area of eucalypt regrowth. The ground cover is formed by the *Themeda-Capillipedium* group.

FIG. 4. Root system of *Eucalyptus papuana* in black clay soil of transect 2. (The camera looks obliquely down into the pit.) Under the basal whorl of main horizontal roots a small taproot can be seen, which divides into upward-bending roots.

where the shoots originate. These vertical roots taper rapidly and the deepest penetrations observed were about 0.9 m. From them branch off horizontal and downward rootlets of diameters varying between 1 and 2.5 mm.

Cycas media has its main distribution on the slopes; some specimens, however, were found near gullies and the gallery forest margin. It was completely absent on the intermediate, flatter parts of the transects. Usually *Cycas* remains low, 0.5 or 1 m high, but occasionally it reaches heights of 4 m.

For the sake of completeness the occurrence is mentioned of a few specimens of *Pandanus* sp., *Antidesma ghaesembilla, Timonius timon,* and *Desmodium umbellatum,* growing on black clay soil along the gullies and creeks.

The Ground Layer

GENERAL COMPOSITION: The ground layer is composed mainly of grasses, of which *Themeda australis, Heteropogon contortus,* and *Sehima nervosum* are the commonest; *Capillipedium spicigerum* and *Sorghum nitidum* are subordinate; and *Cymbopogon procerus, Dichanthium superciliatum, Themeda novoguineensis,* and *Panicum* sp. are occasionally found. The season was not very favourable for the study of other herbs. Some dried sedges were found, of which only *Eleocharis monostachyos* on black clay soils was recognizable. Among the forbs the Papilionaceae were best represented: *Lourea obcordata, Crotalaria linifolia, Alysicarpus vaginalis, Uraria lagopodioides, Pycnospora lutescens, Tephrosia ?maculata,* and four species not yet identified, of which two were twiners. Among the others were: *Passiflora foetida* (Passifloraceae), *Evolvulus alsinoides* (Convolvulaceae), *Melothria maderaspatana* (Cucurbitaceae), *Tridax procumbens* (Compositae) *?Borreria* sp. (Rubiaceae), and several Labiatae. Because of the general poor condition

FIG. 5. Root system of *Albizia procera* consisting of rootstocks connecting the trunks and giving anchorage to the shrubs or trees, and of vertical roots scattered along the rootstocks.

of these plants at this time of the year, no attempt has been made to study their distribution.

A feature observed locally at transect 1 and common on transect 2 was a crust of greenish or reddish brown algae, which could cover as much as 20% of the ground. These algae were not restricted to the flatter areas, but occurred also on the slopes. Mosses occurred sparsely and were commonest on the lower slopes.

INFLUENCE ON TERRACETTES: Grass tussocks may play a role in the formation of terracettes, which are especially common on steeper slopes but occasionally can be seen in flatter areas. A number of tussocks form an obstacle to the runoff flow and soil material accumulates at the upslope side. Differences in level at the two sides are mostly a few centimeters, but may become more than a decimeter; factors leading to enlargement of this difference include slope angle, age of tussock, and texture of soil material. Tussocks contribute in this way to stability of the slopes (Mabbutt, unpublished data).

COMPOSITION OF THE GRASS COVER: The investigation was concentrated on the grasses, which generally were fruiting and therefore had probably reached their maximum production; *Sehima* had already lost most of its inflorescences. The overall height of the grass cover was about 1.1 m on the flat parts of the transects, decreasing to 0.9 m on the slopes. The culms were mostly fairly erect; locally, however, they could be more or less inclined. Foliage cover averaged about 50%, but extreme local variations occurred; almost bare areas could lie next to areas with nearly 100% cover. These changes are related to microtopography—depressions have a more open vegetation—and cover of the soil by grit and gravel, whilst severe disturbance during the war could have been a factor in some of the cases. Trees and shrubs did not seem to have a noticeable influence on the grass cover.

The grass cover was sampled near each of the soil pits and on the steep side of the hill at transect 2. A series of 10 plots was cut along a line at right angles to the direction of the main transect or following the contour, the plots spaced three paces apart. In a few cases burnt areas made a deviation of the scheme necessary. A plot was delineated by a frame of 28.3×70.7 cm, comprising an area of 0.2 m^2 (Figs. 6 and 7). The grasses were cut at about 1 cm above the ground, and the species were kept separately. Some plots seemed to contain also some material from earlier seasons. The samples were dried in sun and wind for several days, keeping them indoors at night, after which they were weighed. At this stage they could still have held up to 10% moisture, but this drying at least made the samples mutually comparable. In addition, in each plot records were made of the total cover of the tussock bases as left after cutting; the number and the diameter of the base of the tussocks per species; the length of some of the longest culms; and the area covered by leaf litter, algae, grit and gravel, and stones. Moreover, a series of 10 plots gave frequency figures for the species.

The production per series, expressed as the average dry weight per sample plot of 0.2 m^2, appeared to be very variable and the 95% confidence limits to the means showed that only the series with lowest production significantly differed from the four with highest production. Also, the figures for *Themeda australis,* the only species with consistently high frequency and showing a tendency to increasing production downslope, failed to show significant differences.

Because of these nonsignificant differences, series have been combined in groups, according to the relative importance of the species in the composition of the sward (percentage of species in total dry weight of a series). Three series remained separate because of their strongly deviating composition; the others were in-

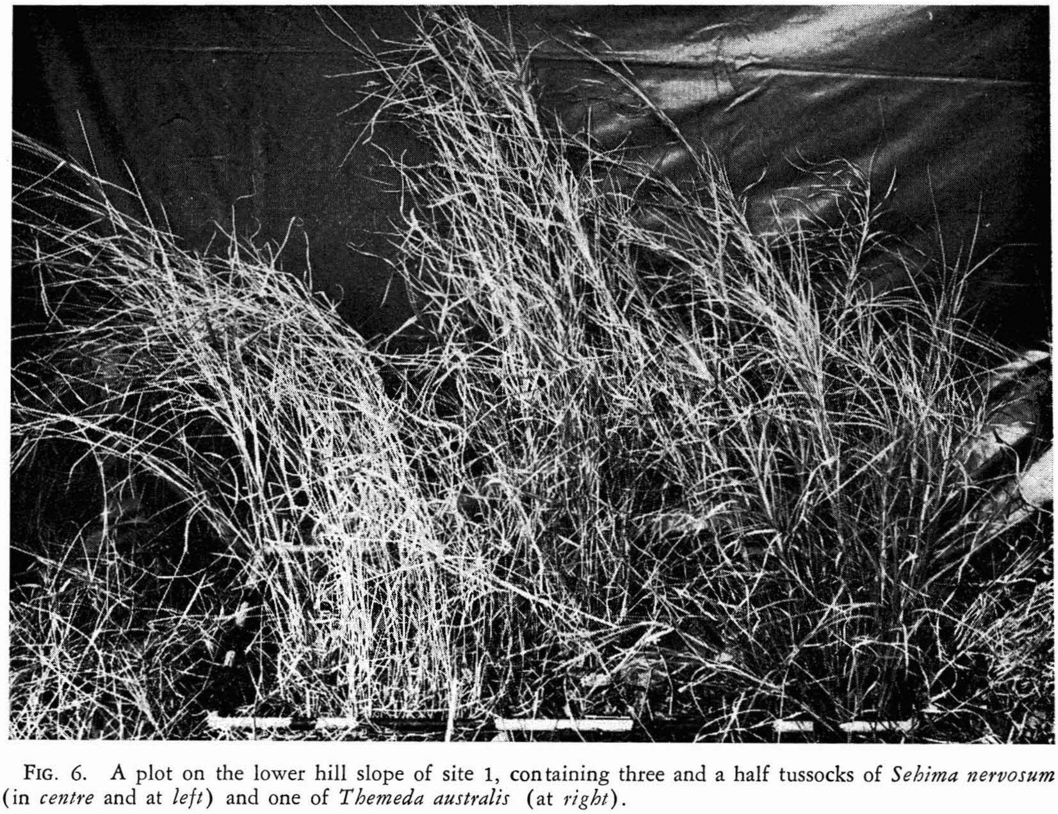

FIG. 6. A plot on the lower hill slope of site 1, containing three and a half tussocks of *Sehima nervosum* (in *centre* and at *left*) and one of *Themeda australis* (at *right*).

FIG. 7. The same plot after cutting shows the tussock bases, some leaf litter, and scattered gravel. The frame adapted from Daubenmire (1959) comprises an area of 0.2 m^2 and is painted to divide by sight the area into squares of 10%, 5%, and 2½% to facilitate estimation of cover.

corporated in three groups of 6, 6, and 7 series respectively, called the *Themeda-Heteropogon* group, the *Themeda-Capillipedium* group, and the *Themeda-Sehima* group. The three remaining series are the *Themeda* series, the *Themeda-Sorghum* series, and the *Sehima-Heteropogon* series. Of the three groups the production of the *Themeda-Heteropogon* group and of the *Themeda-Capillipedium* group are not significantly different, but the *Themeda-Sehima* group produces significantly less than the two other groups (Table 2).

Other data on the groups are given in Table 3. There appears to be a good correlation between the composition of the sward by weight and the basal cover of the tussocks. Also, total production and total basal cover show the same correlation. An inverse correlation exists between basal cover of the tussocks and the number of tussocks: with increasing number of tussocks the basal cover decreases, due to the poorer quality of the tussocks, which is also reflected in the average length of the largest culms.

The *Themeda* series consists of a pure but rather poor stand of *Themeda australis.* The *Themeda-Sorghum* series contains about equal

TABLE 2

TOTAL GRASS PRODUCTION OF THE *Themeda australis-Eucalyptus* SAVANNAH*

GROUP AND SERIES	AVERAGE GRASS PROD. (GM)
Themeda-Heteropogon group	126 ± 17
Themeda-Capillipedium group	115 ± 16
Themeda-Sehima group	81 ± 10
Themeda series	76 ± 32
Themeda-Sorghum series	119 ± 60
Sehima-Heteropogon series	83 ± 18

* Figures give the average production of grass in grams of air-dry matter per plot of 0.2 m^2, with the 95% confidence limits to the means.

quantities of *Sehima nervosum, Sorghum nitidum,* and *Heteropogon contortus,* and double that amount of *Themeda australis,* with a little *Dichanthium superciliatum.* The third series, the *Sehima-Heteropogon* series, with a production almost the same as the *Themeda-Sehima* group, consists of about equal quantities of *Heteropogon contortus* and *Sehima nervosum,* with *Themeda australis* accounting for only 6% of the dry matter.

DISTRIBUTION PATTERNS (Fig. 2): The *Themeda-Heteropogon* group occupies the lowest parts of both transects, with slopes varying between 0°30′ and 3°, and occurs on black clay soil as well as on texture-contrast soil, the former with a 20 or 30 cm deep crumbly topsoil, the latter with a crumbly topsoil of only 5 or 10 cm. Deeper layers have a blocky, lenticular, or columnar structure, are black, dark grey, or dark brown, and frequently have calcium carbonate concretions. The pH in upper layers varies between 5.5 and 7.0, and increases at depth to 8.5. Some 20% of the ground is covered by litter, mainly of the eucalypts, and 10% is covered by grit and gravel, both showing a great local variation.

The *Themeda-Capillipedium* group occupies the intermediate parts of the transects. At transect 1 it occurs on texture-contrast soil alternating with the *Themeda-Heteropogon* group, at transect 2 on texture-contrast soil and adjacent regosol; consequently it occurs over

TABLE 3

SPECIFIC DATA OF THE GROUND COVER GROUPS
(T-H = *Themeda-Heteropogon* group; T-C = *Themeda-Capillipedium* group;
T-S = *Themeda-Sehima* group)

	T. australis	*H. contortus*	*C. spicigerum*	*Sorghum nitidum*	*Sehima nervosum*	OTHER GRASSES	TOTALS
Weight (g/m²)							
T-H	517	87	10	13	2	–	629
T-C	407	76	78	3	12	1	577
T-S	218	50	3	–	131	4	406
Percentage composition of sward by weight							
T-H	82	14	2	2	–	–	100
T-C	72	13	13	–	2	–	100
T-S	53	12	1	–	33	1	100
Basal cover of tussocks (%)							
T-H	4.05	0.84	0.10	0.06	0.005	–	5.08
T-C	3.24	0.73	0.95	0.01	0.2	0.01	5.02
T-S	1.66	0.54	0.02	–	1.36	0.11	3.67
Percentage areas of tussock bases							
T-H	81	16	2	1	–	–	100
T-C	63	14	19	–	4	–	100
T-S	45	15	–	–	37	3	100
Number of tussocks per m²							
T-H	14.7	3.4	1.6	0.5	0.2	–	20.4
T-C	15.6	3.1	4.2	0.1	0.3	0.2	23.5
T-S	15.3	4.8	0.7	–	6.9	0.2	27.9
Frequency (%)							
T-H	96	43	10	10	2	–	
T-C	93	33	32	3	7	3	
T-S	84	43	4	–	73	3	
Average length of longest culms (cm)							
T-H	143	111	135	102	95		
T-C	139	111	135	115	95		
T-S	117	96	105	–	89		

quite a range of topography, on slopes from 0°30′ to 20° (average 8°). The soils have in common a rather thin crumbly topsoil, 7–15 cm deep, which is underlain by massive structured sandy loam or sandy clay loam. Deeper layers are greyish-brown or yellow-brown clays in the case of texture-contrast soil, or brown, reddish-brown, or yellowish-red sandy loams to sandy clays in the case of regosol, often with manganese concretions. The pH of the top layer varies between 5.5 and 8.5, of deeper layers between 4.0 and 8.0. About 30% of the ground is covered by litter, but the area covered by grit and gravel is much the same as in the *Themeda-Heteropogon* group.

The *Themeda-Sehima* group occupies the higher parts of the transects; it occurs on regosol on hills with slopes varying between 11° and 24° (average 15°). Only a 5–15 cm-deep sandy loam topsoil has a crumbly structure; deeper layers are sandy loams or finer textured soils, to clays, with a massive structure, dark brown, merging into reddish colours. Pieces of weathering rock are present, sometimes already at depths of 35 cm. The pH of the topsoil is 6.5–7.5, of deeper layers 5.0–7.0. About 38% of the ground is covered by litter and 25% by grit and gravel, whilst stones and rock fragments cover 3.5%.

The *Themeda* series occurs on the texture-contrast soil of transect 1. One of the main characteristics of its locality is the excessive cover of grit, which averages 53%. The *Themeda-Sorghum* series occurs on black clay soil, of which the upper horizon appeared to contain red soil material, which disturbance is presumably caused by wartime road works. The *Sehima-Heteropogon* series occurs on the steep hill slope of transect 2 (28°), which for almost half the surface is covered by rock outcrops and fragments.

With regard to an explanation for the rather simple group distribution pattern, there is no direct correlation with soil type or with slope angle. Differences in cover of grit and of stones, in the thickness of the crumbly topsoil, in the colour of the deeper soil layers, and in the nature of concretions they contain, however, do not rule out the possibility of a great influence of soil moisture regime. On the other hand, this influence was not closely expressed by the root distribution, which will be treated in the next section. An autecological study of the grass species rather than investigation of group patterns might perhaps contribute more to an explanation. Factors also to be taken into account are, for instance, the frequency and intensity of fires, the severity of runoff, the lengths of periods of waterlogging, and ability for germination and regeneration. Observations at Katherine, N.T., Australia, have revealed a marked response of sward composition to short-term variations in rainfall, *Themeda australis* becoming dominant in drier years (Norman, 1963). A similar interaction could be expected to occur in the area of investigation.

ROOT SYSTEMS OF GRASSES: The distribution of the grass roots in the sections of the pits was studied by spraying the walls with a fine jet hose.

The root systems of *Themeda australis, Heteropogon contortus, Sehima nervosum,* and *Sorghum nitidum* appeared to be of much the same structure. Roots spread in horizontal, vertical, and intermediate directions from the tussock base, forming a dense "corona" with a radius of 1 or 2 dm which becomes more open at greater distances.

In the black clay soil the crumbly topsoil, especially the fine crumbly upper part, is densely rooted; numbers of roots gradually diminish in the underlying heavy clay; usually roots are frequent at 0.9 m and a few are still present at 1.8 m. Roots sometimes seem to follow the planes along which the clay cracks on drying; in other cases they seem to penetrate at random.

In the texture-contrast soil, horizontal roots spread densely through the superficial layer, about 10 cm thick, of friable sandy loam or loamy sand, with a fair amount of oblique and vertical roots penetrating in the underlying massive layer, which is rather resistant to washing. Roots penetrating in the clayey subsoil at about 0.3 m depth are usually few, about 4 per dm^2, sometimes more, which may be due to a less massive structure of the topsoil. Deepest roots are observed at 1 m. Several grass roots penetrated deeper horizons by following the vertical roots of the eucalypts, closely pressed against the bark.

In the red regosol, roots spread in all directions in the superficial, crumbly layer and in the upper part of the massive layer of the sandy (clay) loam, regardless of whether or not the surface shows terracettes. The density of the "corona" around the base of the tussocks is less than that in texture-contrast soil. Rather many roots penetrate deeper, into the layer with weathered rock fragments. Deepest roots are observed at 1.3 m.

Consequently, rooting patterns except for being somewhat more diffuse in the regosols are not very different in various kinds of soil, and only a firm, massive, sandy loam layer as encountered in certain texture-contrast soil profiles seems to be unfavourable for deeper root development.

Ecological Significance of the Results

The investigation revealed that correlations between vegetation and soil conditions seem to have only a localised validity. For instance, the distribution pattern of *Eucalyptus alba* encountered on transect 2, viz. its restriction to texture-contrast soils, is not consistent with that on transect 1, where *E. alba* occurs over the whole transect. Also, a hypothesis based on observations at transect 1, that the boundary between the *Themeda-Capillipedium* and the *Themeda-Sehima* ground cover groups coincides with the boundary between texture-contrast soil and regosol, would appear untenable when applied to transect 2. On the other hand, black soils carry only the *Themeda-Heteropogon* group, which however also extends over other soils.

Some conditions find ready expression in the vegetation (e.g., steep, rocky slopes are covered with a *Sehima-Heteropogen* ground cover, and disturbed soils with a *Themeda-Sorghum* ground cover), but generally the determining factors remain unknown. The presence of an algal cover, great local variations in grass cover, and differences in certain soil characteristics mentioned in the discussion on the ground cover groups, suggest a great influence of soil moisture, whilst terracettes and local concentrations of grit and gravel point to slope wash as an important factor. On the other hand, differences in moisture regime were hardly, if at all, expressed by rooting patterns as the root systems of the grasses as well as those of *E. papuana* appeared to be similar for different soils, whilst *E. alba* showed a considerable variation within one soil type.

Observations over a period of years, also during the wet season, and on a regional basis could lead to more conclusive results, but an investigation into the influences of burning will probably reveal fire to be the overriding factor of the environment.

COMPARISON WITH AUSTRALIAN VEGETATION

Savannahs comparable in physiognomy and to a certain extent also in floristic composition occur in the higher rainfall areas of tropical and subtropical Australia, but relevant literature is scarce and is concerned mainly with the characteristics of the ground cover for use as natural pasture.

At Katherine, N.T., Arndt and Norman (1959) studied a savannah vegetation of a richer floristic composition but which included most of the species encountered at Port Moresby. Predominant in the ground cover are *Sorghum plumosum, Themeda australis,* and *Chrysopogon fallax.* The dry matter yield for unburnt areas of a lightly grazed pasture was about 110 g/m^2 at the end of the dry season (October), and rose to about 290 g/m^2 at the end of the wet (April–May). For areas burnt at the end of the dry season the dry matter yield at the end of the wet season was only about 140 g/m^2.

Shaw and Bisset (1955) have given figures for subtropical Queensland, which can be as low as 60 g/m^2 for dry season yield and as high as 425 g/m^2 for yields at the end of the wet season.

The figures obtained for the *Themeda australis-Eucalyptus* savannah in Papua are much higher than those mentioned above. Oven-drying of the samples instead of air-drying would have resulted in figures about 10 to 15% lower, which gives a figure of, say, 530 g/m^2, which still is much higher than the figures for Katherine and Queensland. Because our observations are from only one season, it is impossible to say how near they are to the average. On the other hand calculations by Fitzpatrick (1965) about the periods of useful pasture growth demonstrate that the growing season at Jackson's

Airport could be nearly twice as long as at Katherine, viz. 41 weeks against 22: this would certainly contribute to the difference in production between these stations.

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SUMMARY

Themeda australis-Eucalyptus savannah covers extensive areas in the monsoonal coastal lowlands of Papua. The ground layer is dominated by grasses, mainly *Themeda australis, Heteropogon contortus,* and *Sehima nervosum;* the tree layer is formed by three species of *Eucalyptus.*

This type of savannah has been investigated on two transects near Port Moresby. Observations have been made on its composition and structure, and on rooting habits of trees and grasses. Quantitative data for the grass cover have been determined.

Patterns in the vegetation coincide only locally with some topographic and soil factors, and it is suggested that further investigation may reveal burning as an agent overriding the influences of other factors.

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