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Vegetation mapping in the Uluguru Mountains (Tanzania, East Africa)

T. PÓCS

Abstract

Pócs, T. (1976). Vegetation mapping in the Uluguru Mountains (Tanzania, East Africa). *Boissiera* 24: 477-498 + 1 map.

The author presents vegetation maps of the Uluguru Mountains, Tanzania. 35 different vegetation units are described. Maps showing the topography, geology, main annual rainfall, duration of the dry season, and potential agricultural land are also given.

Résumé

Pócs, T. (1976). Cartographie végétale des Monts Uluguru (Tanzanie). *Boissiera* 24: 477-498 + 1 carte. En anglais.

L'auteur présente des cartes de végétation des Monts Uluguru en Tanzanie. 35 types de végétation sont décrits. Des cartes indiquant la topographie, la géologie, les moyennes annuelles de précipitation et les zones potentielles d'agriculture sont aussi fournies.

Introductory remarks

An area of 800 km² was mapped in the Uluguru Mountains, Morogoro District, Eastern Tanzania. 35 vegetation units were distinguished. The large map covers (scale 1:50 000) 760 km², representing almost the whole of the Northern Ulugurus. The other map, more detailed, covering 40 km² (Fig. 7) represents the central part of the Southern Ulugurus, the Lukwangule Plateau. These two maps are accompanied by the following small scale ones showing the surface relief (Fig. 1), the geology (Fig. 2), the broad outline of the natural vegetation belts (Fig. 3), the main annual rainfall (Fig. 4), the duration of the dry season (Fig. 5) and the agricultural potential (Fig. 6). The latitudes and longitudes of the larger mapped area are 37°33' to 37°48' E and 6°45' to 7°00' S respectively. The smaller, mapped area is situated a few kilometres southwards. The altitudinal range of the area is 295-2664 m above sea level. The rainfall varies between 600 and 3500 mm/year. The vegetation of the uncultivated areas is very variable: lowland, submontane and montane rain forests dominate the eastern slopes, mossy and subalpine elfin forests occupy the main ridge; finally the drier types of forest, woodland, and savanna woodland are more common on the western slopes and on the foothills in rain-shadow.

The old crystalline range of the Uluguru Mountains forms a part of the inselberg chain on the eastern border of the Central African Plateau. Geologically, the

Ulugurus are built up of Usagaran (Pre-Cambrian) rocks. The main ridge consists of pyroxene granulites, the eastern foothills of gneisses and dolomitic marble, while the western foothills consist of gneiss and migmatites, often covered with sand and other juvenile layers.

Due to the constant easterly direction of the rain-carrying winds, the rainfall is very unevenly distributed. On the eastern slopes the mean annual rainfall varies between 1300 and 2900 mm, with almost no dry season. The main ridge (altitude 1800-2600 m) gets far more than 3000 mm. Finally the western slopes and foothills, in rain-shadow, are much drier, with 800-2000 mm annual rainfall and with a distinct dry season of 2-5 months. In some cases this long dry season is interrupted by a short rainy season in December.

Due to the very variable surface structure and rainfall distribution, and due to the old age and long isolation of these mountains, a very rich flora and vegetation has developed, a flora which is related to that of the Usagara, Ukaguru, Nguru and Usambara Mountains in Tanzania and with a definite affinity to that of Madagascar and the Mascarenes. Once the eastern slopes were covered up to the foothills with forest, which is a rare phenomenon in East Africa. The mountains are surrounded by woodland and savanna and the forest flora of each ridge has developed independently during a long time. Thus a large number of endemic species is known from the Uluguru Mountains: e.g. among the woody plant species more than 40 are endemic.

The principal aims of this vegetation mapping were to study the natural distribution and ecology of different vegetation units and to find out the limiting environmental factors. An attempt has been made to estimate the agricultural potential of each natural vegetation unit (see Fig. 6) with special reference to possible introduction of new crops into areas of cassava and maize monocultures.

The project was approved by the Office of the Vice-President of Tanzania. The author is very thankful for the financial aid granted by the Research and Publication Committee of the University of Dar es Salaam during his four years' stay in Morogoro, where he was a Senior Lecturer in Botany at the Crop Science Department of the Faculty of Agriculture. He is also indebted to the staff of the East African Herbarium, Nairobi, for the identification of plant specimens, and to his assistants, Messrs. P. S. Mwanjabe and M. Lung'wecha, to his students, colleagues and friends who often accompanied him on his field trips, and finally to Mrs. I. Bakalár, who made the draughtsman's work during the final preparation of the maps.

A brief description of the mapped vegetation units

1. Lowland semi-evergreen or evergreen rain forest on graniolite

The former large lowland forests on the eastern slopes have been cut and are now substituted by fields of maize, cassava, upland rice, and robusta coffee, sometimes by *Citrus* cultures, except a small but representative area including the Mangala, Milawilila and Gambaula Forest Reserves in the Mwuha Valley, N of Tawa Village. These lowland rain forests develop at 300-500 m altitude by an annual rainfall of about 2300 mm. There is practically no dry season. The canopy is about 30-40 m tall, formed by *Ficus* sp., *Chlorophora excelsa*, *Antiaris toxicaria*, *Celtis wightii* and *Albizzia gummifera*. In the lower strata, *Mussaenda monticola*,

Leptaulus holstii, *Tabernaemontana usambarensis* and *Dialium holtzii* are remarkable. In the herbaceous layer *Bolbitis gemmifera*, *Pilea holstii*, *Scleria lithosperma*, *Geophila ioides*, *Olyra latifolia*, *Chlorophytum filipendulum* and *Sansevieria braunii* are codominant. *Asparagus racemosus* is a common climber, *Platynerium angolense* and *Rhipsalis cassytha* are the only macro-epiphytes.

2. Lowland evergreen and semi-evergreen rain forest on dolomitic marble

In the lowland area the forest cover has remained much more intact on the 300 m high karstic plateau of the Kimboza area (Kimboza and Ruvu Forest Reserves between Mkuyuni and Matombo villages). The rough, rocky, and often waterlogged surface is not favourable for agriculture. These lowland forests are luxuriant, with several endemic species. The trees, 20-40 m tall and forming the canopy, are: *Parkia filicoidea*, *Khaya nyasica*, *Sterculia appendiculata*, *Aningeria pseudoracemosa*, *Elaeis guineensis* (20 m tall specimens!), and *Celtis* sp. A dense understorey is formed by 2-10 m tall trees, such as *Allophylus pervillei*, *Uvariodendron gorgonis*, *Grandidiera boivinii*, *Leptonychia usambarensis*, *Garcinia livingstonei*, *Drypetes natalensis*, etc.

Among the shrubs, *Zenkerella egregia*, *Craterogyne cameruniae*, *Sloetiopsis usambarensis*, *Cola stelechantha* and *Sorindeia madagascariensis* are common, while the most characteristic herbs are *Calloopsis volkensii*, *Coleotrype buchwaldiana*, *Cyperus alternifolius* subsp. *flabelliformis*, *Cyclosorus opulentus* and *C. extensus*.

Common epiphytes are: *Platynerium angolense* (also on marble rocks), *Asplenium nidus*, *Microsorium punctatum*, *Davallia chaerophylloides*. There are some rare epiphytic orchids, too, e.g. *Aerangis kirkii*. *Culcasia falcifolia* is a notable hemi-epiphyte, and among the climbers *Cnestis confertifolia*, *Dioscorea sansibarensis*, *Strophanthus zimmermannianus* could be mentioned. The most characteristic feature of this forest type is the mass of 6-12 m tall specimens of *Pandanus* cf. *engleri*, usually covered with moss and fern epiphytes. In some waterlogged places in the centre of the plateau, dense and pure, about 10 m high stands of *Pandanus* occur.

3. Dry semi-evergreen forest with succulents

This interesting type of lowland forest is closely related to the coastal forests and thickets in Tanzania occurring between the Pugu Hills and Chalinze. The last, isolated patches are situated on the north-western spurs of the Uluguru Mountains, namely on the foot of the Mindu and Nguru ya Ndege Hills. Once, their distribution area was probably much larger and they are now substituted by secondary savanna. The 8-12 m high canopy is made up of *Azelia quanzensis*, *Euphorbia candelabrum*, *Commiphora pteleifolia*, *Coffea zanguebariae* and *Grandidiera boivinii*. The high percentage of succulents, such as *Euphorbia tirucalli* and several *Sansevieria* species, is typical. Epiphytes, e.g. *Microgramma ovariensis*, are very rare. In the Kitulanghalo Forest Reserve north of the Uluguru, this forest type is very rich in 4-6 m tall *Encephalartos hildebrandtii* specimens.

4. Riverine or fringing forest

These forests are mostly evergreen, bordering permanent or temporary streambeds in the submontane or lowland woodland and savanna belt. In the submontane

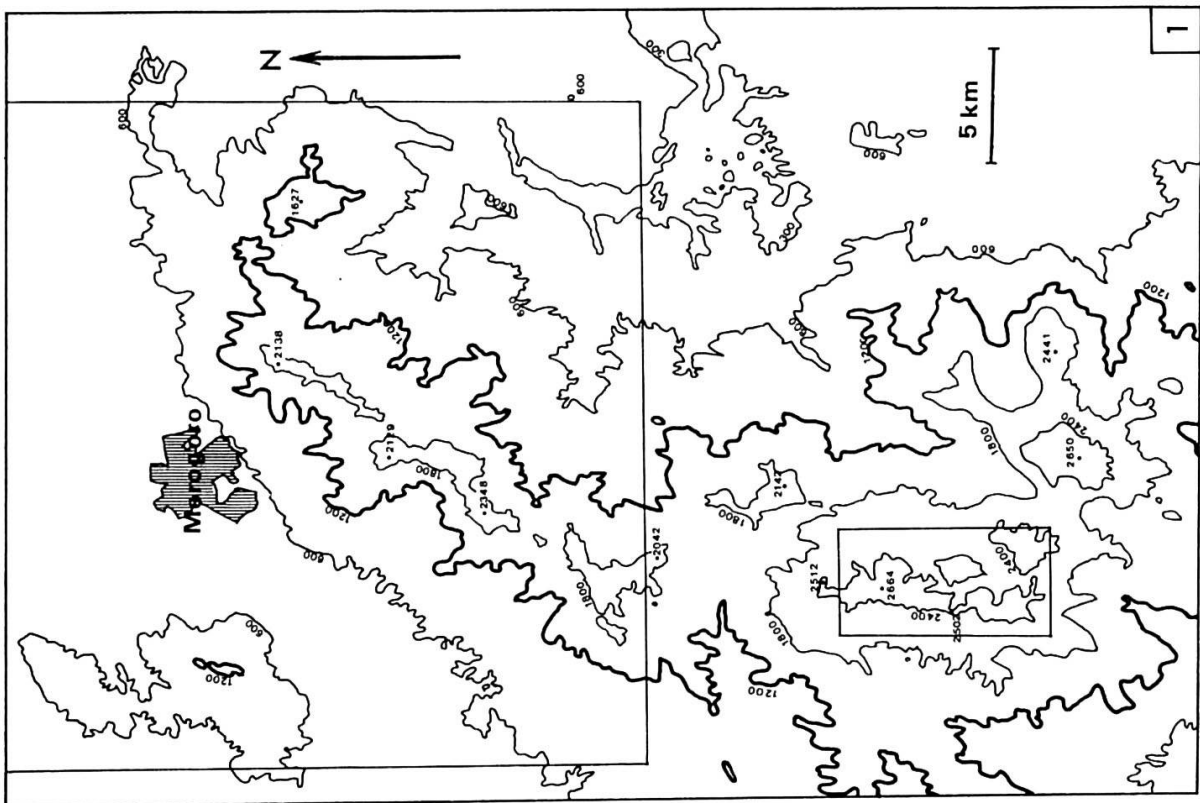
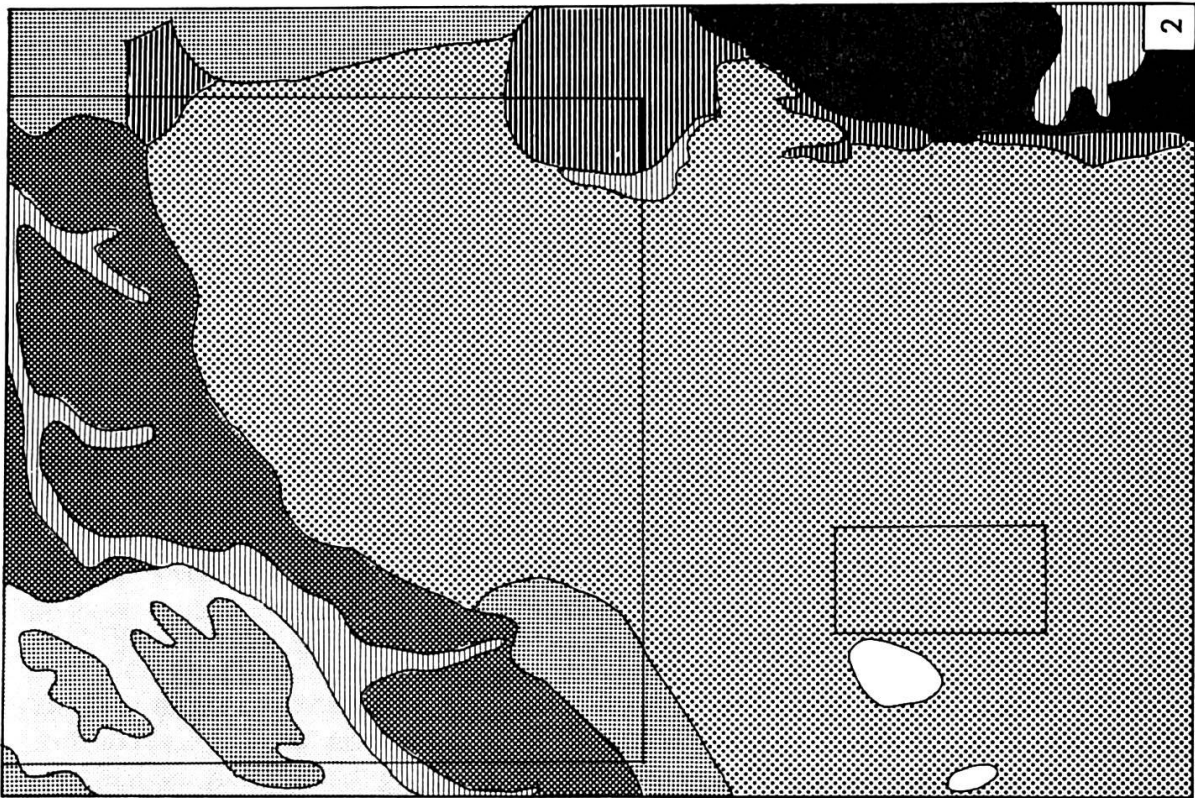


Fig. 1. – Relief map of the Uluguru Mountains indicating the position of the two areas where vegetation mapping was carried out.

Fig. 2. – The geology of the Uluguru Mts. based on the geological survey maps of Tanzania (highly reduced and simplified).
1: Precambrian migmatite (quartzite); 2: Precambrian pyroxene granulite; 3: Precambrian calcite and dolomite marbles; 4: Coarse karroo sandstone and conglomerate; 5: Thick deposits of noegene red and reddish brown soils; 6: Neogene superficial sands and sandy hillwash; 7: Alluvium; 8 (The blank patches): Neogene caolinitic soils and residuals.

Fig. 3. – A broad outline of the natural vegetation belts in the Uluguru Mts.
1: Low altitude savanna and savanna woodland; 2: Submontane woodland; 3: Lowland evergreen and semi-evergreen forest; 4: Submontane evergreen and semi-evergreen forest; 5: Montane evergreen forest; 6: Subalpine belt with elfin woodland, moorland and bamboo thicket.

Fig. 4. – The main annual rainfall in the Uluguru Mts. The rain-gauge stations and their annual means in mm are indicated.

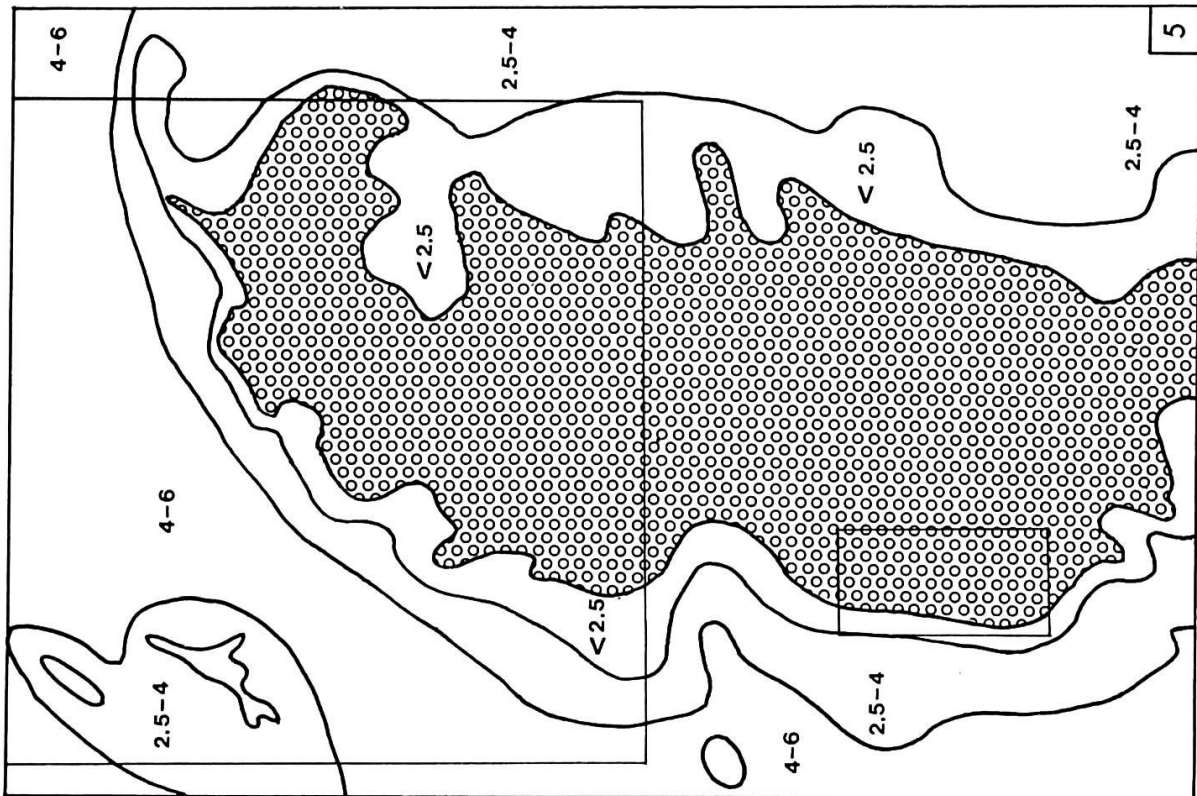
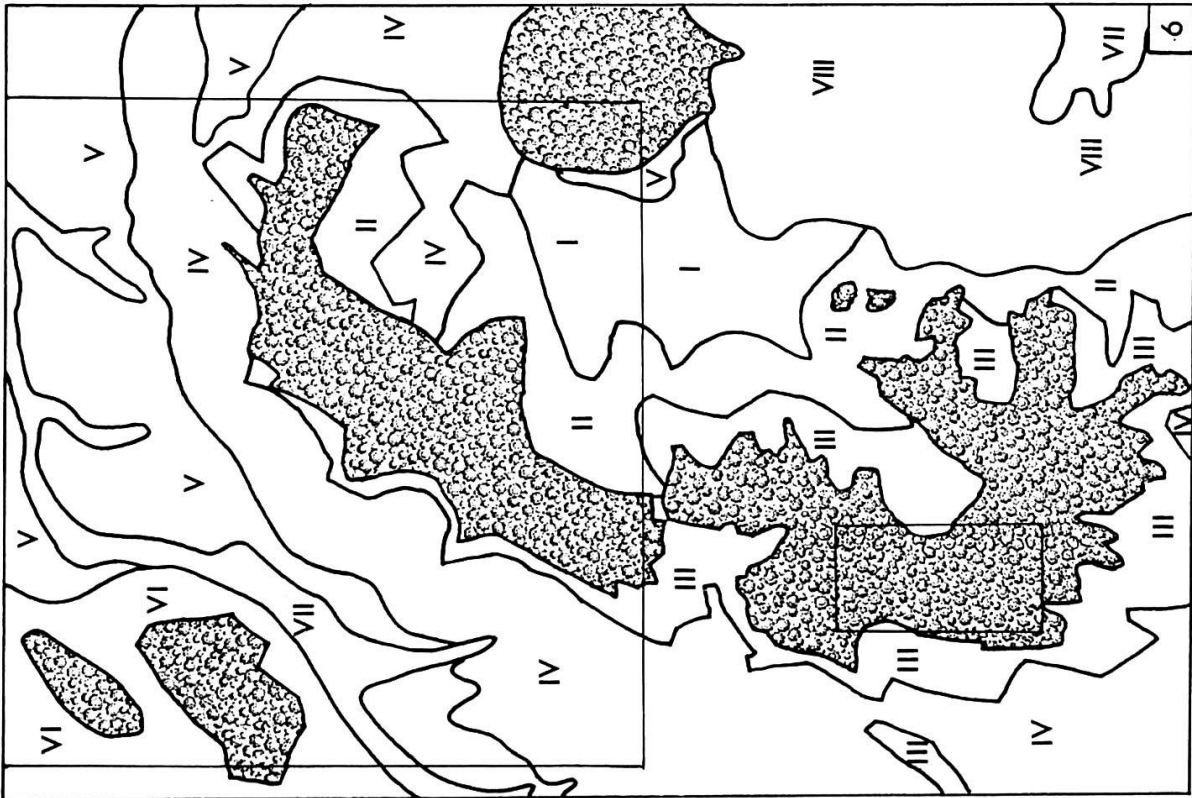


Fig. 5. – The duration of the dry season in months. In the central area (stippled) the dry season is shorter than one month or practically absent.

Fig. 6. – Potential agricultural zones in the Uluguru Mts.

- I. Lowland forest zone. – Rainfall 1800-2400 mm/year without a serious dry season. Annual mean temperature higher than 24°C. On deep soils yam, cocoyam, sweet potato, coconut, cocoa, oil palm, black pepper could be grown along the present plantations of *Citrus* fruits, pineapple, rice, and robusta coffee.
- II. Submontane forest zone. – Rainfall 1700-3000 mm/year without dry season. Annual mean temperature 20°-24°C. Cocoyam, yam, upland rice, *Citrus* fruits, pineapple could be grown on a larger scale than at present. Arabica coffee ought to be substituted by tea, *Cinchona*, tung, and cardamom as cash crops. An area specially suitable for dairy farming.
- III. Montane forest zone. – Rainfall 1500-3000 mm/year, without a definite dry season. Annual mean temperature below 20°C. Where not occupied by the Forest Reserve (stippled area) vegetables are actually grown together with maize and cassava. Instead of the two latter crops others ought to be introduced: tea, *Cinchona*, tung, Irish potatoes, trees and hedges for erosion control.
- IV. Submontane woodland zone on ferrallitic soils. – Rainfall 700-1500 mm/year with a definite, 2-4 months' long dry season. Annual mean temperature 18-24°C. Besides the present cassava and maize monocultures, more beans, *Citrus*, pawpaw, kenaf ought to be introduced. Careful erosion control is necessary.
- V. Lowland savanna and savanna woodland area. – Rainfall 650-900 mm/year with a 4-6 months' long dry season, often prolonged. Annual mean temperature 24-26°C. Instead of sisal, more cotton, kenaf, peanut, safflower and *Citrus* should be introduced.
- VI. Woodland zone on sandy soil. – Climate as by type V. An area suitable for large-scale peanut production.
- VII. Valley grassland and swamp areas. – Climate as above. Together with swamp rice, more sugar-cane and cotton could be grown.
- VIII. Low woodland area, on basic karroo beds. – Rainfall 1000-1400 mm with a 3-4 months' dry season. Annual mean temperature above 25°C (up to 27°). A potential cashew area and suitable for dairy farming. – Stippled areas: major actual and potential forest reserves.

subtype, the tallest, and dominant, tree species are: *Bridelia micrantha*, *Pachystele brevipes*, *Parkia filicoidea*, *Dalbergia lactea* and *Syzygium cumini*. Common climbers are: *Smilax kraussiana*, *Rhoicissus tridentatus* and *Clematis hirsuta*. Smaller trees and shrubs are: *Saba florida*, *Mellera lobulata*, *Ficus thonningii*, *Voacanga lutescens*, *Anona senegalensis* and *Psychotria riparia*. Epiphytes are rare: e.g. *Asplenium nidus*, *Antrophium immersum* and *Psilotum nudum*. Among the herbs, *Gonotypus boivini*, *Aneilema aequinoctiale* and *Mariscus dubius* seem to be common. In the lowland subtype, *Grewia goetzeana* and *Sterculia appendiculata* are important tree species. Among the shrubs, *Deinbollea borbonica*, *Schizozygia coffaeoides* and *Ipomoea irwiniae* can be mentioned.

5. Submontane semi-evergreen forest

This forest type forms a definite belt on the eastern slopes between 500 and 800 m above sea level. In appearance and floral composition it is related to the forests near Sigi in the Eastern Usambara Mountains. Although it is a high forest with a 30 m tall canopy formed by *Albizzia gummifera*, *Diospyros* sp., *Chlorophora excelsa*, *Sapium ellipticum* and others, it is drier than a rain forest, and, being bordered by the agricultural area, it usually has a secondary character. The epiphytes are rare (e.g. *Asplenium nidus*); tree ferns occur only in deep ravines, near streams.

6. Submontane rain forest

Submontane rain forests form an almost continuous belt on the eastern slopes between 800 and 1500 m above sea level, and occur also as isolated patches in the deep valleys of the western slopes and on the mist-wrapped summits of the isolated hills on the mountain borders. These forests are the most luxuriant among the rain forests and far the most productive timber habitats of the Ulugurus. Their requirements are: 2500-3000 mm of annual rainfall and no dry season. Both floristically and in general appearance they are very closely related to the rain forests near Amani in the Eastern Usambara Mts. where they are called "intermediate wet forests" by Moreau (1935). The 30-50 m high canopy is made up of *Parinari excelsa*, *Myrianthus holstii*, *Albizzia gummifera*, *Newtonia buchananii*, *Sapium ellipticum*, *Trema orientalis*, *Cylicomorpha parviflora*, *Maesopsis eminii*, *Allanblackia stuhlmannii*, *Ocotea usambarensis* and *Afrocrania volkensis*. The last three species, being montane, reach their lower limit here. Those giant trees are heavily loaded with epiphytes. Among the 34 vascular epiphytic species found, *Asplenium nidus* is the most common, sometimes forming 40 kg heavy nests in the crowns. Other taxa are: 3 *Lycopodium* species, 23 ferns (3 *Hymenophyllaceae* among them), 5 orchids (e.g. *Oberonia disticha*, *Bulbophyllum intertextum*), etc. The giant trees are often buttressed.

Common shrubs are *Rytigynia kidaria*, *Peddiea volkensis*, *Maytenus undata*, and *Mussaenda monticola*. Very characteristic in this vegetation type are some *Commelinaceae* subshrubs, such as *Palisota orientalis*, *Pollia condensata* and the endemic *Pollia bracteata*. Other endemic shrubs can be mentioned: *Pseuderanthemum campylosiphon*, *Psychotria griseola*, *Micrococca holstii*. The herbaceous layer is usually dense, composed of ferns (*Asplenium obscurum*, *Marattia fraxinea*, *Diplazium hyophilum*, *Lonchitis occidentalis*, 4 *Pteris* species, etc.), zingiberoids (*Aframomum*, *Renealmia engleri*), and grasses (*Setaria caudula*, *Isachne mauritiana*,

Leptaspis cochleata). On shady rocks the tall *Lobelia longisepala* and the large-leaved *Antrophium mannianum* are typical representatives.

7. Mesophilous montane forest

In the northern part of the Ulugurus, between 1500 and 1850 m, these montane evergreen forests occupy the steeper slopes and ridges, alternating with the montane rain forests of the valleys. In the Southern Ulugurus they dominate on the western slopes between 2000 and 2400 m while, on the eastern slopes, they are subordinate and the montane rain forests occupy a much larger area (Fig. 7).

The canopy is 20-30 m high. While in the submontane rain forest, a rich lower tree stratum also develops (*Mitragyne rubrostipulata*, *Rawsonia uluguruensis*, *Alsodeiopsis schumannii*, *Dracaena steudnerii*, etc.), the canopy is usually unistratose in the montane belt. The codominant trees are: *Podocarpus milanjanus*, *Ocotea usambarensis*, *Afrocrania volkensis*, *Ficalhoa laurifolia*, *Cussonia spicata*, etc. The trees are usually not buttressed. The vascular epiphytes are not common: about 12 species, 6 of which are ferns (only 2 *Hymenophyllaceae* species). Interesting epiphytic orchids are: *Bulbophyllum (Genyorchis) stolzii* and *Sphyrarhynchus schliebenii*.

Among the more common shrubs the following are worth mentioning: *Mostuea brunonis*, *Chassalia parviflora*, *Ch. violacea*, *Lasiodiscus usambarensis*, *Galineria coffeoides*, *Memecylon myrtilloides*, *Erythrococca usambarica*, *Euphorbia usambarica*, and *Bridelia brideliifolia*. Woody herbs are: *Crassocephalum mannii*, *Conyza newii*, *Vernonia adoensis*. Also here the endemic *Ensete ulugurensis* is the commonest plant. The herbaceous layer is very various according to the conditions. On sharp ridges an acidophilous type exists with the following codominant species, viz. *Blechnum ivohibense*, *B. punctulatum*, *Blotiella stipitata*, *Gleichenia umbraculifera*. On deeper humus, different *Impatiens* species, *Aneilema dispernum*, *Sanicula elata*, *Thalictrum rhynchocarpum* and *Selaginella kraussiana* may form a rich layer together with ferns, such as *Didimochlaena truncatula*, *Asplenium frieseorum*, *Adiantum hispidulum*, etc.

8. Montane rain forest

As mentioned above these forests occur in the same belt as the mesophilous ones but under more humid conditions: in valleys or on the rainier eastern slopes (cf. also Fig. 7), where the mean annual precipitation is about 3000 mm. The canopy consists of species similar to those mentioned above but includes also a few hygrophilous elements, e.g. *Myrianthus holstii*. On the other hand, in a lower storey, many tree ferns (4 species) and sometimes the giant bamboo (*Arundinaria alpina*) appear. This forest is also very rich in epiphytes: 65 taxa including 4 *Lycopodium* species, 34 ferns, 3 *Peperomia* species, and about 10 orchids. Among the ferns the high proportion of *Hymenophyllaceae* (12) and *Elaphoglossum* (6) species indicate a very humid microclimate. In the herbaceous layer the ferns play the most important rôle: they constitute more than 70% of the species. Such hygrophilous ferns as *Ctenitis lanuginosa*, *Asplenium hypomelas*, and *Diplazium pseudoporrectum*, are common together with representatives of the families *Urticaceae* (*Elatostema zimmermannii*, *E. orientale*, *E. welwitschii*) and *Acanthaceae* (*Brachystephanus africanus*, *Isoglossa lactea*). Among the climbers, *Begonia meyeri-johannis* and the rare *Sericostachys tomentosa* (*Amaranthaceae*) can be cited.

9. Montane mossy forest

On both sides of the main ridge, between 1850 and 2400 m, mossy forests develop in areas where the annual rainfall exceeds 3000 mm. Thus there is no mossy forest on the relatively dry western escarpment of the Lukwangule Plateau in the Southern Ulugurus (Fig. 7). The canopy of mossy forests varies in height between 10 and 25 m. The whole length of the tree trunks and of the liana and tree fern stems is completely coated with a dense fur of bryophytes, and even from the branches and twigs long moss beards hang down. The canopy of mossy forests is mainly composed of the same tree species as that of the other montane forests. In addition, *Rapanea pulchra*, *Podocarpus ensiculus*, *Schefflera polysciadia*, *Rauvolfia volkensis*, and *Melchiora schliebenii* occur as medium-sized trees. The strangler *Schefflera barteri* is not rare. The canopy is often formed by pure stands of 8-12 m tall specimens of *Cyathea manniana*. The *Cyathea* stems bear a special epiphyte community of bryophytes: *Lejeunea cyathearum*, *Rhizofabronia perssonii*, and *Leiomeles bartramioides*. In the shrub layer the endemic *Lasianthus* species are not rare, e.g. *L. pedunculatus*, together with *Zenkerella cappariaceae*, *Rawsonia uluguruensis* and *Alsophila schliebenii*. In the herbaceous layer the crimson *Impatiens uluguruensis*, *Cardamine africana*, *Cryptotaenia africana*, *Cinnobryum oreophila*, and *Carex castanostachya* are elements that occur also in the elfin forest. On the shady, moss-covered rocks characteristic synusia are formed by *Gesneriaceae* species: *Saintpaulia goetzeana* and *pusilla*, *Streptocarpus bullatus*, *Linnaeopsis alba*, together with ferns, such as *Grammitis pygmaea* and *Elaphoglossum phanerophlebium*. The epiphytic vegetation is also rich in vascular plants. Out of 28 species, 4 are *Lycopodium* species and 20 ferns, 8 of which belong to the family *Hymenophyllaceae*. Orchids play no important rôle.

10. Subalpine elfin forest

In the permanent mist zone, above 2100 m in the northern and above 2400 m in the southern part of the Ulugurus, the most peculiar plant community of this area is found, which is far the richest in indigenous species (taxa marked with an asterisk * below). The elfin forests of the Uluguru Mts. are comparable with the giant *Erica arborea* heath of the Kilimanjaro and Ruwenzori Mts., because they form the forest line on the subalpine Lukwangule Plateau. Now and then an obvious frost effect is observable, especially on the ferns and on the semi-succulent epiphytes. On the other hand, the structure and floristic composition of the elfin forest are completely different from those of the *Erica arborea* heath of Kilimanjaro. Sclerophyllous trees and shrubs, 3-6 m high, form the very dense, unistratose canopy: *Syzygium parvulum**, *S. sclerophyllum*, *Allanblackia ulugurensis**, *Podocarpus milanjanus*, *Cussonia lukwangulensis**, *Polyscias stuhlmannii*, *Ternstroemia polypetala**, *Melchiora schliebenii*, *Garcinia volkensis*, *Agauria salicifolia*, *Ochna oxyphylla*, *Pittosporum goetzei**. In this canopy, the small tree fern *Alsophila schliebenii** and the endemic giant *Lobelia* of the Ulugurus, *Lobelia lukwangulensis** occur together.

In the understorey, small shrubs and tall herbs are intermixed: *Psychotria cyathicalyx**, *Diodrychium schliebenii**, *Pentas pseudomagnifica**, *Sabicea arborea**, *Erlangea schimperii*, *Stapfiella ulugurica**, *Hedythyrus thamnoides*, *Lasianthus wallacei** and *L. kilimandscharicus*, *Blotiella glabra*, *Streptocarpus hirsutissimus** (also as epiphyte), *Macrothelypteris aubertii*, *Polystichum zambeziacum* and many

Acanthaceae subshrubs. The community is rich in epiphytes. Among the vascular plants, *Vittaria isoetifolia*, *Hymenophyllum triangulare* and *H. capillare*, *Grammitis barbulata*, 3 *Xyphopteris* spp. and many small orchids (*Stolzia atrorubra* and *Tridactyle stipulata*) are to be mentioned. All trunks and branches are embedded in such a thick cloak of bryophytes, that the diameter of tree and shrub stems seems to be doubled. The roots and the whole peaty ground is often covered with a 20 cm thick moss carpet.

11. Occurrence of montane bamboo (*Arundinaria alpina*)

According to aerial photos studied, the summit area of Kimhandu in the Southern Ulugurus (2650 m) is densely covered with a bamboo thicket above 2400 m altitude. In the Northern Ulugurus, I have seen subalpine bamboo bush only on the very steep Magari Peak, where it grows on almost vertical rock walls as it also does in the summit areas of the Nguru and Kanga Mountains. In the montane rain forest belt of the Southern Ulugurus, on the other hand, *Arundinaria alpina* is quite common intermixed with forest trees, and along the upper Mgeta Stream, at 2200 m altitude, it forms almost pure, 20 m high stands. The lowermost occurrence of *Arundinaria alpina* in the Ulugurus is situated on the Mgeta River above the Hululu Falls, south of the Bunduki Forest Station, at 1630 m above sea level.

12. Montane and subalpine heath

Primary heath vegetation is quite rare in the Ulugurus. It is found on exposed rocky ridges. The dominant taxon is usually *Philippia pallidiflora* subsp. *usambarensis*, specimens of a man's height, associated with *Dissotis polyantha*, *Rapanea* sp., *Ternstroemia polypetala*, and *Rytigynia kidaria*. In the poor herbaceous layer, representatives of the family *Gleicheniaceae*, especially *Gleichenia elongata*, are typical. One of the most beautiful endemic species of the Ulugurus, *Urogentias ulugurensis* (monotypic genus), also lives on the heath-covered rocky Palata Ridge.

13. Complex of secondary savanna and cultivated land on ferralitic soils

The savanna belt of the Uluguru area is highly cultivated, the only remnants being small patches of primary or secondary savanna. Therefore the question is open, whether a real savanna woodland ever existed or whether these patches are derivatives of more closed woodland communities. Anyhow, not far from here in the Dakawa area, primary and untouched wooded savanna exists under similar climatic conditions (rainfall 700-1000 mm, dry season 4-6 months). There are two types of savanna woodlands in the area, one on bound, ferralitic soil on the slopes of the foot-hills of the Uluguru Mountains, the other on loose sandy soil at the foot of the Nguru ya Ndege and Mindu Hills near Morogoro Town, on the outskirts of the Ulugurus.

The remnants of wooded savanna vegetation on ferralitic soils can be characterized by the presence of *Adansonia digitata* and *Kigelia aethiopica* (near streamlets in valley bottoms). Acacias and other small deciduous trees form a loose network in the grass layer much devastated by human activity (grazing, bush fire). The commoner tree species of this savannalike vegetation are: *Acacia circummarginata*, *A. sieberiana*, *A. clavigera*, *A. goetzei*, *A. brevispica*, *Cassia abbreviata* subsp. *beareana*, *Piliostigma thonningii*, *Olax dissitiflora*, *Commiphora africana*, etc. The

main crops of the cultivated land within this area are: maize, sorghum, cassava, cotton, sisal, pawpaw, banana, and mango.

14. *Savanna woodland on loose sandy soils*

On sandy soils at the same altitude as the above-mentioned vegetation type, i.e. below 600 m, one finds the other savannalike vegetation type. On the map, this more natural savanna (no. 14) has been distinguished from the agricultural areas of the same belt, where the savanna woodland occurs only as remnants (no. 24). This savanna woodland is a little more closed than the type described under no. 13. The loose tree and shrub layers are formed by *Cassia auriculata*, *Markhamia obtusifolia* and *M. acuminata*, *Hymenocardia acida*, *Tamarindus indicus*, *Uvaria kirkii*, *Combretum collinum*, *Sclerocarya caffra*, and *Ochna ovata*. In the herbaceous layer *Heteropogon contortus*, *Perotis patens*, *Fimbristylis hispidula*, *Bulbostylis pilosa*, *Maerua edulis*, and *Thylacium africanum* are common.

Both these savannalike vegetation types seem to be rather fire-products than climatic climaxes.

15. *Submontane Pterocarpus-Combretum woodland*

This is the most important woodland community of the Ulugurus. It occupies or occupied most of the western and northern slopes of the mountains below 1400 m altitude. The year is sharply divided into dry and rainy seasons. The rainfall is 900-1300 mm per year, with a dry season of 2.5-3.5 months.

The tree layer of these woodlands is well developed, sometimes quite closed, consisting of deciduous trees. Important codominant tree species are: *Pterocarpus angolensis*, *Julbernardia globiflora*, *Acacia macrothyrsa*, *Xeroderris stuhlmannii*, *Albizia versicolor*, *Dalbergia melanoxylon*, *Brachystegia bussei*, *Erythrina abyssinica*, *Sterculia quinqueloba*, *S. africana*, *Canthium huillense*, *Cussonia kirkii*, *Combretum ghasalense*, *C. collinum*, *C. zeyheri*, *C. apiculatum*, etc. The trees are very variable in size, often crooked. Bush fires highly influence this community, too, and often develop it into a landscape with open tree stands or even into a secondary bush.

Under the loose network of treebranches, a very dense herbaceous layer is present in which the commonest species are: *Sporobolus pyramidalis*, *Hyparrhenia rufa*, *Kyllingia crassipes*, *Mariscus sieberianus*, *Acroa lanata*, *Cassia grantii*, *Indigofera garckeana*, *Cassia polytricha* var. *pulchella*, *Biophytum petersianum*, *Urginea altissima* (on rocks), *Silene burchellii*, *Acrocephalus galeopsifolius*, *Gerbera viridiflora*, and *Ophioglossum reticulatum*.

16. *Submontane miombo (Brachystegia-Julbernardia) woodland*

The miombo vegetation is more wide-spread on the northern and western foothills than in the central part of the Ulugurus. The most beautiful miombos are found near the summits of the Mindu and Nguru ya Ndege Hills, where, due to the mist effect, the trees are wrapped up in a rich epiphytic vegetation.

The more or less closed miombo canopy, even 15-25 m high, is made up of *Brachystegia boehmii*, *B. microphylla*, *B. spiciformis*, *Julbernardia globiflora*, *Syzygium cordatum*, *Albizia harveyi*, *A. versicolor*, *Parinari curatellifolia*, *Uapaca kirkiana*, and *Xeroderris stuhlmannii*. On the SE ridge of the Nguru ya Ndege Hill a

miombolike community exists which is formed by an almost pure stand of *Monotes elegans* (*Dipterocarpaceae*).

In the miombo nearly no shrub layer is developed. The herbaceous layer is rich, composed of amongst others *Bulbostylis pilosa*, *Tristachya nodiglumis*, *Scleria bulbifera*, *Eragrostis aspera*, *Indigofera ambelacensis*, *Polygala albida*, and *P. petitiiana*. In burnt places *Bidens schimperi* may be very common. Rare plants in the miombos of the Ulugurus are: *Disperis kilimanjarica*, *Biophytum turianiense* and *Schizaea dichotoma*.

A most peculiar phenomenon is observed on the summits of isolated hills west and north of Morogoro (Mindu and Nguru ya Ndege): at an altitude of 1200-1300 m, where, even during the dry season, cloud formation is common, a very rich epiphytic vegetation develops on the miombo trees or even on solitary *Acacia* specimens, consisting of orchids, ferns, and other phanerogams and cryptogams. Even epiphyllous liverworts live on *Parinari curatellifolia* leaves in seemingly dry miombo vegetation. More than 20 epiphytic vascular plant species were observed here, among them 2 hanging *Lycopodium* and 12 fern species. Most interesting are the orchid balls formed by *Polystachya* cf. *isochiloides*. Sometimes more than 40 balls of 30-50 cm diameter occur on one and the same tree, representing a remarkable biomass and humus accumulation. Although this epiphytic vegetation has a very special character, it is related to the epiphytic vegetation of the submontane rain forest (e.g. the presence of *Belvisia spicata*, *Peperomia tetraphylla*, *Rhipsalis cassytha*, *Drynaria laurentii*, *Oberonia disticha*, etc.).

17. Montane *Protea-Agauria* woodland

At the altitude of 1000-1500 m the steepest mountain ridges bear a rich woodland community of *Protea gaguedii*, *Agauria salicifolia*, and *Erythrina abyssinica*. In the herbaceous layer, *Helichrysum kirkii*, *Clematopsis scabiosifolia*, *Lefeburia longepedicellata*, *Desmodium barbatum*, *Crotalaria hissopifolia* and *C. laburnifolia* are typical. This woodland community found in dry rocky places, penetrate even into the forest belt. This vegetation type is described from the neighbouring mountains by Burt (1942) under the name of "*Protea-Dombeya* highland grassland".

18. Montane secondary grassland

On drawing the map it was impossible to define precisely, whether the existing grasslands were derivatives of woodland or forest vegetation. In most cases, anyhow, these grasslands originate from woodland on sloping ground, the natural border of the woodland and forest belts being intensively cultivated. The typification of the Uluguru grasslands needs a further study. The difficulties arise from the fact that shifting cultivation is very common in the Ulugurus, and many places in the dense agricultural zone are kept for several years as "grasslands". On the map, those areas are indicated as "secondary grassland", more or less free from cultivation being either too steep or stony, or situated far from settlements.

Dominant grasses and herbs in different grassland types are: *Hyparrhenia rufa* (in the place of former *Pterocarpus-Combretum* woodland), *H. diplandra*, *Brachiaria brizantha*, *Beckeropsis unisetata*, *Arthraxon quartinianus*, *Cleistachne sorghoides* (wet places in valley bottoms). *Polygala macrostigma* and *Habenaria splendens* are the most beautiful plants of these grasslands. *Setaria pallidifusca*,

S. homonyma and *S. orthostycha* are common in the place of former submontane rain forest on valley slopes near the actual forest edge.

19. *Permanent swamps and lakes*

In the Ngerengere and Mgeta River valleys there are permanent swamps. Where the water level was not so high, these swamps as well as all former valley grasslands, were turned into rice fields (paddy) or into sugar-cane cultures. In the more waterlogged places, these swamps remained more or less intact, with among others *Phragmites mauritianus* associated with *Ph. vulgaris* and *Cyclosorus interruptus* or sedges (*Cyperus exaltatus* and *C. sphacelatus*) as the dominating species.

20. *Cultivated forests*

Cultivated forests are mainly found in the Morogoro and Bunduki areas. In the savanna woodland belt along streamlets and in valley bottoms, *Tectona* and *Khaya nyasica* are cultivated. On slopes in the woodland belt, *Eucalyptus*, *Cupressus lusitanica* (near forest edges), *Acacia mearnsii* and *Cassia* spp. are grown, while in the forest belt, especially around Bunduki, *Cryptomeria japonica*, *Pinus patula* and *Grevillea robusta* develop successfully.

21. *Cultivated land replacing lowland rain forests (1, 2 above)*

The main crops are: swamp rice (paddy), cocoyam and tania, robusta coffee, coconut, and *Citrus* fruits. The abandoned but formerly intensive culture of kapok (*Ceiba pentandra*) is notable.

22. *Cultivated land replacing submontane forests (5, 6 above)*

The main crops are: upland rice, cassava, maize, sweet potato, arabica coffee, cocoyam, coconut, pineapple, and *Citrus* fruits.

23. *Cultivated land replacing montane forests (7, 8 above & Fig. 7)*

The main crops are: maize, beans, vegetables, arabica coffee, banana, apple, plum, guava.

24. *Cultivated land replacing savanna woodland on sandy soils (14 above)*

The main crops are: cassava, maize, ground-nut, sorghum, pawpaw, banana, sisal.

25. *Cultivated land replacing submontane woodlands (15, 16 above)*

The main crops are: cassava, maize, sorghum, pawpaw, banana, mango, sweet potato.

26. *Cultivated land replacing valley grassland and swamps (19 above)*

The main crops are: swamp rice, sugar-cane, sweet potato.

27. Rock-vegetation in different vegetation belts

As the areas covered with rock-vegetation mostly have a vertical direction, they usually take up very little space on a vegetation map. As this is the case here, it was impossible to distinguish the variable types on this map. According to altitude and surrounding vegetation, at least the following 4 main groups can be distinguished.

a. Vegetation on marble rocks in the lowland rain forest belt at about 300 m

On the more open rock walls a community occurs dominated by fleshy herbs, such as *Zamioculcas* sp. and *Cyanotis cuneata*. Scattered small trees are: *Erythrina sacleuxii* and *Obetia pinnatifida*, *Pandanus* cf. *engleri* and columnarlike *Euphorbia* species form a more closed bush layer on the top of the rocks.

b. Vegetation on graniolite rocks in the submontane belt between 600 and 1500 m

On open rock surfaces in the woodland belt, the vegetation is very variable. In the crevices of dry rock walls below 800 m *Actinopteris radiata* usually forms a community together with *A. dimorpha* and *Pellaea involuta*. On half-shady rock walls the endemic *Coleachloa microcephala* is common below 1500 m. In rock crevices, above 800 m, a very interesting succulent community exists formed by the endemic *Aloë morogoroensis*, *Streptocarpus saxorum*, *S. caulescens*, *Mohria caffrorum*, *Cheilanthes multifida*, *Polystachya dendrobiiflora*, and *Cynorkis uncata*. At the same altitude but on flat, dry rock surfaces an *Aloë* species together with *Aeolanthus repens*, *Pentas longituba* var. *magnifica*, *Rhoicissus tridentatus*, and *Microcoelia exilis* have been observed.

c. Vegetation on shady graniolite rocks in the montane forest belt between 1500 and 2500 m

The most beautiful rock-vegetation is found on very shady, mossy rock walls between 1500 and 2000 m: *Saintpaulia goetzeana*, *S. inconspicua*, *S. pusilla*, and *Elaphoglossum phanerophlebium*. Between 1900 and 2400 m *Streptocarpus hirsutissimus*, *S. bullatus*, *Linnaeopsis alba*, and *Pityrogramma rupicola* form an interesting sciophyte community. On the rocks of stream beds and in spray-affected places, there is an *Elaphoglossum spathulatum* community.

d. Vegetation on open rock surfaces in the subalpine belt between 2200 and 2600 m

Exposed rocks near and above the forest line bear (see also Fig. 7) a vegetation formed by *Allochaete* sp., *Carex castanostachya*, *Streptocarpus hirsutissimus*, *Lobelia unamata*, *Aristea alata* subsp. *abyssinica*, *Cliffortia nitidula*, *Phyllicia emirnensis*, *Blaeria breviflora* and *B. kiwuensis*, *Impatiens sodenii*; in shady crevices: *Gleichenia polypodioides*.

28. *Xerophyta scabrida* (Velloziaceae) bush

Below 1000 m, in very dry, exposed rocky places, there is a peculiar xerophytic bush of half a meter's height, formed by the shrubby monocotyledon *Xerophyta scabrida*. This open bush dries up completely during the dry season, but becomes vivid green during the rains. The species are highly adapted to very dry conditions.

Below the shrubs there is usually a dense mat formed by the poikilohydric *Selaginella dregei*, often accompanied by *S. mittenii*, too. In the herbaceous layer either poikilohydric ferns (*Actinopteris dimorpha*, *Pellaea schweinfurthii*, *P. adiantoides*) or geophytes (*Ophioglossum costatum*, *O. gomezianum*, *O. lancifolium*), or therophytes are present (*Borreria arvensis*, *Oldenlandia herbacea*, *Heliotropium strigosum*). The fibrous and persistent leaf sheaths of *Xerophyta* absorb some humidity even during the driest periods and give home for epiphytes. Along with mosses and lichens, even epiphytic orchids e.g. *Polystachya tayloriana* can survive there. A similar pioneer community colonizing bare rock faces is described by Jackson (1956) from the Imatong Mountains on the Sudan-Uganda border.

[The following numbers refer to the map presented here as Fig. 7.]

31. Subalpine grassland of the Lukwangule Plateau

Between 2300 and 2664 m, the Lukwangule Plateau in the Southern Ulugurus is dominated by a grassland with scattered trees and shrubs: e.g. *Agauria*, *Myrica salicifolia*, *Adenocarpus mannii* and *Berberis holstii*. The codominants in the grass stratum are: *Panicum lukwangulense*, *Andropogon amethystinus*, *Agrostis kilimandscharica* and *Pteridium aquilinum*. Other common species are: *Geranium vagans*, *Helichrysum cymosum* subsp. *fruticosum*, *H. abietinum*, *Senecio cyaneus*, *Lobelia holstii*, and *Blaeria johannis*. This grassland forms a mosaic vegetation with elfin forest and moorland, the latter occupying the valley bottoms. There is no doubt that the grassland in its present form and extent is secondary, the result of fires caused by man walking over the plateau from one village to another. In 1969 I have seen freshly burnt areas, where *Pteridium aquilinum*, a *Hypoxis* species and *Bulbostylis atosanguinea* were very common. On the other hand, the elfin forest definitely reaches its uppermost limit in some places and the presence of some afroalpine species in the grassland (e.g. *Agrostis kilimandscharica*) and the tree fern *Blechnum tabulare* in the southern part of the plateau points to the fact, that a subalpine grassland exists here although to a small extent.

32. Spring bogs

Near the springs and along the streamlets of the Lukwangule Plateau at 2300-2500 m above sea level, a spring bog community occurs which is rich in afroalpine elements. These spring bogs, together with the moorland discussed below (no. 33), are with certainty primary communities. They represent always treeless, subalpine vegetation types. The most characteristic elements of spring bogs in the Southern Ulugurus are *Alchemilla johnstonii* and *Ranunculus oreophytus*. They are often accompanied by *Cardamine obliqua*, *Anagallis angustiloba*, *Viola abyssinica*, *Andropogon amethystinum*, *Panicum snowdenii*, *Carex greenwayi*, *Scirpus setaceus* and *Hydrocotyle sibthorpioides*. Interesting elements are *Peucedanum winkleri* and *Disa stairsii*.

33. Subalpine moorland in the valleys of the Lukwangule Plateau

The valley bottoms are occupied by a very homogeneous moorland community, dominated by *Pycreus nigricans*. *Cynorkis buchwaldiana* subsp. *nyassana* is an interesting element here.

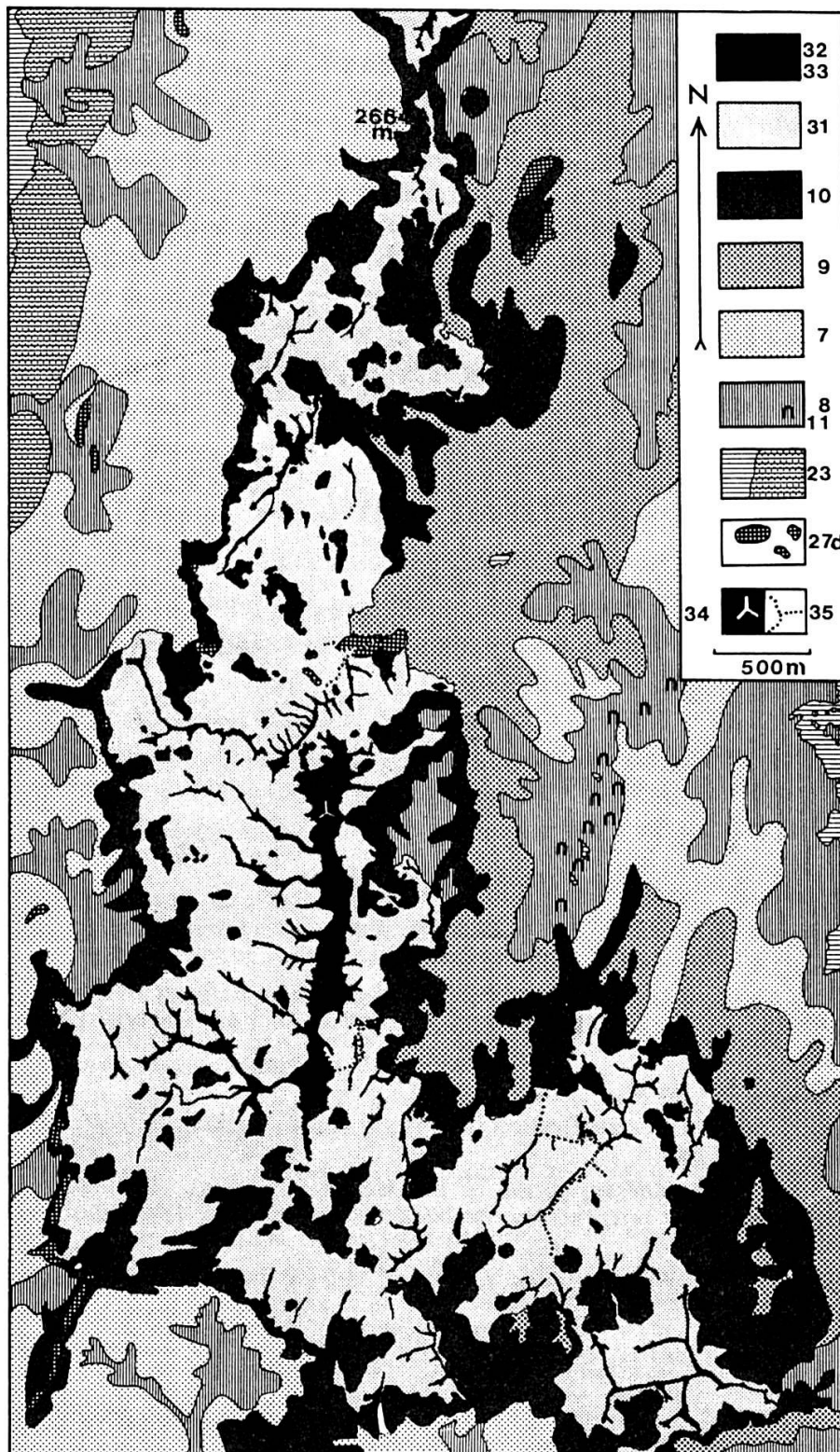


Fig. 7. – Vegetation map (40 km²) of the Lukwangule Plateau in the Southern Uluguru Mts. The different vegetation units (31-35) are described in the text (page 494). The other numbers are identical with those of the large Map (described on pp. 478-494).

34. *Sphagnum* bog on the Lukwangule Plateau

Such a bog occurs only in one place, namely where the pathway crosses the plateau near the watershed between the two branches of the Mgeta Springs at 2400 m altitude. Among and on the cushions of two *Sphagnum* species the following taxa have been recorded: *Polytrichum commune* and *Breutelia aristaria* (South African); phanerogams such as *Eriocaulon schimperii*, *Xyris capensis*, *Juncus dregeanus*, *Laurembergia mildbraedii*, *Coelachne africana*, *Hypericum scioanum*, *Anagallis angustiloba*, and *Blaeria patula*. Together they form a very peculiar community.

35. *Cliffortia nitidula* (Rosaceae) bush along watercourses

A dense bush formed by *Cliffortia nitidula*, a shrub 0.5-5 m high with ericoid leaves, occurs along the streams and other watercourses of the Lukwangule Plateau.

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APPENDIX

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