

# Vegetation maps of Ethiopia and Eritrea. A review of existing maps and the need for a new map for the Flora of Ethiopia and Eritrea

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The main features of the existing vegetation maps of Ethiopia and Eritrea, especially those of R.E.G. Pichi-Sermolli from 1957, F. von Breitenbach from 1963 and F. White from 1983, are reviewed. The mapping units on these maps are compared in the light of modern classification of the characteristic species. Later modifications, especially those of I. Friis from 1992 and those of Sebsebe Demissew and others from 1996, are also reviewed. The majority of the long-known vegetation types in the central part of the region have been described, classified and interpreted rather differently by the different authors, and the maps they have produced are therefore at some points notably different. Human activity, especially agriculture for hundreds or thousands of years has had a major impact on the natural vegetation, especially in the highlands, and different authors interpret these secondary vegetation types differently. This is probably one of the main reasons for the discrepancies between the maps. Another reason is that a number of characteristic vegetation types in remote areas, for example the vegetation of the Bale Mountains and various forests in the southwestern part of Ethiopia, have been explored and described in the international literature after printing of the maps of Pichi-Sermolli and Breitenbach. Something was known about these vegetation types while White produced his map, but our knowledge has been completed since. A debate at the 3<sup>rd</sup> International Symposium on the Flora of Ethiopia and Eritrea demonstrated the difficulties with the production of a new, informative vegetation map of Ethiopia and Eritrea at a reasonable scale. Such a map has been planned to accompany the general volume of the Flora of Ethiopia and Eritrea. Suitable criteria for mapping units and additional research that might lead to a satisfactory solution were suggested at the symposium and are discussed further here.

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## Introduction

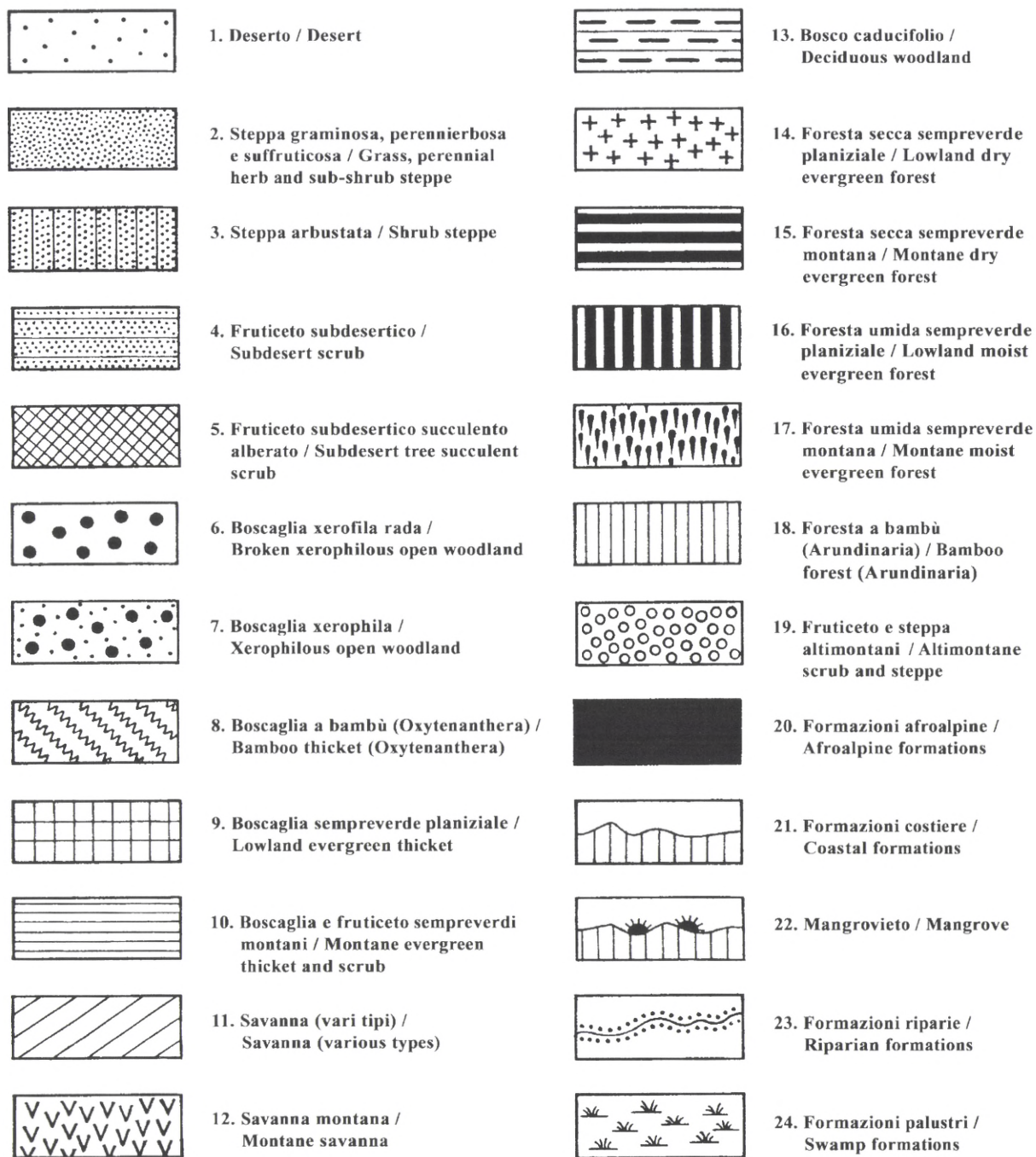
This is a review paper of the representation of the vegetation of Ethiopia and Eritrea on a map in one sheet covering the two countries. Such a

representation will normally require a base map of a scale between *c.*1:2,000,000 and *c.*1:8,000,000, where the mapping of individual patches of forests, swamps, thickets, *etc.* is not

Redolfo E. G. Pichi-Sermelli del.

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← Fig. 1. R.E.G. Pichi-Sermolli's vegetation map of Eritrea, Ethiopia and Somalia (Pichi-Sermolli). For detailed legend, see text. Published as appendix to *Webbia* 13 (1957). Reproduced with permission from *Webbia* and R.E.G. Pichi-Sermolli.

possible, but has to be replaced by mapping the predominant vegetation. This involves an element of generalisation of the directly observed vegetation types, and the concepts behind this generalisation become important. For this reason, the present paper will review the mapping units of the existing vegetation maps of that range of scales in detail. Several of the publications, where the descriptions of the mapping units and the maps themselves are printed, are not readily available, and some of the botanical nomenclature used in the description of the mapping units is now outdated. It has therefore been considered useful to provide a fairly detailed summary of the previously used mapping units, and to present a modernised nomenclature for the plant species mentioned. The review is also intended to bring together comments and opinions on vegetation mapping of Ethiopia and Eritrea of the botanists at the Symposium who had knowledge of the vegetation and flora of Ethiopia and Eritrea, and it is attempted to draw some conclusions.

In the paper, the total area of the two countries is referred to as the *Flora of Ethiopia and Eritrea* area, abbreviated the FEE area. We have tried to standardise and modernise the geographical terms. However, we have consistently used the names of old administrative regions (Shewa, Kefa, Bale, *etc.*) as these units are used for floristic entities in the *Flora of Ethiopia and Eritrea*. For the later representations of the vegetation in the western lowlands, some of the new administrative regions (Benshangul-Gumuz, Gambella) have been used, as they agree better with the areas with lowland vegetation than the traditional administrative units. The entire highland area is referred to as the Ethiopian Highlands. The plateau west of the Rift Valley is referred to as the Western Plateau, and the one east of the Rift as the Eastern Plateau. We have usually only presented our condensed version of the descriptions of the vegetation units as they were described by the

original authors, but in a few cases we have added some comments of our own in sharp brackets.

The history of early vegetation mapping of Eritrea and Ethiopia has been outlined by Pichi-Sermolli (1957: 21-23). The earliest vegetation map of the study area was that of Schweinfurth (1868) in 1:10,000,000. However, this map is mainly of interest for Eritrea and the Sudan border-region, where Schweinfurth had travelled. The rest of the map is not based on original observation. Dove (1890) was the first to emphasise the altitudinal zonation of the Ethiopian vegetation, based on the classical Ethiopian distinction between the agro-ecological zones, in Dove's work referred to as "Quolla," "Woina-Dega" and "Dega." The maps from *c.*1890 to *c.*1945 that cover Ethiopia and Eritrea were basically on too small a scale to be of interest in our work. However, Logan (1946) published a detailed map of the forests of Ethiopia, which was based on rather limited ground survey, in *c.*1:5,000,000. The development that is of interest to us in the context of this paper begins with the map published by Pichi-Sermolli in 1957.

### Pichi-Sermolli's physiognomic and floristic classification and vegetation map (1957)

Pichi-Sermolli made his first approach to a vegetation map of Ethiopia and Eritrea when he contributed an account and a map of the arid regions of Tropical East Africa, including our area. This descriptive text and the map only cover woodlands and more arid areas, and the map is on a very small scale, appearing as part of a review of arid regions around the world (Pichi-Sermolli 1955). Shortly after, he published a descriptive memoir and a map of all the vegetation types in the entire region and accompanied it with a detailed descriptive memoir. The map, which has a scale of

1:5,000,000, maps a total of 24 different vegetation types. A reproduction of the map and an enlarged legend are shown in Fig. 1. Of the 24 mapping units used by Pichi-Sermolli, only 21 vegetation types occur within the borders of Ethiopia and Eritrea (the types numbered 9, 14 and 16 only occur in Southern Somalia):

(1) *Deserto / Desert*

According to Pichi-Sermolli, there is no area absolutely devoid of vegetation in Ethiopia and Eritrea, but there are large areas where the plant cover is so scarce and degraded that it could be referred to as desert. The plant cover, which occurs in these sites, was not well studied before 1957, but Pichi-Sermolli assumed it to show great floristic similarity with that of the various kinds of steppe. On Pichi-Sermolli's map desert is indicated in the central and southern part of the Afar Depression.

(2) *Steppa graminosa, perennierbosa e suffruticosa / Grass, perennial herb and sub-shrub steppe*

According to Pichi-Sermolli, the steppe is not a homogenous vegetation type throughout the area it occupies in Ethiopia and Eritrea, neither physiognomically nor floristically. It ranges from almost vegetationless types, which can be referred to as subdesert steppe, to types with dense vegetation cover of sub-shrubs. There is no sharp floristic distinction between these two extremes, and they also grade into each other physiognomically. No attempt has been made to map these subtypes. On Pichi-Sermolli's map the vegetation type is indicated in the southern part of the Afar Depression, behind the coastal zone in Eritrea, and in a few places in eastern Ogaden.

(3) *Steppa arbustata / Shrub steppe*

According to Pichi-Sermolli, this is a vegetation that resembles the grass and perennial herb and sub-shrub steppe, but in the shrub stratum

there are shrubs up to 4 m high, which are profusely branched from the base and either globular or obconical. These shrubs may be single or grouped in clusters of 2-4. The dominant shrubs are species of *Acacia*. On Pichi-Sermolli's map this vegetation is indicated in the Eritrean lowland below the subdesert scrub and extending into the Afar Depression to the south, and into Sudan to the north, and in a zone north of the northern escarpment of the Eastern Plateau in Harerge. Another area with this vegetation type extends from Somalia into the Ogaden.

(4) *Fruticeto subdesertico / Subdesert scrub*

According to Pichi-Sermolli, this vegetation consists of dwarf trees less than c.3 m high, shrubs, subshrubs and succulent herbs, all spaced out so that one can pass between them fairly easily. Between the woody plants there are tuberous or bulbous herbs and numerous annuals during the rains. Perennial grasses are absent. The shrubs are species of *Acacia*, *Commiphora*, *Jatropha*, *Capparaceae*, etc. On Pichi-Sermolli's map this vegetation type occurs in the Afar Depression in areas surrounding the desert vegetation, and it continues northwards in the lowlands, around the areas of higher ground to Western Eritrea and into the Sudan. In the south, this vegetation is indicated near the southern border of Ethiopia to the east of Dolo-Odo and east of Lake Turkana.

(5) *Fruticeto subdesertico succulento alberato / Subdesert tree succulent scrub*

According to Pichi-Sermolli, this is a scrub of rather scattered shrubs and subshrubs with a sparse upper layer of trees. The shrubs are 1-2 m high, and both the shrubs and subshrubs are usually solitary or in small groups. Many species of both shrubs and subshrubs have succulent features. The trees are up to 6 or 7 m high and usually deciduous, with leaves clustered at the end of the branches or with succu-

lent leaves scattered along the stems, or are cactiform or with dilated trunks. The vegetation incompletely covers the soil, and it mainly occurs on rocky ground and on slopes. Succulent species of the genus *Euphorbia* are well represented. Pichi-Sermolli's map indicates that this vegetation type occurs mostly at the base of the eastern escarpment of the Western Plateau and the northern escarpment of the Eastern Plateau in Harerge. It is also indicated to occur on the mountains in the Afar Depression near the border with Eritrea.

(6) *Boscaglia xerofila rada* / Broken xerophilous open woodland

According to Pichi-Sermolli, the Broken xerophilous open woodland (6) and the Xerophilous open woodland (7) are very closely associated vegetation types. The differences are in the density of the canopy and in the floristic composition, rather than in the general physiognomy. Pichi-Sermolli defines xerophilous open woodland as an open vegetation with woody plants and hemicryptophytes, in which the large shrubs and the perennial grasses are dominant, and in which there are scattered trees of the taxonomic groups which are characteristic of this vegetation type. The large shrubs are 3-5 m high and branched from the base, and they are so widely spaced that it is usually possible to pass between them. The herbaceous stratum is discontinuous, leaving some of the soil bare to be covered by annuals during the rains. The tree stratum is open. The density of the shrub layer is very dependent on the grazing pressure from the herds of the nomadic people in the areas where this vegetation occurs. Among the trees and shrubs, species of *Acacia*, *Commiphora* and *Capparaceae* dominate. On Pichi-Sermolli's map this vegetation type is very widespread in the Ogaden and in less arid parts of the Afar Depression.

(7) *Boscaglia xerophila* / Xerophilous open woodland

According to Pichi-Sermolli, this vegetation type differs from the previous one by the higher density in the tree stratum and in the floristic composition. On Pichi-Sermolli's map this vegetation type occurs on the western slopes of the Eritrean highlands, in the southern part of the Afar Depression and in a zone round the highlands of Harerge and Bale south to Dolo-Odo and across to the northern tip of Lake Turkana. [It seems from this that there are also floristic differences within this vegetation type, as the Sahel vegetation in western Eritrea is somewhat different from the zone round the highlands of Harerge and Bale south to Dolo-Odo and across to the northern tip of Lake Turkana.]

(8) *Boscaglia a bambù (Oxytenanthera)* / Bamboo thicket (*Oxytenanthera*)

According to Pichi-Sermolli, this vegetation type consists predominantly of the lowland bamboo *Oxytenanthera abyssinica*, the culms of which reaches a height of 10-12 m. It forms almost pure stands with rather few other species as infrequent components. On Pichi-Sermolli's map it forms extensive stands in mosaic with the deciduous woodland. This mosaic forms a zone along the western escarpment of the western highlands from Eritrea to Kefa.

(9) *Boscaglia sempreverde planiziale*

This vegetation type occurs only in Somalia.

(10) *Boscaglia e fruticeto sempreverdi montani* / Montane evergreen thicket and scrub

According to Pichi-Sermolli, there are two vegetation types here, distinguished on physiognomy: scrub and thicket. The evergreen scrub consists of evergreen shrubs, small trees or lianas, but with only few taller trees. Tall, candelabra-shapes species of *Euphorbia* may occur.

The shrub stratum is 2-3 m high and consists of sclerophyllous plants or plants with green, leafless and more or less succulent stems, mixed with some deciduous species. Lianas, often with succulent features, are very common. This vegetation type is characteristic of slopes. The evergreen thicket is dominated by 3-5 m high shrubs, from which numerous trees emerge. The trees do not form a continuous canopy above the shrubs. Perennial herbs and grasses are not dominant except in open spaces. Generally, the scrub develops at lower altitudes and in drier places than the thickets. Pichi-Sermolli cites as common species for example *Acockanthera schimperi*, *Carissa edulis*, species of *Euclea*, *Rhamnus*, *Rhus* and *Maytenus*, etc. He includes vegetation with *Juniperus procera*, shrubby *Olea europaea* subsp. *cuspidata* and *Barbeya oleoides* or *Buxus hildebrandtii* under this vegetation type, as well as the almost pure stands of candelabra-shaped species of *Euphorbia* on slopes and escarpments. On Pichi-Sermolli's map this vegetation has been indicated on large areas of the highlands below c.2000 m. Together, the general vegetation type, including both the scrub and the thicket, is indicated throughout the highlands from the northern part of Eritrea southwards to Sidamo and eastwards into Harerge at altitudes between 900 and 2400 m.

(11) *Savanna (vari tipi) / Savanna (various types)*

According to Pichi-Sermolli, savanna is a physiognomically defined vegetation type consisting of mainly xeromorphic herbaceous plants, among which grasses and species of Cyperaceae are the dominant. These plants form a continuous ground cover at least 80 cm high with scattered trees or shrubs, or with grouped trees and clumps of shrubs. African savanna is frequently subject to burning. Pichi-Sermolli has listed a range of rather different vegetation types, which fall within the limits of this physi-

ognomic definition. From western Eritrea he describes a vegetation type with a grass stratum dominated by species of Andropogoneae, small shrubs and scattered trees of *Balanites aegyptiaca* and/or *Acacia seyal*; the type continues southwards in the western lowlands to the Blue Nile. From areas around Lake Tana he describes savanna dominated by *Acacia abyssinica*, *A. seyal* and *A. bavazzanoi* with a short grass stratum on alluvial soils, and a stratum up to 1.8 m on the hills. From the valleys of the Didessa and the Baro Rivers are recorded another savanna with *Acacia*, *Gardenia*, *Protea* and *Stereospermum*. In the Rift Valley between Shewa and Gamo-Gofa the dominant tree species are *Acacia albida*, *A. seyal*, *Balanites aegyptiaca*, and various grasses, of which only some are of the tribe Andropogoneae. On Pichi-Sermolli's map it is also indicated that this vegetation type occurs in the southern lowlands from west of the Omo River to near Dolo Odo, but very little evidence for this is quoted.

(12) *Savanna montana / Montane savanna*

According to Pichi-Sermolli, this vegetation type can be neatly distinguished from all other types of savanna on its physiognomy, ecology and its floristic composition. It consists of a herbaceous stratum usually not higher than 30-80 cm, very rich in perennial grasses and species of Cyperaceae, but also with sub-shrubs and perennial herbs, among which bulbous and rhizomatous plants occur. The monotony of this grassy sward is broken by scattered shrubs or trees, usually rather small. Sometimes the shrubs form clusters or thickets, in the shelter of which larger herbs may occur. This vegetation covers the extensive gently undulating areas of the highlands. In places where the flat ground meets a steep slope, the change to montane evergreen thicket and scrub is abrupt. It is found at altitudes between 1800 and 3000 m. The vegetation occurs in the areas where human activity has been longest

and most intense, and the vegetation is probably in most places derived from forest and other woody vegetation types. This is indicated by the fact that the essential woody species in this vegetation type are all the same that occur in various kinds of forest. It occurs from northern Eritrea to Gamo-Gofa, and from Arsi to Harerge. A small area at Mega is not marked on the map.

(13) *Bosco caducifolio / Deciduous woodland*

According to Pichi-Sermolli, this vegetation consists of deciduous trees, which are 5-12 m high and form a very open canopy, under which there is a heterogeneous ground cover with small trees, shrubs and perennial herbs and grasses. There is a marked seasonality of the flowering and litter-fall of these trees. This vegetation occurs on the western escarpment of the Western Plateau where it forms a zone from western Eritrea to northwestern Gamo-Gofa, interrupted by areas of Bamboo thicket (*Oxytenanthera*). It is found between c.700 and 1800 m, and it also penetrates into the highlands along the big rivers. Characteristically, the canopy contains species of *Boswellia*, *Anogeissus*, *Terminalia*, *Combretum*, *Lannea*, *Lonchocarpus*, *Stereospermum*, *Commiphora*, *Erythrina*, *Dalbergia*, *Gardenia*, *Dombeya*, *Balanites*, *Pilostigma*, etc.

(14) *Foresta secca sempreverde planiziale*

As defined by Pichi-Sermolli, this vegetation type occurs only in Somalia.

(15) *Foresta secca sempreverde montana / Montane dry evergreen forest*

According to Pichi-Sermolli, this vegetation has a canopy in several stories. The tallest storey is very open and irregular, below which there is a more closed stratum of trees and large shrubs, and on the forest floor a stratum of shrubs and herbs. Lianas and epiphytes are frequent. This vegetation type develops at

rather high humidity, but the rainfall is less than that which supports the following type, and a clearly marked dry season exists. Coniferous species (*Juniperus procera* and *Podocarpus falcatus*) dominate most examples of this forest type. A type dominated by *Podocarpus* occurs on both the Western and the Eastern Plateau in association with broad-leaved species. *Juniperus procera*-dominated forest occurs in the driest places. Mixed *Juniperus-Podocarpus* forest is found in the central part of the highlands, particularly Shewa, Harerge and Sidamo. However, other forest types are included here. For example the *Mimusops kummel*-forest around and west of Lake Tana. Finally, Pichi-Sermolli includes here a type called *Acacia abyssinica*-forest, which is found from Lake Tana to Sidamo.

(16) *Foresta umida sempreverde planiziale*

As defined by Pichi-Sermolli, this vegetation type occurs only in Somalia.

(17) *Foresta umida sempreverde montana / Montane moist evergreen forest*

According to Pichi-Sermolli, this vegetation has a canopy in several stories, and consists typically of a fairly compact canopy stratum at 18-25 m, above which 30-50 m tall trees reach. Below there is a stratum of shrubs or small trees up to c.8 m high and a forest floor stratum of herbs or small shrubs. Epiphytes and lianas are common. The stratum of tall trees includes species of *Pouteria* (*Aningeria*), *Morus*, *Olea*, *Trilepisium* (*Bosqueia*), etc. Tree ferns (*Cyathea* sp.), *Ensete ventricosum*, species of *Dracaena* and large, candelabra-shaped species of *Euphorbia* occur in these forests. There are, according to Pichi-Sermolli, at least two or three different associations in this formation, but he felt unable to distinguish between them before further research had been carried out. According to Pichi-Sermolli these forests occur between 1300 and 2300 m in Welega, Ilubabor, Kefa and Sidamo. The extensive forests, the



Hareenna Forest, on the southern slope of the Bale Mountains, were then completely unrecorded in the literature.

(18) *Foresta a bambù (Arundinaria) / Bamboo forest (Arundinaria)*

According to Pichi-Sermolli this is an almost pure vegetation type, dominated by dense stands of the mountain bamboo (*Arundinaria alpina*), associated with a limited number of trees, shrubs and herbs. Pichi-Sermolli has recorded this formation in the southwestern part of Ethiopia between 2300 and 3200 m in very humid areas of Welega, Ilubabor and Kefa.

(19) *Fruticeto e steppa altimontani / Altimontane scrub and steppe*

These formations are, according to Pichi-Sermolli the scrub and steppe vegetation of the highest part of the mountains. They are found at altitudes between 3000 and 3700 m in restricted areas below the Afroalpine formations described as the subsequent number. The formations can develop into two rather different types of vegetation, but many intermediate forms occur. One of the types is the high-mountain scrub, with patches of 3 to 6 m high thickets with *Erica arborea* as the dominant species. The *Erica* shrubs may be associated with *Hypericum*, *Rosa*, *Rapanea*, *Myrica*, *Myrsine*, etc. The other type is the high-mountain steppe, which is much less distributed than the previous type, and may according to Pichi-Sermolli represent degraded high-mountain scrub. Pichi-Sermolli records these formations from the Semien, a number of mountains east of Lake Tana, including Lasta (Mt. Abuna Yosef), the areas around Mt. Guna, etc, mountains in Gojam (Choké Mountains.), mountains west of Addis Ababa, the Chillalo and Galama Mountains in Arsi, the Amaro Mountains in Sidamo, and the Gughe Highlands in Gamo-Gofa. It should be noted that in Pichi-

Sermolli's account there is no record of the extensive areas of this vegetation in Ethiopia found on the Bale Mountains. This extended area only became known in the international literature at a later point.

(20) *Formazioni afroalpine / Afroalpine formations*

Pichi-Sermolli has, because of the rather limited extent of the highest mountain peaks when shown on a map in 1:5,000,000, gathered a number of high altitude vegetation types under this heading, including at 4000-4350 m high-mountain steppe with *Lobelia rhynchopetalum*, dominated by grasses and low *Erica arborea* on rock-formations. At higher altitudes the steppe passes very gradually into various rocky communities with species of *Helichrysum*, grasses, etc., and in damp places massive communities with species of *Carex*, chiefly *Carex monostachya*. According to Pichi-Sermolli, Afroalpine formations are found above approximately 4000 m. On his map, it is indicated the Semien Mountains, in various high mountain massifs east of Lake Tana (Lasta, Guna, etc.), in the Choké Mountains of Gojam, in a few, small mountain massifs west of Addis Ababa, in the Chillalo and Galamo Mountains in Arsi, and in the Gughe Highlands in Gamo-Gofa. However, Pichi-Sermolli points out that associations with characteristic Afroalpine plants can also be found at lower altitudes. It should be noted that in Pichi-Sermolli's account there is no record of the most extensive Afroalpine vegetation in Ethiopia, that on the Sannetti Plateau in the Bale Mountains. This extended area of Afroalpine vegetation only became known in the international literature at a later point.

(21) *Formazioni costiere / Coastal formations*

Pichi-Sermolli gives a detailed account of the coastal formations, but much of his description relates to areas in Djibouti and Somalia. Here, we will only deal with the formations inside the

FEE area. The rocks and the derived soil types at sea level are coralline in origin. The coast is rocky or sandy, often with low scrub rich in Capparaceae, Zygophyllaceae, Chenopodiaceae, Plumbaginaceae, Salvadoraceae, *etc.*, and many grasses. In some places dwarf shrubs may form extensive areas. Salt pans have often specialised grasses. Mangrove vegetation is described separately below.

(22) *Mangrovieta / Mangrove*

Pichi-Sermolli has recorded this formation from a number of localities along the Red Sea coast of the FEE area, where it has the aspect of a daily partly submerged scrub or thicket up to c.6 m high. The dominant species woody species is *Avicennia marina*, in places supplemented with *Rhizophora mucronata*.

(23) *Formazioni riparie / Riparian formations*

Pichi-Sermolli has gathered under this heading a number of formations, which occur along temporary or permanent water courses, as well as on lake shores. Along temporary streams (wadis), there are usually riparian woodlands with species of *Acacia*, *Ficus*, *Hyphaene*, *etc.* Particularly *Hyphaene* is characteristic of lowland riparian vegetation both on the western and eastern side of the Ethiopian highlands. At more permanent streams species of *Tamarix*, *Tamarindus indica*, *Diospyros mespiliformis*, *Syzygium guineense* and a number of evergreen scrubs or climbers are common. In higher rainfall areas there may be more species trees in the riverine forest, for example *Mimusops kummel* and *Phoenix reclinata*. The examples of lake shore vegetation described by Pichi-Sermolli are very varied, they include riparian forests of, for example, *Aeschynomene elaphroxylon* or *Mimusops kummel*, riparian scrub of species of *Sesbania*, reed swamps with species of *Phragmites*, *Typha* and *Cyperus papyrus*, *etc.*

(24) *Formazioni palustri / Swamp formations*

Pichi-Sermolli pointed out that swamp forests hardly occur in the area he described and that there might be great floristic similarity between types of lake shore vegetation and swamp formations. Swamps dominated by grasses and species of Cyperaceae and *Typha* cover extensive areas. Halophile swamps have many species of Chenopodiaceae, especially *Salsola* and *Salicornia*.

### Characteristic features of Pichi-Sermolli's map

The most notable feature of Pichi-Sermolli's classification is the classification of the open vegetation in the lowlands and the vegetation on the plateaux. Large areas of the lowlands surrounding the Ethiopian Highlands are classified as (6) *Broken xerophilous open woodland* and (7) *Xerophilous open woodland* (the *Lowland Steppes* of Breitenbach) or (11) *Savanna (various types)*. The Afar Depression and parts of the western lowlands of Eritrea are characterised by desert (1), various steppes (3-4) and deciduous scrub (4-5). According to Pichi-Sermolli the predominant vegetation types on both the Western and the Eastern Plateau are (12) *Montane savanna* at the higher altitudes (the *Mountain Savannas* of Breitenbach) or (10) *Montane evergreen thicket and scrub* at the lower altitudes (the *Lowland woodland* of Breitenbach).

Pichi-Sermolli's map formed the basis of the representation of the vegetation of Eritrea, Ethiopia, Djibouti and Somalia on the AETFAT vegetation map of Africa in 1:10,000,000 (Keay 1959). The distribution and classification of the woodlands, wooded grasslands, savanna, bushland, semi-desert bushland, grassland and semi-desert grassland according to Pichi-Sermolli do not agree with modern views. This is particularly the case with his vegetation type no. 11, which is now split into a number of unrelated types of Sudanian woodland and

Somalia-Masai *Acacia-Commiphora* deciduous woodland, bushland or scrub. Specifically, it is our impression that it is incorrect to indicate (7) *Xerophilous open woodland* for the western lowlands of the Gambella and Benshangul-Gumuz Region.

In the highlands, it is an oversimplification to indicate that (12) *Montane savanna* is the dominant vegetation in the northern part of the Western Plateau and in the central part of the Eastern Plateau, and that (10) *Montane evergreen thicket and scrub* is dominant in the southern part of the Western Plateau and the peripheral parts of the Eastern Plateau. It is also an oversimplification to say that there is a sharp distinction between (10) *Montane evergreen thicket and scrub* and (12) *Montane savanna*. These two vegetation types have considerable overlap, and were merged for mapping purpose by White (1983). However, there is no doubt that the mapping of the plateau-vegetation is a very complicated problem even today.

### Breitenbach's physiognomic and floristic classification and vegetation map (1963)

Breitenbach's classification of the vegetation types of Ethiopia (then including Eritrea) and vegetation map appeared in the introduction to his mimeographed book *The indigenous trees of Ethiopia* (Breitenbach 1963). The main difference to the classification used by Pichi-Sermolli is a much more detailed and rigid classification of the vegetation based on physiognomy and seen in relation to altitude, humidity and presumed stage in succession. A generalised diagram of altitude and humidity was included in order to position the vegetation types in relation to these factors. The diagram is reproduced here as Fig. 2. Breitenbach has described the problem of fitting the vegetation of a site into a large-scale classification as

identifying its "vegetational character, *i.e.* the developmental or devastational stage as well as the successional trend ..." The philosophy behind the classification is described as follows (Breitenbach 1963: 16-17):

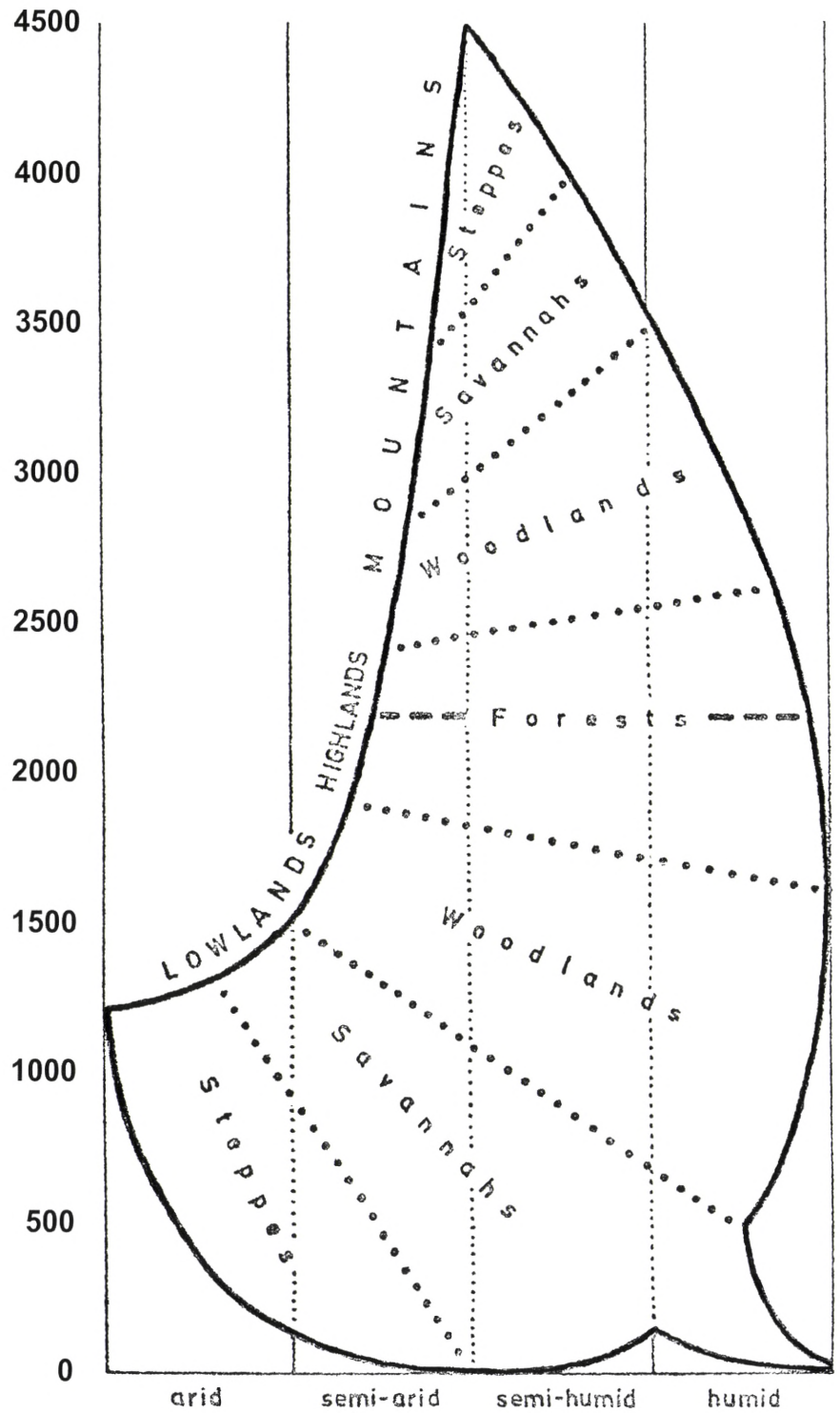
"This vegetational character as expressed by a certain plant community, however, cannot be properly recognised by simple reference to the climax-scheme, for the theory that can be represented in such a simplified and static graph would necessarily become a fiction if applied to the dynamic system of succession.

The true climatic climaxes are very rare, especially in arid and semi-arid zones where the moving forces of succession are weak and the final development-stage held back by degenerative forces, such as fires, grazing, or the various activities of man, so that plant communities of great permanence are perpetuated at subfinal levels, the so-called subclimaxes. In the regions of the nomads and on shifting-cultivation areas, as well as in forests subject to low-grade operations, succession is kept in pro- and retrogressive fluctuation. There are also completely undisturbed sites where the vegetation has not yet reached the climatic climax, due to the immaturity of the soil. On many extreme localities, where continued soil erosion, resistant rock, hyperalkalinity, high water-table, or other negative influences act as permanent natural barriers, succession stopped at an initial or intermediate stage, the so-called physiographic or edaphic climax. Over and above, the mountainous orography of the greater part of Ethiopia exercises additional modifying influences on the arrangement of the plant communities, that are most confusing in the zones of climatic inversion as found in draughty ravines and shady valleys, at exposed escarpments, and in humidity- and cold-depressions.

It is impossible to set up a fully satisfying and reliable detail-scheme of all those mosaic-like intermingling – initial, intermediate, transitory and permanent – vegetation forms and types. The recognition of the vegetational character of a particular site requires a thorough analysis of its static and dynamic elements as indicated by the respective, individual plant community, provided that at least its dominant members and their ecological and sociological range are known.

For the purpose of a general introduction, however, a more summarising method may be useful, as employed in the geobotanical map [discussed later] and surface-cover quotation ... [quoted later], as well as in the following description of the major plant communities of Ethiopia [described in detail later]."

Fig. 2. Diagram of relation between altitude and humidity in the vegetation of Ethiopia and Eritrea, according to Breitenbach (1963). Reproduced with permission from J. von Breitenbach.



Breitenbach's book is now rather rare, and we have therefore decided to describe his highly complex and hierarchically arranged system of vegetation types in some detail in order to make it available for future discussion. We do not think that the strong emphasis on physiognomy and seral stages and climax vegetation in the classification are workable features in connection with vegetation mapping on the scale of 1:5,000,000 to 1:10,000,000, especially not where the topography is as complicated as is the case with Ethiopia and Eritrea. Yet, Breitenbach's classification reflects some very useful observations of characteristic features of Ethiopian and Eritrean vegetation, and it is well worth keeping in mind in the future.

Since many of the species mentioned in Breitenbach's text have now been re-identified, our description of the system will also to some extent be a modern interpretation of Breitenbach's work. Where unambiguous, we have simply replaced Breitenbach's plant names with the ones used in the *Flora of Ethiopia and Eritrea* or other modern sources. Two of his vegetation types have unfortunately names that are outdated for this reason, the *Faidherbia-Thicket* (1.334) because *Faidherbia albida* is now *Acacia albida*, and the *Aningeria-Forest* (2.233) because *Aningeria adolfi-friedericii* is now *Pouteria adolfi-friedericii*; in this account we have chosen not to change the names for these vegetation types.

The four levels in the hierarchy are outlined here in such a way that the typography and indentation indicates the hierarchy, and all generalised statements in the following review are, unless the contrary is clearly indicated, based on the chapter on vegetation in Breitenbach (1963). The lowermost level in the hierarchy is a classification based on altitude (lowlands, highlands, and mountains). The second level represents a sequence of presumed seral stages leading to a climax type (usually steppe, savannah, woodland, and forest). The third

level indicates a moisture gradient (arid, semi-arid, semi-humid, and humid). The fourth level is related to the amount of woody species in the vegetation.

#### (1) LOWLANDS

According to Breitenbach, the lowland vegetation includes only steppes (including semi-desert), savannahs, scrub and woodlands.

##### (1.1) Lowland-Steppes.

According to Breitenbach, these have an irregular or broken ground cover and scattered shrubs or small trees.

##### (1.11) Arid Lowland-Steppe.

According to Breitenbach, this vegetation occurs up to 1300 m on a wide range of soil types, including very degraded skeletal soils; it has sometimes a mosaic of the various subtypes.

##### (1.111) Semidesert

According to Breitenbach, this is the most open type, often occurring on sandy soil; it is reported especially from the Danakil (Afar) Depression and the Ogaden. The usually low plants are very scattered.

##### (1.112) Grass-Steppe

According to Breitenbach, this vegetation type is reported from the Southern Danakil (Afar) Depression and eastern Eritrea; the vegetation is dominated mainly by annual grasses, e.g. *Aristida*, *Chrysopogon*, *Sporobolus*, etc.

##### (1.113) Shrub-Steppe

According to Breitenbach, this vegetation type is reported from the Eritrean lowlands and the western Danakil (Afar) Depression; it consists of scattered, mostly deciduous shrubs up to 3 m high, especially species of Capparaeae, *Acacia*, *Commiphora*, *Grewia*, *Euphorbia*, etc., and many annual grasses.

*(1.12) Semi-Arid Lowland-Steppe*

According to Breitenbach, this vegetation is, in spite of its classification as steppe, composed of low, thicket-forming shrubs and scattered small trees.

*(1.121) Subdesert-Scrub*

According to Breitenbach, this is reported from the lower foothills of the eastern escarpment of the Western Plateau; physiognomy and floristic composition much like Shrub-Steppe, with a ground cover of annual or perennial grasses and small subshrubs.

*(1.122) Succulent-Scrub*

According to Breitenbach, this is reported from areas along the eastern escarpment of the Western Plateau and the Danakil Alps; it contains deciduous shrubs and trees, for example *Sterculia*, *Boswellia*, *Acacia*, *Lannea*, etc., with an understory of scattered shrubs and undershrubs and many succulents, for example species of *Euphorbia*, *Adenium*, *Sansevieria*, *Aloe*, etc.

*(1.123) Scrub-Steppe*

According to Breitenbach, this is recorded from the Eritrean lowlands, the Awash Basin, the eastern part of Harerge and the western lowland parts of Ilubabor and Welega; it contains a stratum of thicket-forming shrubs of for example *Acacia*, *Commiphora*, *Zizyphus*, *Capparis*, *Maerua*, etc., and scattered 3-5 m tall trees, for example species of *Delonix*, *Acacia*, *Adansonia*, *Dobera*, *Lannea*, etc.

*(1.2) Lowland-Savannahs*

The lowland savannahs are, according to Breitenbach, reported to occur over vast areas in the Rift Valley, on the plains surrounding Lake Tana, in the western lowland plains towards the Sudan, on the lower escarpments of both the Western and the Eastern Plateau, and in the lowlands of southern Kefa, Gamo-Gofa, Borana and Welega.

*(1.21) Arid Lowland-Savannahs*

According to Breitenbach, these are floristically related to the Grass- and Shrub-Steppes and occur under very arid conditions at 800-1500 m.

*(1.211) Grass-Savannah*

According to Breitenbach, this is a fairly closed vegetation type with two layers of drought-adapted grasses, an upper with species of *Andropogon*, *Hyparrhenia*, etc., and a lower one with species of *Pennisetum*, *Panicum*, *Eragrostis*, etc. Species of Cyperaceae may also be present.

*(1.212) Shrub-Savannah*

According to Breitenbach, this is a vegetation type with a stratum of scattered small trees, for example *Acacia* and *Ficus*, etc., and shrubs, for example *Gardenia lutea*, over a grass stratum.

*(1.22) Semi-arid Lowland-Savannah*

According to Breitenbach, this group of vegetation types is characterised by larger and more prominent trees than in the previous group.

*(1.221) Scrub-Savannah*

According to Breitenbach, this type is floristically correlated with the Scrub-Steppe. The trees are for example species of *Delonix*, *Acacia*, *Ficus*, *Sterculia*, *Dobera*, *Combretum*, *Moringa*, etc. A shrub stratum may consist of species of *Maerua*, *Grewia*, *Zizyphus*, *Commiphora*, etc. There is no recording of a grass stratum; however, a grass stratum must be present in this vegetation type in order to qualify it as a type of savannah.

*(1.222) Incense-Scrub*

According to Breitenbach, this type is recorded as being common on the western escarpment of the Western Plateau and in the deep river valleys of the plateau at 500-1300 m. The dominant tree is *Boswellia papyrifera*. A stratum of shrubs or shrubby trees includes species of *Pte-*

*rocarpus*, *Lonchocarpus*, *Anogeissus*, *Sterculia*, *Combretum*, *Commiphora*, *Pseudocedrela*, *Lannea*, *Sclerocaria*, etc. We do not agree with this characterisation, which fits very large areas of the western escarpment, as many of the species here referred to as scrubs in fact usually reach tree height. Again, there is no recording of a grass stratum; however, a grass stratum must be present in this vegetation type in order to qualify it as a type of savannah.

(1.223) *Tree-Savannah*

According to Breitenbach, this type is recorded as being floristically related to *Acacia*-Thicket (1.311), and is best developed at 800-1500 m. It consists of trees and big shrubs, for example species of *Piliostigma*, *Cassia*, *Entada*, *Ficus*, *Sterculia*, *Terminalia*, *Combretum*, *Balanites*, *Stereospermum*, etc. Again, there is no recording of a grass stratum; however, a grass stratum must be present in this vegetation type in order to qualify it as a type of savannah.

(1.23) *Semi-humid Lowland-Savannah*

According to Breitenbach, this is a very heterogeneous assembly occurring under widely different ecological conditions.

(1.231) *Coastal-Plain Thicket, Salt-Marsh Thicket*

According to Breitenbach, the Coastal-Plain Thicket occurs along the coasts of Eritrea from sea level up to 700 m; it consists of rather few species, for example a species *Lycium*, with groups of the palm *Hyphaene thebaica*. Salt-Marsh Thicket also contains species of *Tamarix*, *Suaeda*, etc.

(1.232) *Thicket-Savannah*

According to Breitenbach, this is a vegetation type occurring from sea-level up to 800 m, with many species of shrubs and small trees, but Breitenbach does not state where it occurs. The woody stratum contains species of *Acacia*,

*Dalbergia*, *Ficus*, *Euphorbia*, *Phyllanthus*, *Ximenia*, *Zizyphus*, *Balanites*, *Lannea*, *Strychnos*, *Gardenia*, *Steganotaenia*, *Cordia*, and the bamboo *Oxytenanthera*. The ground cover is a continuous grass and Cyperaceae stratum. It is said to be floristically related to Scrub-Savannah (1.221) and Lowland-Bamboo-Thicket (1.233). We think that from its floristic composition it is likely that this type represents a dense form of the vegetation types, which occur on the western escarpment of the Western Plateau.

(1.233) *Lowland-Bamboo Thicket*

This type occurs up to 1300 m on the western escarpment of the Western Plateau and in the deep river valleys of the plateaux. It is a tall thicket strongly dominated by the bamboo *Oxytenanthera abyssinica*, which in many places forms almost pure stands.

(1.24) *Humid Lowland-Savannah*

Under this heading is, according to Breitenbach, gathered a number of coastal and riparian scrub formations.

(1.241) *Mangrove-Scrub*

According to Breitenbach, this vegetation type is only found on the Red Sea coast of Eritrea; dominated by *Avicennia marina* and *Rhizophora mucronata*.

(1.242) *Riparian Scrub*

According to Breitenbach, this type is found along seasonal and permanent water courses below 700 m. Dominant trees and shrubs are *Acacia*, *Ficus*, *Tamarix*, *Zizyphus*, *Hyphaene*, etc.

(1.3) *Lowland-Woodlands*

According to Breitenbach, the woodlands have an upper storey up to 12 m high, which form a more or less closed canopy over a thicket of up to 3 m high shrubs. They occur on the more elevated plains and plateau-escarpments.

*(1.31) Semi-arid Lowland-Woodland*

According to Breitenbach, these types are common at lower altitudes of both the Western and the Eastern Plateau.

*(1.311) Acacia-Thicket*

According to Breitenbach, this type occurs at 1000-1800 m and is floristically related to the Tree-Savanna (1.223) and *Acacia*-Forest (2.111). Its tree stratum is dominated by species of *Cassia*, *Acacia*, *Entada*, *Ficus*, etc. A shrub stratum includes species of *Grewia*, *Euphorbia*, *Maytenus*, *Zizyphus*, *Rhus*, etc.

*(1.312) Euphorbia-Thicket*

According to Breitenbach, this type is found in drier habitats than the previous one and is characterised by the big, candelabra-shaped species of *Euphorbia* which form dense stands up to 12 m high. A number of trees and shrubs are associated, especially species of *Acacia*, *Cassia*, *Maytenus*, *Euclea*, *Rhus*, *Carissa*, etc. A number of climbers, for example *Pterolobium stellatum*, are characteristic.

*(1.32) Semi-humid Lowland-Woodland*

According to Breitenbach, these types occur at the same altitudes as the previous types, but at slightly higher rainfall, and the species are mainly composed of broad-leaved species.

*(1.321) Combretum-Thicket*

According to Breitenbach, this type is recorded at 700-1600 m and contains a number of deciduous trees over a mainly deciduous thicket. The tree stratum contains species of *Annona*, *Albizia*, *Cussonia*, *Entada*, *Combretum*, *Terminalia*, *Stereospermum*, etc. The lower strata contain species of *Grewia*, *Securidaca*, *Croton*, *Maytenus*, *Harrisonia*, *Gardenia*, etc.

*(1.322) Croton-Thicket*

According to Breitenbach, this type is recorded at 1200-1800 m and contains a number of

deciduous trees over a mainly evergreen thicket. The tree-stratum contains species of *Acacia*, *Albizia*, *Ficus*, *Croton*, *Combretum*, *Terminalia*, *Olea*, *Ehretia*, etc. The lower strata contain species of *Gnidia*, *Croton*, *Catha*, *Carissa*, *Maytenus*, *Bersama*, *Ozoroa*, *Rhus*, etc.

*(1.33) Humid Lowland-Woodland*

According to Breitenbach, this is a heterogeneous assembly of vegetation types in higher rainfall areas, along streams and in places with high ground water table.

*(1.331) Balanites-Thicket*

According to Breitenbach, this is a vegetation type, which develops on flood plains where the water table is near the surface, and is found up to 1600 m. The tree stratum is dominated by *Balanites aegyptiaca*. Other important trees are species of *Acacia*, *Dichrostachys*, *Ficus*, *Tamarindus*, *Kigelia*, *Vitex*, etc.

*(1.332) Albizia-Thicket*

According to Breitenbach, this is a vegetation type found at 1200-1700 m in areas with fairly high precipitation. The dominant trees are species of *Albizia*; other trees in the canopy are species of *Millettia*, *Schefflera*, *Trema*, *Ficus*, *Ritchiea*, *Croton*, *Euphorbia*, *Maesa*, *Diospyros*, etc. Lower strata include species of *Bridelia*, *Bersama*, *Dodonaea*, *Pistacia*, *Carissa*, *Vernonia*, etc. Although not specifically mentioned by Breitenbach, there seems from his floristic enumeration to be considerable similarity between this vegetation type and some of his types of Semi-Humid Lower Highland-Forests (2.12).

*(1.333) Tamarindus-Thicket*

According to Breitenbach, this type occurs on river banks at 500-1200 m. The dominant canopy species is *Tamarindus indica*, together with species of *Acacia*, *Ficus*, *Salix*, *Tamarix*, *Zizyphus*, etc.



*(1.334) Faidherbia-Thicket*

According to Breitenbach, this type occurs on river-banks and lake-shores, and in humid valleys with high water table at 1000-1700 m. The dominant canopy species is *Acacia (Faidherbia) albida*. A wet stage in the development of this vegetation at river-lagoons and on lake shores is a thicket with the pioneer species *Aeschynomene elaphroxylon*.

*(2) HIGHLANDS*

According to Breitenbach, forests, ranging from the uppermost forms of the lowland vegetation to the mountain vegetation, at 1600-2600 m constitute the natural climax vegetation of the highlands.

*(2.1) Lower Highland-Forests*

According to Breitenbach, these forests are floristically related to the more closed types of Lowland-Woodlands.

*(2.11) Semi-Arid Lower Highland-Forests*

According to Breitenbach, this is only represented by one vegetation type, the *Acacia*-Forest.

*(2.111) Acacia-Forest*

According to Breitenbach, this type is characteristic of the dryer areas at 1800-2200 m, and is prevalent on south- or west-facing slopes. The vegetation has a canopy of the flat-crowned *Acacia abyssinica* under which there is a lower storey of big, mainly evergreen shrubs and smaller trees with species of *Carissa*, *Calpurnia*, *Celtis*, *Dombeya*, *Maytenus*, *Allophylus*, *Rhus*, *Olea*, *Vernonia*, etc. Trunks of the larger trees have epiphytes, and climbers may be prominent.

*(2.12) Semi-humid Lower Highland-Forests*

According to Breitenbach, these are prominent in semi-humid areas at 1700-2200 m.

*(2.121) Celtis-Forest*

According to Breitenbach, this type is found on north- and east-facing slopes or in cool depressions. The 25-35 m high, dominant canopy species is *Celtis africana*. Other trees in the upper part of the canopy are species of *Prunus*, *Croton*, *Syzygium*, *Apodytes*, *Ekebergia*, *Olea*, etc. In the lower part of the canopy are species of *Millettia*, *Schefflera*, *Trema*, *Pittosporum*, *Dombeya*, *Bersama*, etc.

*(2.122) Polyscias-Forest*

According to Breitenbach, this type is developed in warmer positions than the previous one. *Polyscias fulva*, *Prunus africanus*, species of *Albizia*, etc dominate the upper canopy. The lower strata have considerable floristic similarity with the previous type and the *Acacia* forest (2.111).

*(2.123) Podocarpus-Forest*

According to Breitenbach, this is be the climax of the two previous types, the *Celtis*-Forest (2.121) and the *Polyscias*-Forest (2.122). The dominant species in the 40-45 m high upper canopy is *Podocarpus falcatus*. The lower strata are less well developed, but may in open spaces contain trees, which also occur in the two previous types.

*(2.13) Humid Lower Highland-Forests*

According to Breitenbach, these forests include the broad-leaved rain forests of Ethiopia, as seen by Breitenbach. They occur at 1600-2200 m in the humid parts of Kefa and Ilubabor, but with isolated patches in Welega (Didessa Valley, Dembidollo), Southern Shewa (Gibat), and Sidamo (Jem-Jem). [As will be seen further on in this account, later authors have reported more sites].

*(2.131) Syzygium-Forest*

According to Breitenbach, this is a pioneering association in cool places. The canopy is dom-

inated by *Syzygium guineense* subsp. *afromontanum*. The lower strata are floristically rather similar to those of the *Celtis*-Forest (2.121) and the *Polyscias*-Forest (2.122).

(2.132) *Cordia*-Forest

According to Breitenbach, this is a pioneer type in warmer sites, especially on south- and west-facing slopes. *Cordia africana* and species of *Albizia* dominate the canopy. The lower strata are floristically rather similar to those of the *Celtis*-Forest (2.121) and the *Polyscias*-Forest (2.122), but the forest floor is richer in species, and there are many epiphytes and climbers.

(2.133) *Olea*-Forest

According to Breitenbach, this is the climax of the two previous types, the *Syzygium*-Forest (2.131) and the *Cordia*-Forest (2.132). It ascends in humid and warm sites into the Upper Highland-Forests. The upper canopy is 40-50 m high, the dominant species are *Olea welwitschii* (*Olea capensis* subsp. *welwitschii*), *Trilepisium madagascariensis* (*Bosqueia phoberos*), *Morus mesozygia*, *Pouteria (Aningeria) adolfi-friedericii*, *Pouteria (Aningeria) altissima*, *Manilkara butugi* and *Fagaropsis angolensis*. [However, this has been demonstrated to be incorrect. Apart from *Olea welwitschii*, all other enumerated species belong to a forest type, which descends the western escarpment, but was unknown to Breitenbach in 1963].

(2.134) *Mimusops*-Forest

According to Breitenbach, this is a type which is mainly confined to riverine and lake-shore forests at 1600-2000 m. The dominant canopy species is *Mimusops kummel*; many lower canopy species are common with the *Syzygium*-Forest (2.131) and the *Cordia*-Forest (2.132).

(2.135) *Ficus*-Forest

According to Breitenbach, this is also a riverine type said to be restricted to altitudes at 1800-

2200 m. The dominant canopy species is *Ficus sur* (*F. mallotocarpa*; *F. riparia*).

(2.2) *Upper Highland-Forests*

According to Breitenbach, these forests have a close floristic relation to the Mountain-Woodlands.

(2.21) *Semi-arid Upper Highland-Forests*

According to Breitenbach, these forests occur in more arid areas at 2200-2500 m. They are floristically connected with the Semi-arid Lower Highland-Forests and likewise represented by only one type (*Acacia*-Forest (2.111)).

(2.211) *Acacia*-Forest

According to Breitenbach, these are very similar to the *Acacia*-Forest (2.111) of Semi-arid Lower Highland-Forests.

(2.22) *Semi-humid Upper Highland-Forests*

According to Breitenbach, these forests develop in semi-humid regions at 2200-2500 m and represent serial stages in the upper part of the coniferous forests.

(2.221) *Sideroxylon*-Forest

According to Breitenbach, this is one of the early stages (or stages in regrowth) of the forests on cold, north- and east-facing slopes. The 10-20 m high canopy is dominated by *Sideroxylon oxyacantha* (*Spiniluma oxyacantha*). Other trees in the canopy are species of *Olinia*, *Schefflera*, *Cussonia*, *Dombeya*, *Croton*, *Ekebergia*, and *Olea*.

(2.222) *Galiniera*-Forest

According to Breitenbach, this is an analogous forest type on warm, south- and west-facing slopes. A prominent member in the 10-15 m high canopy is *Galiniera saxifraga* (*Galiniera coffeeoides*). Other trees in the canopy are species of *Prunus*, *Dombeya*, *Croton*, *Ilex*, *Apodytes* and *Olea*.

*(2.223) Juniperus-Forest*

According to Breitenbach, this is the climax of the two previous types, the *Sideroxylon-Forest* (2.221) and the *Galiniera-Forest* (2.222). The canopy is in some places at higher altitudes almost completely dominated by *Juniperus procera*. At lower and moister places this forest type overlaps and mingles with the *Podocarpus-Forest* (2.123). [*Juniperus procera* also occurs in a rather different association in dry parts of the Borana region and in other southern localities, where it represents an evergreen forest stage surrounded by deciduous scrub].

*(2.23) Humid Upper Highland-Forests*

According to Breitenbach, this is the highest altitude part of the broad-leaved forests.

*(2.231) Ekebergia-Forest*

According to Breitenbach, this is the forest type developed in more cold sites. The most prominent tree in the canopy is *Ekebergia capensis* (*Ekebergia rueppelliana*). Other canopy trees are species of *Ficus*, *Croton*, and *Syzygium*. Lower canopy trees are species of *Millettia*, *Olinia*, *Trema*, *Pittosporum*, and *Bersama*.

*(2.232) Apodytes-Forest*

According to Breitenbach, this is the type developed in warmer sites. The most prominent tree in the canopy is *Apodytes dimidiata*. Other canopy trees are species of *Prunus*, *Ficus*, *Croton*, *Trichilia*, *Allophylus*, and *Phoenix*. Lower trees are species of *Poslyscias*, *Schefflera*, *Dombeya*, *Maesa*, *Galiniera*, etc.

*(2.233) Aningeria-Forest*

According to Breitenbach, this is the climax of the two previous types, the *Ekebergia-Forest* (2.231) and the *Apodytes-Forest* (2.232). The upper part of the canopy is dominated by *Pouteria* (*Aningeria*) *adolphi-friederici*. According to Breitenbach, other trees in the canopy are *Pouteria* (*Aningeria*) *altissima*, *Morus mesozygia*

and *Fagaropsis angolensis*. [These latter species are in fact characteristic at lower altitudes and at high rainfall].

*(2.234) Schefflera-Forest*

According to Breitenbach, this is the riverine and riparian forest type among the Humid Upper Highland-Forests. The most prominent member of the canopy is *Schefflera abyssinica*.

*(3) MOUNTAINS*

According to Breitenbach, the physiognomical types at mountainous altitudes are woodlands above the forests, and above savannahs and steppes.

*(3.1) Mountain-Woodlands*

According to Breitenbach, an open canopy of 5-12 m high trees above a scrub-stratum dominates the physiognomy of these vegetation types.

*(3.11) Semi-arid Mountain-Woodlands*

These can, according to Breitenbach, be found on dry, stony slopes at 2400-3000 m and is in Ethiopia and Eritrea only represented by one type.

*(3.111) Protea-Thicket*

According to Breitenbach, this type is associated with the *Acacia-Forest* (2.111 and 2.211) and the mountain savannah types *Grass-Savannah* (3.211) and *Scrub-Savannah* (3.212). The dominant woody species is *Protea gaguedi*, which is sometimes accompanied by a number of other woody plants, for example species of *Gnidia*, *Pittosporum*, etc. [Breitenbach does not mention the ground cover; in our experience these woody plants are almost always associated with a dense grass layer which frequently burns].

*(3.12) Semi-humid Mountain-Woodlands*

According to Breitenbach, these develop in more humid sites at 2400-3400 m.

*(3.121) Juniperus-Thicket*

According to Breitenbach, this vegetation type is mainly found in sites on warm, south- and west-facing slopes. It is open, and between the often poorly developed specimens of *Juniperus procera* there are species of *Cussonia*, *Gnidia*, *Dombeya*, *Croton*, *Maytenus*, *Rapanea*, etc. [We have been in doubt whether this could possibly be taken to represent the *Juniperus*-dominated vegetation of the Borana region, but are convinced that it must represent high-altitude *Juniperus*-dominated vegetation in the northern part of the Western Plateau, for example in Tigray].

*(3.122) Hagenia-Thicket*

According to Breitenbach, this vegetation type, mainly found in cooler sites on north- and east-facing slopes, has *Hagenia abyssinica* as its dominant species. The canopy also contains species of *Olinia*, *Schefflera*, *Dombeya*, *Ilex*, *Hypericum*, *Maytenus*, *Nuxia*, *Galiniera*, and patches of the montane bamboo, *Arundinaria alpina*. [There is no mentioning of a ground cover, but according to our experience, the woody species listed are usually associated with a fairly continuous grass and herb stratum].

*(3.13) Humid Mountain-Woodlands*

According to Breitenbach, these, only represented by one vegetation type, *Arundinaria-Thicket*, are only developed in areas of high humidity at 2500-3400 m.

*(3.131) Arundinaria-Thicket*

According to Breitenbach, this vegetation type is dominated by dense and almost monospecific stands of the montane bamboo, *Arundinaria alpina*. A few individuals of *Juniperus*, *Hagenia*, *Schefflera*, *Dombeya*, *Ilex*, *Hypericum*, *Galiniera*, etc. may also occur. [The ground cover is sparse and consist of herbs with turgid fleshy stems and low grasses].

*(3.2) Mountain-Savannahs*

According to Breitenbach, these occur mainly above the Mountain-Woodlands at altitudes up to 3500 m in dry regions and 4000 m in humid regions. The main physiognomic feature is a blanket of Poaceae and Cyperaceae dotted with spots of isolated or irregularly grouped shrubs or small trees. Breitenbach points out that although he thinks this vegetation naturally occurred at fairly high altitudes above the forests and the mountain woodlands they now also occur as secondary vegetation (seral stages) following clearing for cultivation or pastures at lower altitudes over large areas of both the Western and the Eastern Plateau.

*(3.21) Semi-arid Mountain-Savannahs*

According to Breitenbach, these are restricted to the fairly dry sites, which at this altitude are not very extensive.

*(3.211) Grass-Savannah*

According to Breitenbach, this vegetation type occurs on wind-exposed sites of the high mountain plateaux. It has virtually no shrubs or trees.

*(3.212) Scrub-Savannah*

According to Breitenbach, this vegetation type is very like the previous one, but has scattered groups or larger, but broken thickets of species of *Erica*, *Protea*, *Hypericum*, *Rhus*, *Rosa*, etc.

*(3.22) Semi-humid Mountain-Savannahs*

According to Breitenbach, these more humid types are floristically very variable.

*(3.221) Shrub-Savannah*

According to Breitenbach, this vegetation type has isolated or small groups of small trees or large shrubs, for example species of *Acacia*, *Erica*, *Hypericum*, and *Echinops*.

*(3.222) Tree-Savannah*

According to Breitenbach, this more humid type has scattered taller trees, for example species of *Acacia* and *Maytenus*, and groups of shrubs, for example species of *Olinia*, *Erica*, *Agauria*, *Buddleja*, *Brucea*, etc. At the highest altitudes, stands and scattered individuals of giant lobelia, *Lobelia rhynchopetalum*, may be common.

*(3.3) Mountain-Steppes*

According to Breitenbach, this is reported from the highest parts of the mountains at 3200-4500 m.

*(3.31) Semi-arid Mountain-Steppe*

According to Breitenbach, this is a mosaic of pioneer associations on rocky slopes at 3200-4500 m.

*(3.311) Rupestrian Steppe*

According to Breitenbach, this is a complex vegetation type with a thin blanket of grass and herbs between rocks, dominated by species of *Carduus*, *Urtica*, *Arabis*, etc.

*(3.32) Semi-humid Mountain-Steppe*

According to Breitenbach, these vegetation types are found under less extreme conditions at 3500-4500 m.

*(3.321) Shrub-Steppe*

According to Breitenbach, this vegetation type is found in more sheltered places and consisting of a mosaic of patches of *Erica arborea* scrub, sometimes with *Lobelia rhynchopetalum*, and a blanket dominated by grasses, especially species of *Poa*, *Festuca*, *Agrostis*, etc. [We are surprised that Breitenbach has nowhere in these high altitude vegetation types found reason to mention the extensive areas dominated by species of *Helichrysum*, for example *Helichrysum spinosum*].

*(3.322) Grass-Steppe*

According to Breitenbach, this is found in the highest, moist and most wind-swept peaks and consists of tufts *Carex monostachya*, *Deschampsia caespitosa*, etc.

### Characteristic features of Breitenbach's map

The basic categories in this system are physiognomic. The subordinate categories are based on local rainfall aspects (in each basic category arranged in the sequence arid, semi-arid, semi-humid, and humid) and succession (in each subordinate category arranged in a sequence from pioneer types to climax types). Breitenbach has therefore decided to map only seven basic categories. These are (1.1) *Lowland-Steppes*, (1.2) *Lowland-Savannahs*, (1.3) *Lowland-Woodlands*, (2.1 + 2.2) *Highland-Forests*, (3.1) *Mountain-Woodlands*, (3.2) *Mountain-Savannahs* and (3.3) *Mountain-Steppes*.

Breitenbach's surface-cover quotations refer to these categories and are as shown in Table 1.

**Table 1.** The areas in sq.km. and the land areas in % of total area covered by Breitenbach's major vegetation types. Data from Breitenbach (1963: 19)

	Area (sq. km.)	%
Mountain-Steppes	10,000	1
Mountain-Savannahs	167,000	15
Mountain-Woodlands	8,000	1
Highland-Forests	42,000	4
Lowland-Woodlands	275,000	24
Lowland-Savannahs	147,000	13
Lowland-Steppes	485,000	42
Total land area	1,134,000	100
Rivers and lakes	10,000	
Total	1,144,000	

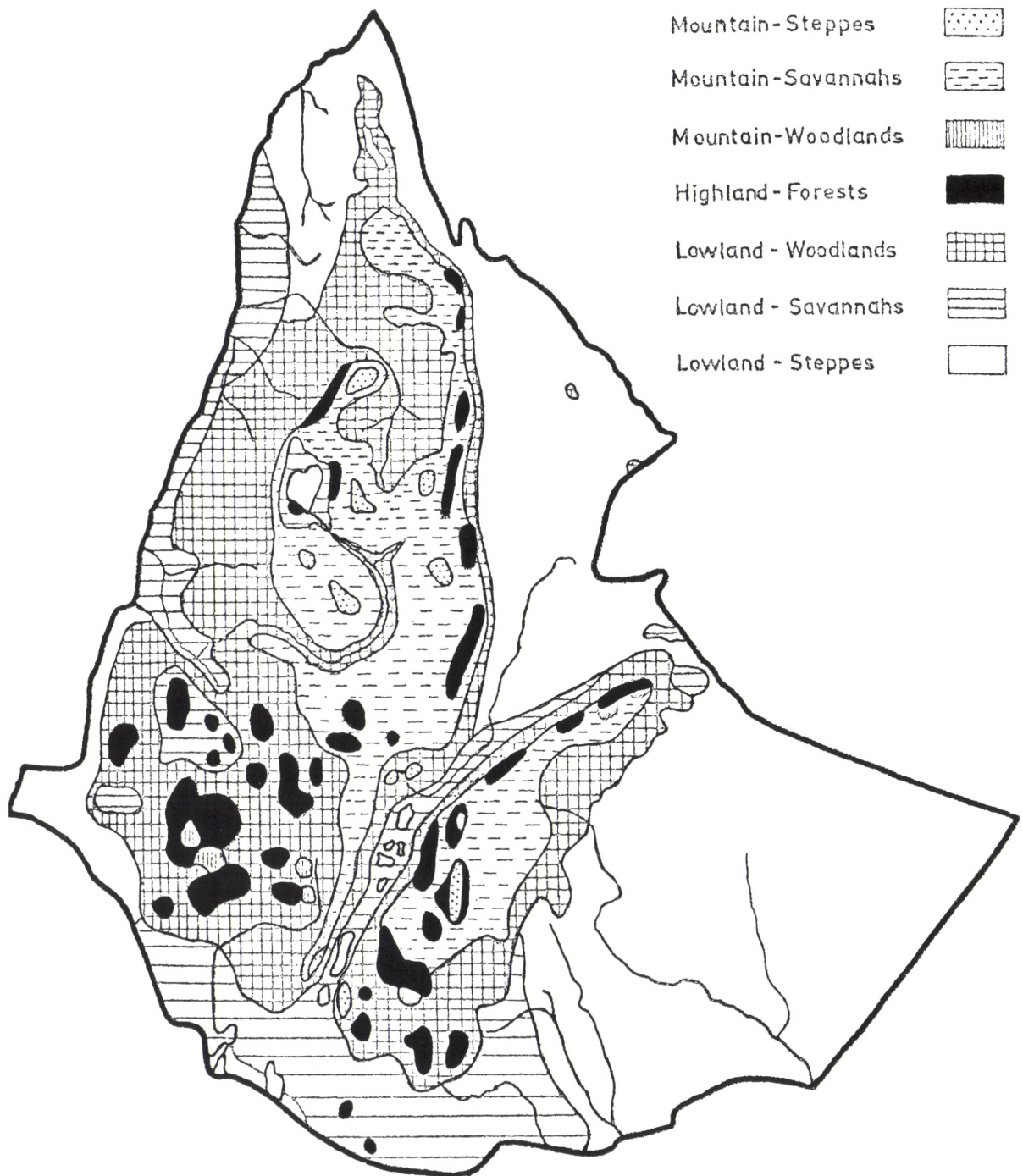


Fig. 3. Map of the vegetation of Ethiopia and Eritrea, according to Breitenbach (1963). Reproduced with permission from J. von Breitenbach.

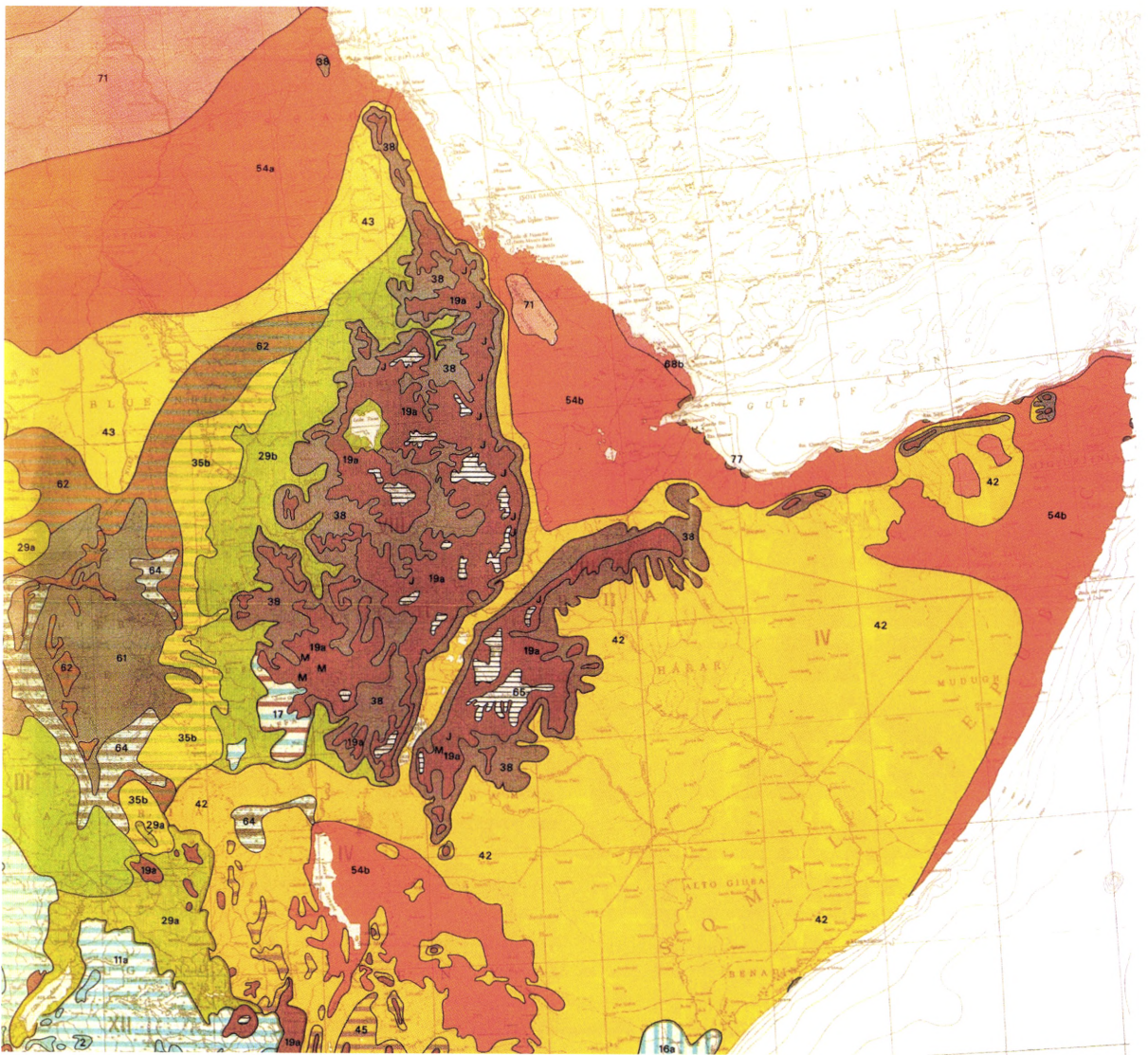
The borders drawn on the vegetation maps of Pichi-Sermolli (1957) and that of Breitenbach (1963) are surprisingly similar, as can be seen from a reproduction of the map in Fig. 3. Hence the extent and delimitation of the mapping units are almost identical, but the descriptions and the terminology of the mapping units are conspicuously different. It can be seen from Breitenbach's map that he considers the major parts of lowlands to be covered by (1.1) *Lowland-Steppes* and (1.2) *Lowland-Savannahs*. The former is indicated in the places where Pichi-Sermolli has (6) *Broken xerophilous open woodland*, (7) *Xerophilous open woodland* and desert and various steppes. The latter is indicated in the places where Pichi-Sermolli had (11) *Savanna (various types)*. Both the higher, northern part of the Western Plateau and the central part of the Eastern Plateau are, according to Breitenbach, largely covered by (3.2) *Mountain-Savannahs*, while Pichi-Sermolli has indicated (12) *Montane Savanna* in exactly the same areas. The most striking difference between the maps of Breitenbach and that of Pichi-Sermolli relates to the western and southern parts of the Western Plateau (incl. most of Kefa, Ilubabor and Welega and the western parts of Gojam, Gonder and Tigray). In these areas Breitenbach has indicated the presence of (1.3) *Lowland-Woodlands* in the places where Pichi-Sermolli has two rather different vegetation types, (10) *Montane evergreen thicket and scrub* and (13) *Deciduous woodland*. On Breitenbach's map the conventional signs for Highland-Forests, representing both (2.1) *Lower Highland-Forests* and (2.2) *Upper Highland-Forests*, is indicated in the place of Pichi-Sermolli's (15) *Montane dry evergreen forest* and (17) *Montane moist evergreen forest*. Breitenbach has indicated very small areas with (3.1) *Mountain-Woodlands*, these areas agree almost exactly with Pichi-Sermolli's areas indicated for (18) *Bamboo thicket (Arundinaria)*, while there is no indication of the geographical position of the other vegeta-

tion types which Breitenbach has placed under (3.1) *Mountain-Woodlands*. Finally, (3.3) *Mountain-Steppes* are indicated in the place of Pichi-Sermolli's (19) *Altimontane scrub and steppe* and (20) *Afroalpine formations*.

It is positive feature with Breitenbach's system that it makes it very clear that each major vegetational unit consists of a whole series of subunits that have some mutual relationship, often representing humid or drier aspects on adjacent mountain slopes, or seral stages of a succession. The drawbacks are that it often difficult to relate his very complex hierarchical system to what we actually see in the field, and that it will be impossible to map such a complicated set of units on a map at a scale of c.1:5,000,000.

#### F. White's chorologically based vegetation map (1983)

White's important map from 1983 covered the whole of Africa; 14 vegetation types and mosaics were recorded from Ethiopia and Eritrea. The part of the map which covers Ethiopia is reproduced in Fig. 4. Only seven of the 14 vegetation types recognised from the area by White are widespread, viz. (19a) *Undifferentiated montane vegetation (Afromontane)*, (29b) *Sudanian undifferentiated woodland (Ethiopian type)*, (38) *Evergreen and semi-evergreen bushland and thicket*, (42) *Somalia-Masai Acacia-Commiphora deciduous bushland and thicket*, (43) *Sahel Acacia wooded grassland and deciduous bushland*, (54b) *Semi-desert grassland and shrubland (Somalia-Masai type)*, and (65) *Altimontane vegetation in tropical Africa*. Two vegetation types, (19a) *Undifferentiated montane vegetation (Afromontane)*, including forests, and (38) *Evergreen and semi-evergreen bushland and thicket*, dominate both the Western and the Eastern Plateau according to White's classification, while the higher parts of the plateau are classified as (65) *Altimontane vegetation in tropical*



**Fig. 4.** Map showing the Ethiopian and Eritrean part of F. White's vegetation map of Africa (White 1983). For detailed legend, see text where the relevant numbers can be found. Reproduced with permission from UNESCO (UPO/D/A/2000-088 of 13 July 2000).

Africa. The lowlands are dominated by (29b) Sudanian undifferentiated woodland (Ethiopian) to the west, and (42) Somalia-Masai Acacia-Commiphora deciduous bushland and thicket, (43) Sahel

Acacia wooded grassland and deciduous bushland and (54a) Semi-desert grassland and shrubland (Somalia-Masai) to the north, east and south. Below all fourteen types are enumerated.



## FOREST TRANSITIONS AND MOSAICS

### (17) *Cultivation and secondary grassland replacing upland and montane forest (African)*

This mapping unit represents areas where the original vegetation, now destroyed, probably originally contained a mixture of Afromontane and lowland species. Ib Friis recalls having informed Frank White at the time when the latter compiled the vegetation map about the mixed forests in Kefa and Ilubabor, and about how quickly these forests were disappearing. On White's vegetation map this vegetation is indicated for the southwestern part of Kefa.

### (19a) *Undifferentiated montane vegetation (Afromontane)*

["J" indicates *Juniperus procera* forest; "M" indicates Mixed forest]. This mapping unit contains a number of vegetation types in White's phytocorion Afromontane archipelago-like regional centre of endemism. In White's descriptive memoir, he has subdivide this mapping unit into the following types, which are difficult to distinguish:

*Afromontane rain forest*, a multi-storeyed forest with *Pouteria (Aningeria) adolfi-friedericii* as a characteristic species in the highest stratum.

*Undifferentiated Afromontane forest*, usually shorter than the previous type, with for example *Apodytes dimidiata*, *Ilex mitis*, *Ocotea kenyensis*, *Podocarpus falcatus*, *Prunus africana*, *Juniperus procera*, etc.; most of the species in this type a very widespread.

*Single-dominant Afromontane forest*, including *Juniperus procera* forest, in dry areas, and *Hagenia abyssinica* forest, at the upper limit of the Afromontane forest, sometimes mixed with *Hypericum revolutum*.

*Afromontane bamboo*, dominated by *Arundinaria alpina*, and with few other tree and shrub species.

*Afromontane evergreen bushland and thicket* is according to White's concept almost synony-

mous with the *Ericaceous* belt of Hedberg (1951), but *Ericaceous bushland* occurs also at lower altitudes and on rocky outcrops, etc.

*Afromontane and Afroalpine scrubland* is according to White also dominated by *Ericaceous* species, but is shorter and have more forbs (especially geophytes), grasses and *Cyperaceae*. It seems to be defined as a high-altitude vegetation type.

*Afromontane and Afroalpine grassland* is according to White mostly a derived vegetation type, although small areas of grassland may have existed before the coming of man. Characteristically, many of the grass species in this vegetation belong to the *Festuceae*, *Aveneae* and *Agrostaeae*, as opposed to the many *Andropogoneae* and *Panicaceae* at lower altitudes. When not too heavily grazed or burnt, the vegetation is often invaded by forest-precursor shrubs, small trees and climbers that may form thickets.

On White's vegetation map this vegetation is indicated for the highlands throughout from northern Eritrea to Gamo-Gofa and to Harerge. It surrounds small islands of (65) *Altimontane vegetation in tropical Africa*.

## WOODLAND

### (29b) *Sudanian undifferentiated woodland (Ethiopian type)*

While most of the Sudanian woodland is characterised by many woody species of *Leguminosae* subfam. *Caesalpinoideae*, these species are rather infrequent in the eastern part, and one of the characteristic species, *Isoberlinia doka*, does not cross the Nile except for a short distance in Uganda. The Ethiopian type is dominated by widespread species, for example *Anogeissus leiocarpus*, *Balanites aegyptiaca*, *Boswellia papyrifera*, *Combretum collinum*, *Dalbergia melanoxylon*, *Erythrina abyssinica*, *Gardenia ternifolia*, *Lonchocarpus laxiflorus*, *Piliostigma thonningii*, *Sterculia setigera*, *Stereospermum kun-*

*thianum* and *Terminalia brownii*. A few tree species, for example *Combretum hartmannianum*, are endemic to the Sudanian woodlands east of the Nile. On White's vegetation map this vegetation type is indicated along the western escarpment of the Western Plateau from western Eritrea to Gamo-Gofa, descending to the Nile Valley and penetrating into the highland along the large river valleys. On White's vegetation map the area round Lake Tana has been marked with the conventional sign (colour) of the (29b) *Sudanian undifferentiated woodland (Ethiopian type)*, which must be based on a misunderstanding.

#### WOODLAND MOSAICS AND TRANSITIONS

(35b) *Transition from undifferentiated woodland to Acacia deciduous bushland and wooded grassland (Ethiopian type).*

According to White, this unit forms the transition from the edaphic grasslands of the Flood Region of the Nile [and its tributaries] to the *Anogeissus-Combretum hartmannianum* woodland flanking the Ethiopian highlands on their western side. *Acacia seyal* and *Balanites aegyptiaca* occur throughout, except for patches of thornless woodland dominated by *Combretum hartmannianum*, *Sterculia setigera*, *Stereospermum kunthianum* and *Adansonia digitata*. On White's vegetation map this vegetation type forms a zone on the western side of (29b) *Sudanian undifferentiated woodland (Ethiopian type)*.

#### BUSHLAND & THICKET

(38) *Evergreen and semi-evergreen bushland and thicket.*

According to White, this unit often forms transition between the Somalia-Masai and Afromontane Regions. For cartographic reasons it has on his vegetation map been placed partly in the former and partly in the latter.

White quoted Ib Friis as the authority for a note on evergreen bushland on the Ethiopian escarpment: the bushland was stated to be of several types. For the above-mentioned cartographic reasons, White included within the borders of Ethiopia and Eritrea most of the evergreen bushland and thicket within the boundary of the Afromontane region, although some might occur at low altitudes and be of different type. Some of the evergreen bushland with *Buxus*, *Barbeya* clearly belongs with the Somalia-Masai Region. On White's vegetation map this vegetation forms a zone around (19a) *Undifferentiated montane vegetation (Afromontane)* on both the Western and the Eastern Plateau. The largest areas of this vegetation are indicated in the deep river valleys of the western part of the Western plateau, but also elsewhere there are extensive areas indicated.

(42) *Somalia-Masai Acacia-Commiphora deciduous bushland and thicket.*

White includes under this unit the climax vegetation over the greater part of the Somalia-Masai Region. Characteristically, it is a dense bushland, 3-5 m tall with scattered emergent trees up to 9 m. Locally it is impenetrable and then forms thickets. The dominant species of *Acacia* and *Commiphora* are spiny shrubs that branch from near the base, and thus impede progress even in open types except along game or cattle tracks. Most species are deciduous. Only a few species have clearly developed trunks, especially *Acacia tortilis*, species of *Delonix* and *Terminalia*, etc. On White's vegetation map very large areas are indicated as covered by this vegetation type, from the lower Omo Valley and the southernmost part of Gamo-Gofa to the border with Somalia, in the Rift Valley, surrounding the Eastern Plateau, and forming a narrow band along the eastern escarpment of the Western Plateau.

(43) *Sahel Acacia wooded grassland and deciduous bushland.*

According to White, the Sahel wooded grassland is a widespread type in the southern higher rainfall areas of the Sahel, where annual rainfall is between 250 and 500 mm. It occurs on sandy soil, which is less common than the black, cracking clays in the Nile Valley. On White's vegetation map this vegetation type occurs in western Eritrea, where *Acacia senegal* dominates it.

*SEMI-DESERT VEGETATION*

(54a) *Semi-desert grassland and shrubland (Northern Sahel type)*

According to White, these grasslands and shrublands occur at annual rainfall lower than 250 mm, and predominantly on sandy soils. The dominant grasses are annual species. There is usually an admixture of bushes and small bushy trees, the density of which is partly determined by local conditions. The canopy covers less than 10%. The chief woody species are *Acacia tortilis*, *Balanites aegyptiaca*, and species of *Commiphora* and *Capparaceae*. On White's vegetation map this vegetation type occurs in the north-western Eritrea.

(54b) *Semi-desert grassland and shrubland (Somalia-Masai type)*

According to White, vegetation in the Somalia-Masai region at annual rainfall between 100 and 200 mm is often semi-desert grassland, which usually grows on deep sand, while shrubland occurs on stony soils. Gypseous soils support a considerable number of endemic succulents, especially species of *Euphorbia*. M.G. Gilbert is quoted for the information that *Stapeliad* succulents are usually found on limestone rather than gypsum. On White's vegetation map this vegetation type occurs extensively in the Afar Depression and along the coast along the Red Sea and the Gulf of Aden.

There are also marked areas with this vegetation along the border between Ethiopia and Kenya from south of Mega to just west of Lake Turkana, but here the vegetation does not penetrate far into Ethiopia.

*GRASSLAND*

(61) *Edaphic grassland in the Upper Nile basin.*

According to White, the Upper Nile basin has extensive areas of dark, cracking Pleistocene clays. The grasses are as in mapping unit (62). On White's vegetation map this vegetation type is only indicated from the extreme western part of the Ilubabor lowlands (now Gambella Region), but it is very likely that other areas of pure grassland may occur in the seasonally flooded areas also closer to the western escarpment of Western Plateau.

*EDAPHIC GRASSLAND MOSAICS*

(62) *Edaphic grassland mosaics with Acacia wooded grassland.*

According to White, this vegetation is characterised by grass species of *Schoenfeldia*, *Cymbopogon*, *Sorghum*, *Hyparrhenia*, *Sehima*, etc. At rainfall above 570 mm *Acacia nilotica* and *A. seyal* is the dominant species, while *Acacia mellifera* dominates at lower rainfall. On White's vegetation map this vegetation occurs only in a small area around and south of Humera at the triple border between Sudan, Ethiopia and Eritrea and in a small area west of Jikau in western Ilubabor. Otherwise it forms a zone in the adjacent parts of Sudan outside (35b) *Transition from undifferentiated woodland to Acacia deciduous bushland and wooded grassland (Ethiopian type)*.

(64) *Edaphic grassland mosaics with semi-aquatic vegetation*

According to White, this is a mosaic of various types of Sudanian wooded grassland, grassland

and swamp communities. By far the largest constituent is seasonally flooded grassland dominated by *Hyparrhenia rufa* and *Setaria incrassata*. On White's vegetation map there is indicated a patch of this vegetation west of the lower part of the Omo River and other areas in the lowlands near the border between Kefa and Sudan.

#### ALTIMONTANE VEGETATION

##### (65) *Altimontane vegetation in tropical Africa*

Under this mapping unit White has included a number of types that are cartographically difficult to separate.

##### *Afromontane evergreen bushland and thicket, pro parte*

As mentioned above, this is according to White's concept almost synonymous with the Ericaceous belt of Hedberg (1951). Here only the high altitude Ericaceous belt is included.

##### *Afromontane scrubland, pro parte.*

As mentioned above, this is according to White's concepts also dominated by Ericaceous species, but is shorter and have more forbs (especially geophytes), grasses and Cyperaceae.

##### *Afromontane and Afroalpine grassland, pro parte*

As mentioned above, most montane grassland is believed to be secondary, including some Afroalpine grassland types.

##### *Mixed Afroalpine communities in tropical Africa*

According to White, Afroalpine vegetation is physiognomically very mixed, being based on five distinctive Afroalpine life-forms, which do not fit the major physiognomic categories of areas at lower altitudes, but are closely paralleled in the paramo-vegetation in South Amer-

ica. There are also less specialised life forms in the Afroalpine communities.

On White's vegetation map the Altimontane vegetation is indicated in the Semien, in various massifs to the east of lake Tana, in the Choké Mountains of Gojam, in high mountains north-east and west of Addis Ababa, in the Guraghe Mountains in Shewa, in the mountains of Gamo-Gofa, Arsi, and Bale, and in the Amaro Mountains in Sidamo.

#### DESERT

##### (68b) *Red Sea coastal desert.*

According to White, the Red Sea coastal plain is 15-20 km wide and receives very little rainfall. There are halophytic communities and littoral salt marches on the coast itself, and no other vegetation except in the wadis. On White's vegetation map there is a belt of this vegetation marked along the Red Sea coast from the border with Djibouti.

##### (71) *Regs, hamadas, wadis*

On White's vegetation map the part of the Afar Depression which is largely below sea level is marked as mapping unit (71), and on a map of the Somalia-Masai Region in the descriptive memoir there is indication of (71) "Stony desert" in the "Danakil Depression," but we have not been able to find any references to this in the text of the descriptive memoir.

#### AZONAL VEGETATION

##### (77) *Mangrove*

According to White, the mangrove of Eritrea occurs on sandy mud over coral rock in shallow bays and is dominated by *Avicennia marina*. On White's vegetation map no areas along the Red Sea coast of Eritrea are indicated as mangrove.

White's classification of vegetation is primarily based on his phytochoria, which in our area involve (1) *the Sudanian regional centre of endemism,*

(2) the Afromontane archipelago-like centre of endemism, including (3) the Afroalpine archipelago-like region of extreme floristic impoverishment, (4) the Somalia-Masai regional centre of endemism, and (5) the Sahel regional transition zone.

The following is an indication of how the vegetation types are distributed like this on White's phytochoria.

#### *Sudanian region*

(29b) *Sudanian undifferentiated woodland (Ethiopian type).*

(35b) *Transition from undifferentiated woodland to Acacia deciduous bushland and wooded grassland (Ethiopian type).*

(61) *Edaphic grassland in the Upper Nile basin.*

(62) *Edaphic grassland mosaics with Acacia wooded grassland.*

(64) *Edaphic grassland mosaics with semi-aquatic vegetation.*

#### *Afromontane archipelago-like centre:*

(17) *Cultivation and secondary grassland replacing upland and montane forest (African).*

(19a) *Undifferentiated montane vegetation (Afromontane).* ["J" indicates *Juniperus procera* forest; "M" indicates Mixed forest].

(38) *Evergreen and semi-evergreen bushland and thicket (partly).*

#### *Afroalpine archipelago-like region:*

(65) *Altimontane vegetation in tropical Africa (partly, also (2) Afromontane archipelago-like centre).*

#### *Somalia-Masai region:*

(42) *Somalia-Masai Acacia-Commiphora deciduous bushland and thicket.*

(54b) *Semi-desert grassland and shrubland (Somalia-Masai type).*

(38) *Evergreen and semi-evergreen bushland and thicket (partly, also (2) Afromontane archipelago-like centre).*

(68b) *Red Sea coastal desert.*

(71) *Regs, hamadas, wadis.*

#### *Sahel transition zone:*

(43) *Sahel Acacia wooded grassland and deciduous bushland.*

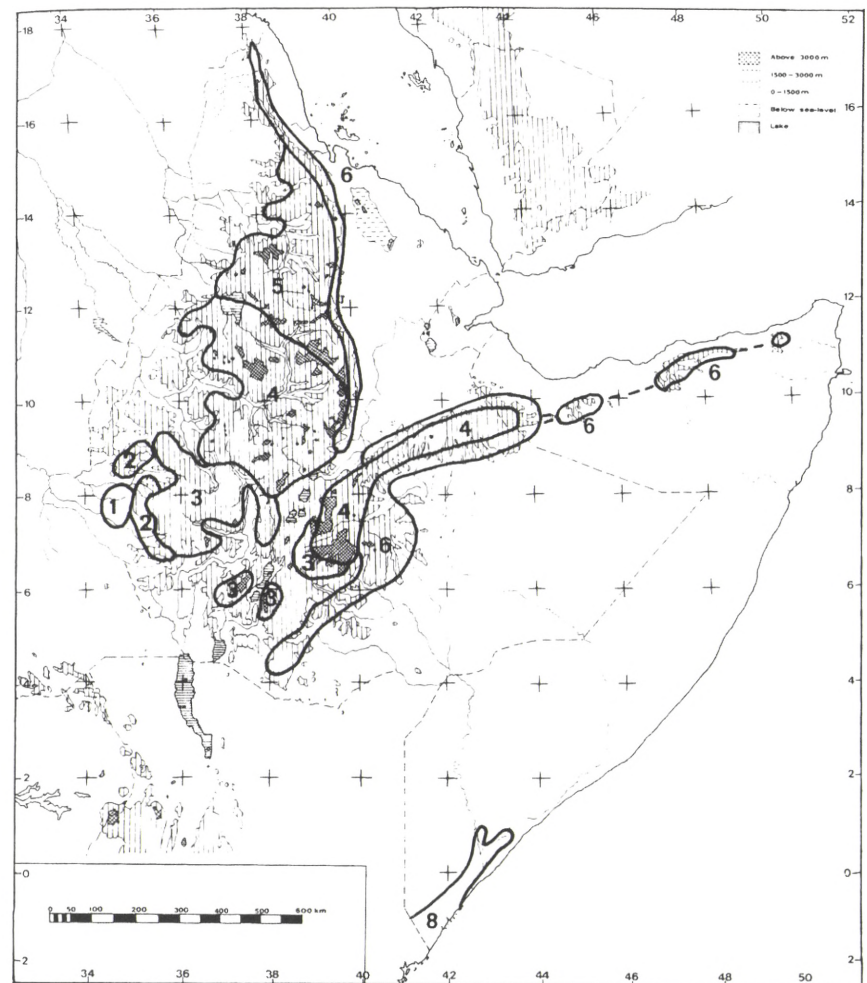
(54a) *Semi-desert grassland and shrubland (Northern Sahel type).*

This classification is not quite detailed enough to fit the requirements for a vegetation map to accompany the *Flora of Ethiopia and Eritrea*, and areas particularly rich in species are not easily noticed as a separate vegetation type. It lacks some of the forest types, which have been discovered in southwestern Ethiopia after the publication of White's map in 1983.

#### Friis (1992)

Friis (1992) made an attempt to classify the forests on the Horn of Africa based on direct observations on collecting trips to hitherto less known forested areas, mainly in SW Ethiopia, and on the mapping of distributions of a considerable percentage of the distribution of the forest trees. This resulted in an improved understanding of the extent of the forests, their floristic composition and the relationship between the rainfall and the floristic composition in the forests on both the Western and the Eastern Plateau. The classification and terminology of the vegetation types largely followed that of White (1983), but some vegetation types not recognised from Ethiopia by White were nevertheless found to be present in previously less studied parts of the country. The detailed floristic work also rested on the intensive work of the Ethiopian Forest Inventory (Chaffey 1978a, 1978b, 1978c, 1979). The most important step was the recognition and floristic characterisation of the lowland semi-deciduous forest (*Dry peripheral semi-deciduous Guineo-Congolian forest*) and the altitudinally transitional forest (*Transitional rain forest*) not known from the region by White. These forests are described as no. (1) and (2) below. Friis (1992) did not produce a new vegetation map of the

**Fig. 5.** Map showing the approximate outline of areas with the floristic forest types recognized by Friis (1992): (1) lowland dry peripheral semi-evergreen Guineo-Congolian type forest; (2) transitional rain forest; (3) broad-leaved Afromontane rain forest; (4) undifferentiated Afromontane forest, including various types of upland forest with *Podocarpus*; (5) dry single-dominant Afromontane forest, with *Juniperus procera* in the canopy and *Olea europaea* subsp. *cuspidata* in the understorey; (6) transition between dry single-dominant Afromontane forest and East African evergreen and semi-evergreen bushland and thicket; (8) transition between Zanzibar-Inhambane undifferentiated forest, the Zanzibar-Inhambane scrub forest and the Zanzibar-Inhambane evergreen and semi-evergreen bushland and thicket (southern Somalia). Riverine forest (7) and mangrove (9) are not shown. Reproduced with permission from author and publisher.



area, but he attempted to illustrate the general areas where his forest types could be found as enclaves in farmland, the map is reproduced here as Fig. 5.

*(1) Dry peripheral semi-deciduous Guineo-Congolian forest*

According to Friis, these forests are restricted to the Baro Lowlands of western Ilubabor, and have only become known in fairly recent years. Chaffey (1979) made the first inventory of a forest of this type. The name of this vegetation, adopted from White (1983), who used it for for-

est in the Sudanian Region, may sound almost nonsensical in an Ethiopian context, but comparison of the floristic composition of these Ethiopian forests with lowland forest types in the woodland regions of Ghana, as presented by Hall & Swaine (1981), shows that the Ethiopian forest would fall within the West African type referred to by Hall & Swaine as *Dry semi-deciduous forest*. These Ethiopian forests occur on sandy soils, and are semi-deciduous, with a 15-20 m tall, more or less continuous canopy of *Baphia abyssinica* (endemic to south western Ethiopia and adjacent areas of the Sudan), mixed with

less common species of *Celtis*, *Diospyros*, *Lecaniodiscus*, *Malacantha*, *Trichilia*, *Zanha*, and *Zanthoxylum*. Above the main canopy emerge species of *Alstonia*, *Antiaris*, *Celtis*, and *Milicia*. Below the closed canopy is a more or less continuous stratum of small trees and shrubs. The ground is mostly covered by thick litter, and there are apparently very few species on the forest floor, for example the widespread forest grass *Streptogyna crinita*.

### (2) Transitional rain forest

According to Friis, scattered examples of these forests are known from the western escarpment of the Ethiopian Highlands, in Welega, Ilubabor and Kefa. The forests occur between 500 and 1500 m. The rainfall is close to 2000 mm per year, with rain all year round. Chaffey (1979) provided some information, but most information is based on recent observations. The transitional rain forests are most similar in physiognomy and composition to the humid broad-leaved Afromontane rain forests of south western Ethiopia described below, with the addition of species from the lowland forest described above, and some species only known from humid forests of other countries, probably because the true lowland forests in Ethiopia are too dry for them. The canopy includes *Pouteria* (*Aningeria*) *altissima*, species of *Anthocleista*, *Campylopermum*, *Celtis*, *Elaeodendron*, *Ficus*, *Garcinia*, *Manilkara*, *Morus*, *Phoenix*, *Trichilia* and *Trilepisium*.

### (3) Afromontane rain forest

According to Friis these forests occur in the south-western part of the Ethiopian Highlands at altitudes between 1500 and 2600 m, at annual rainfall between 700 and 1500 mm. The Harena Forest on the southern slopes of the Bale Mountains is the easternmost example of these forests. The forests characteristically contain a mixture of *Podocarpus* and broad-leaved species in the canopy, but *Podocarpus* is never a

single dominant and becomes gradually more infrequent towards the southwest in Kefa and Ilubabor as the rainfall increases, while *Pouteria* (*Aningeria*) *adolphi-friederici* becomes more prominent in the same direction. The drier parts of these forests are floristically very similar to those in the humid parts of the central highlands. The more or less continuous canopy consists of medium-sized trees, 10-30 m tall, including species of *Albizia*, *Ilex mitis*, *Prunus africana*, *Ocotea kenyensis*, *Polyscias fulva*, *Prunus africana*, *Sapium ellipticum*, *Syzygium guineense* subsp. *afromontanum* and *Olea capensis* subsp. *hochstetteri* or *O. welwitschii*. There are only one or two emergent species from the 20-30 m high canopy, *Pouteria* (*Aningeria*) *adolphi-friederici* or *Podocarpus falcatus*. The smaller trees and large shrubs form a discontinuous stratum. The most humid forests have dense stands of tree ferns (*Cyathea*) in the ravines. The epiphytes included ferns, orchids, and *Peperomia*. Lianas are present, and about 25 species have been recorded. The ground cover is comparatively lush, and rich in ferns, grasses, and herbaceous dicotyledons. *Arundinaria alpina* is not uncommon at higher altitudes in this area. A transition between *Acacia abyssinica* woodland and this type of forest exists and is described under the following type.

### (4) Undifferentiated Afromontane forest

Friis sees the forests on both the Western and the Eastern Plateau as a gradient from wet to dry types, and generally the vegetation on the plateaux as a mosaic. The mosaic consists of humid sites, where areas of forest and evergreen (or semi-evergreen) bushland are now largely replaced by derived vegetation due to agriculture, and more well drained sites or sites in rain shadow, where the original vegetation had been wooded grassland, woodland or deciduous bushland. The undifferentiated Afromontane forests are either *Juniperus-Podocarpus* forests, or single dominant *Podocar-*

*pus* forests, both with an element of broad-leaved species. They occur especially on the plateaux of Shewa, Welo, Sidamo, Bale and Harerge at altitudes from 1500-2700 m, with annual rainfall between 700 and 1100 mm. Presently, the few larger patches still extant appear widely separated by areas of cultivation and wooded grassland. The canopy is usually dominated by *Podocarpus falcatus* with *Juniperus procera*, *Croton macrostachyus*, *Ficus spp.*, *Olea europaea* subsp. *cuspidata*, etc. There is usually a rather well developed stratum of small to medium-sized trees. Scrambling species and true lianas are common. Epiphytes include species of *Peperomia*, ferns and orchids. The ground cover is rich in ferns, grasses, sedges, and small herbaceous dicotyledons. At the upper limit of this type of forest, between 3000-3400 m, there is often a more open type of woodland or evergreen bushland with *Erica arborea*, *Gnidia glauca*, *Hagenia abyssinica*, *Hypericum revolutum*, *Jasminum stans*, *Morella (Myrica) salicifolia*, *Myrsine africana*, *Myrsine (Rapanea) melanophlœeos*, *Rosa abyssinica*, and *Nuxia congesta*. Clumps of the mountain bamboo (*Arundinaria alpina*) may occur, but on the plateaux the species does not appear to form extensive stands such as are found in East Africa. *Acacia abyssinica* may form a very dense stand, a dense woodland or a forest, the canopy of which is mixed with broad-leaved species. Lianas and a ground cover of partly hygrophilous herbs may occur.

(5) *Dry single-dominant Afromontane forest of the Ethiopian Highlands*

According to Friis, this forest occurs especially on the Western and the Eastern Plateau in Tigray, Gonder, Welo and Harerge at altitudes from (1600-) 2200-3200 (-3300) m with an annual rainfall between 500 and 1500 mm. The typical dominant species in the upper storey of these forests is *Juniperus procera*, with *Olea europaea* subsp. *cuspidata* and a number of other species in the lower storeys.

(6) *Dry single-dominant Afromontane forest of the escarpments and transition between single-dominant Afromontane forest and East African evergreen and semi-evergreen bushland*

According to Friis, this category includes a range of physiognomic types, from typical forest to evergreen scrub with dispersed trees, but floristically the whole range is connected. The forest-like types exist in parts of Eritrea, on the eastern escarpment of the Ethiopian Highlands, and on the northern escarpment of the Somali Highlands; the bushland-like types with trees occur scattered in the previous areas, on the south eastern slope of the eastern Highlands. It extends along the mountain chain in northern Somalia. Throughout the range of the type it occurs on rocky ground with unimpeded drainage from an altitude of about 1500 m to about 2400 m at an annual rainfall of between 400 and 700 mm. The dry juniper forests of Sidamo occur at altitudes between 1500 and 2000 (-2200) m at an average rainfall of 400-700 mm. In an open stratum of smaller trees species of the following genera occur *Acokanthera*, *Apodytes*, *Barbeya*, *Berchemia*, *Brucea*, *Cadia*, *Halleria*, *Mimusops*, *Olea europaea* subsp. *cuspidata*, *Pistacia*, *Rhus*, *Schrebera*, *Sideroxylon* and *Tarchonanthus*. The dry juniper forests of Sidamo form the southern extension of this type. Other characteristic species include (in Bale and Harerge) *Dracaena ellenbeckiana*, *Buxus hildebrandtii* and *Barbeya oleoides*.

(7) *Riverine forests*

According to Friis, the riverine and riparian forest vegetation of the study area is very variable, and the floristic composition is dependent on altitude and geographical location. Only a brief summary can be given here. Common tree species in these forests are species of *Ficus*, *Lepisanthes senegalensis*, *Nuxia oppositifolia*, *Salix mucronata*, *Trichilia emetica*, *Diospyros mespiliformis*, *Mimusops kummel*, *Tamarindus indica*, *Acacia albida*, *Tamarix nilotica*, *Breonadia*



*salicifolia*, and *Phoenix reclinata*. There is often a shrub layer, and lianas and vascular epiphytes occur. The ground cover includes grasses, ferns, and a few herbaceous dicotyledons.

Riparian vegetation at larger lakes may include *Acacia albida*, species of *Ficus*, *Phoenix reclinata* and *Aeschynomene elaphroxylon*.

(8) *Transition between Zanzibar-Inhambane undifferentiated forest, ZI scrub forest and ZI evergreen and semi-evergreen bushland and thicket*

This woody vegetation from the coastal areas of southern Somalia is a forest type that does not occur in the FEE-area.

(9) *Mangroves*

Mangrove vegetation occurs along the Red Sea coast, where the major component is *Avicennia marina*, but in a few places *Rhizophora mucronata* is locally also important.

This attempt only deals with the forests. It assumes that the vegetation in the forest areas has been dominated by forests as described before human disturbance and farming changed the landscapes and attempts to map the extent of the forests by mapping characteristic species of forest trees also where they have been left outside the intact forests.

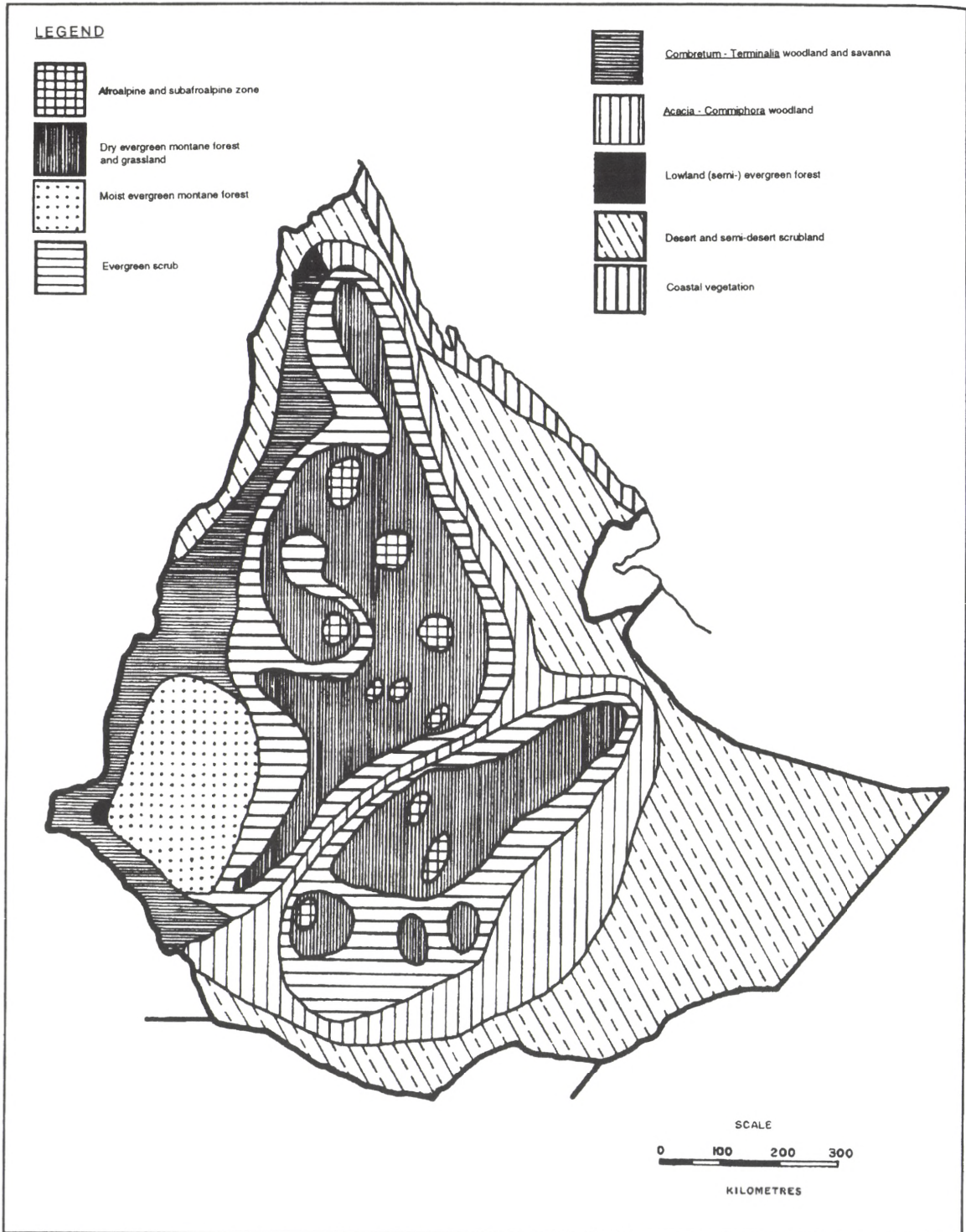
Sebsebe Demissew, Mengistu Wondafrash and Yilma Dellelegn (1996)

Sebsebe, Mengistu and Yilma (1996) published the descriptions of the mapping units and a vegetation map of Ethiopia. These vegetation types and the map reflects discussions going on among Ethiopian botanists and conservationists, and they are summarised in the Conservation Strategy of Ethiopia (CSE 1997). The importance of deforestation and the expanding man-made grasslands was stressed in a paper by Tewolde B.G. Egziabher (1988) which

attempt to discuss the vegetation of the Afroalpine and Afromontane zones as a whole, based on the author's long experience from all parts of the highlands. The paper also makes a number other interesting observations, for example that the vegetation limits differ considerably between the different parts of the country, and that eastern facing escarpments are generally dryer than western facing ones. The *Juniperus procera* forest occurs only above 2200 m in the north, but down to 1500 m in the south. The upper limit of the montane *Acacia* wooded grassland [*Acacia* woodlands' in the paper] is at 1900 m in the north, but at 900 m in the southwest. These differences are the effect of rainfall and moisture superimposed on the effect of the temperature decline with increasing altitude. But the clearly visible effects of these two factors are blurred by the long period of intense human interference almost everywhere in the Ethiopian highlands. In view of these complications, Sebsebe Demissew *et al.* (1996) decided to simplify the vegetation map as much as they thought possible and accepted only eight vegetation types for Ethiopia proper. The map is reproduced as Fig. 6. The mapping units are:

*Desert and semi desert scrubland*

According to Sebsebe Demissew *et al.* this vegetation is highly drought tolerant, but due to external influence, for example around watering points, the land can locally be completely devoid of vegetation. The soils are alluvial. Small trees and shrubs occur, including species of *Acacia*, *Commiphora*, *Boscia*, *Cadaba*, *Maerua* and *Zizyphus*, as well as succulents, including species of *Euphorbia* and *Aloe*. The grass species are mainly annual, such as *Dactyloctenium aegyptium*, while another characteristic species, *Panicum turgidum*, is perennial. This vegetation type occurs in the Afar Depression, the Ogaden, around Lake Chew Bahir and the Omo delta.



*Acacia-Commiphora, small-leaved, deciduous woodland*

According to Sebsebe Demissew *et al.* this vegetation is characterised by drought resistant trees and shrubs, either deciduous or with small, evergreen leaves. The trees and shrubs include species of *Acacia*, *Balanites*, *Commiphora*, *Capparis*, *Combretum*, and *Terminalia*. The ground cover is rich in subshrubs, including species of *Acalypha*, *Barleria*, and *Aerva*. This vegetation type occurs in the northern, eastern, central and southern part of the country at 900-1900 m.

*Moist evergreen forest*

According to Sebsebe Demissew *et al.* this vegetation type is characterised by one or more closed strata of evergreen trees. There are tall emergent trees, medium-sized trees that normally form a canopy, and understorey of shrubs. Characteristic emergent trees include *Pouteria (Aningeria) adolfi-friedericii*, *Albizia gummifera*, *A. grandibracteata*, *Macaranga capensis* and *Ocotea kenyensis*. None of the tall trees are endemic to Ethiopia. Typical understorey species include *Chionanthus mildbraedii* and *Psychotria orophila*. There are many epiphytes and lianas, some of which are endemic. The ground cover is not continuous, it includes a number endemic species. This vegetation type occurs in the western and south-western part of the country, in south Bale (including the important Harena forest), north Borana, west Welega, Ilubabor and Kefa. It occurs in the western part of its range at altitudes at 1500-2400 m, with average annual temperature of 18-20° C, and annual rainfall of 1500-2400 mm. In the southern part of the range (Borana and

Bale) it occurs up to 2800 m at annual rainfall around 1500 mm.

*Lowland, semi-evergreen forest*

According to Sebsebe Demissew *et al.* this vegetation type is characterised by one or more closed strata of trees, which may be deciduous or evergreen. There are tall emergent trees, including *Celtis toka*, *Diospyros abyssinica*, *Mala-cantha alnifolia*, and *Zanha golungensis*, medium sized trees which often form a closed canopy, and a low shrubby understorey with species like *Alchornea laxiflora*, *Oncoba spinosa* and *Whitfieldia elongata*. [In fact the "tall emergent species" mentioned by Sebsebe Demissew, Mengistu and Yilma are more frequently species of the upper, closed canopy. The truly emergent species are very large, individual trees that belong to the genera *Alstonia*, *Antiaris*, *Celtis* or *Melicia*. In places, the near-endemic *Baphia abyssinica* forms an almost monospecific canopy. Lianas may occur. The forest floor is often very dark and poor in species.] The forests categorised in this vegetation type occur in the Gambella region (previously the western lowland part of Ilubabor) at 450-650 m with average maximum temperatures of 35-38° C, mean annual temperatures of 18-20° C, and annual rainfall of 1300-1800 mm. The forests occur mainly on sandy soils, but usually with high ground water table.

The account by Sebsebe Demissew *et al.* lacks the altitudinal transitional forest described by Friis (1992). It is, as mentioned previously, known from altitudes around 1000 m in Kefa, at similar altitudes in Ilubabor north of Tepi, and is also represented in Welega at Dembidollo.

← Fig. 6. Map showing the vegetation types of Ethiopia and Eritrea according to Sebsebe Demissew *et al.* (1996). The legend includes the following vegetation types, which are further described in the text. (Left column, from top down): *Afroalpine and subalpine zone*; *Dry evergreen montane forest and grassland*; *Moist evergreen montane forest*; *Evergreen scrub*. (Right column, from top down): *Combretum-Terminalia woodland and savanna*; *Acacia-Commiphora woodland*; *Lowland (semi-) evergreen forest*; *Desert- and semi-desert scrubland*; *Coastal vegetation*. Reproduced with permission from author and publisher.

*Combretum-Terminalia, broad-leaved, deciduous woodland and savanna*

According to Sebsebe Demissew *et al.* this vegetation type is characterised by small to moderately sized trees with fairly large deciduous leaves. Species of *Terminalia*, *Combretum*, *Lanana*, *etc.* and *Boswellia papyrifera*, *Anogeissus leiolepis* and *Stereospermum kunthianum* are common. The solid-stemmed lowland bamboo *Oxytenanthera abyssinica* is prominent in river valleys [and locally on the escarpment] of western Ethiopia. The ground cover is a tall stratum of perennial grasses, including species of *Cymbopogon*, *Hypparrhenia*, *Echinochloa*, *Sorghum* and *Pennisetum*. This vegetation type has been burning annually for such a long time that the plants show clear adaptation to fire, and it must be assumed not to be adversely affected by controlled annual fires. It occurs along the western escarpment of the Western Plateau, from the border region between Ethiopia and Eritrea to western Kefa and the Omo Zone; it is the dominant vegetation in what is now Benshangul-Gumuz and Gambella Regions, where it occurs at 500-1900 m. At the upper limit it frequently abuts on to Afromontane Moist Evergreen forest. It penetrates into the Western Plateau along the large river valleys.

*Dry evergreen Montane Forest and Grassland Complex*

According to Sebsebe Demissew *et al.* this vegetation type represents a complex system of successions involving extensive grasslands rich in legumes, shrubs and small to large-sized trees. The common tree species include *Juniperus procera*, *Olea eurpaea* subsp. *cuspidata*, *Celtis africana*, *Euphorbia ampliphylla*, *Mimusops kummel* and *Ekebergia capensis*. A number of shrubs are also characteristic. The grasses include genera from several tribes, and not only predominately temperate ones. The ecotone between forests and grassland is occupied by *Acacia* woodland with *Acacia abyssinica*, *A. negrii* and *A.*

*pilisipina*. This is a zone where sedentary, cereal-based agriculture has been going on for thousands of years. Very few areas have what can be described as natural vegetation. In many places the forests have been replaced by woodlands and grassland on the gentle slopes with deep soil, and by evergreen bushland on the steeper slopes with thin soil.

*Afroalpine and sub-Afroalpine vegetation*

According to Sebsebe Demissew *et al.* this vegetation type is characterised by small trees, shrubs and shrubby herbs at the lower altitudes and giant herbs, small herbs and grasses (the five distinctive Afroalpine life forms of Hedberg (1951) mentioned previously under White (1983)). The evergreen shrubs include *Erica arborea* and *Hypericum revolutum*. Typical shrubby-based herbs are a number of species of *Helichrysum*. *Lobelia rhynchopetalum* is alone among the giant rosette herbs with stems. The grasses mainly belong to tribes dominant in the temperate regions, and include species of *Festuca*, *Poa* and *Agrostis*.

*Riparian and swamp vegetation*

According to Sebsebe Demissew *et al.* this vegetation type consists of at least two physiognomically different types, riverine and riparian forest, and open, almost treeless swamp vegetation. Typical trees in riverine forest are *Celtis africana*, *Ficus sycomorus*, *Mimusops kummel*, *Tamarindus indica*, *Syzygium guineense*, *Kigelia aethiopum* and species of *Acacia*. The swamps are dominated by species of Cyperaceae, grasses and many herbs.

*Coastal vegetation*

Sebsebe Demissew *et al.* do not describe this, since their account only deals with Ethiopian vegetation.

On the map of Sebsebe Demissew *et al.* both the Western and the Eastern Plateau are dominated by *Dry evergreen montane forest and grass-*

land, surrounded at slightly lower altitudes by *Evergreen scrub*. Still lower on the western escarpment were extensive areas of *Combretum-Terminalia* woodland and savanna, and on the eastern escarpment equally extensive *Desert and semi-desert scrubland* which continued in the Sahel area in northwestern Eritrea.

There is some similarity with the map of Pichi-Sermolli in the distribution of the *Dry evergreen montane forest and grassland* at higher altitudes and in the northern parts of the Western Plateau and in the central part of the Eastern plateau. This is the distribution of Pichi-Sermolli's (12) *Montane savanna*. The distribution of the *Evergreen scrub* at lower altitudes and in large parts of the southern end of the Western Plateau is somewhat reminiscent of Pichi-Sermolli's (10) *Montane evergreen thicket and scrub*.

This is a simple representation, but some of the information in White's vegetation map on the lowland vegetation has been lost, and the problem of how to map and refer to the complex plateau vegetation is not yet completely solved.

In the Conservation Strategy of Ethiopia (1997) the following vegetation types are used as the basis for discussions and plans: *Desert and semi-Desert Scrubland*, *Acacia-Commiphora (Small Leaved Deciduous) woodland*, *Lowland Semi-Evergreen Forest*, *Combretum-Terminalia (Broad-Leaved Deciduous) Woodland*, *Moist Evergreen Forest*, *Evergreen Scrub*, *Dry Evergreen Montane Forest and Montane Grassland*, *Afro-alpine and Sub-afroalpine Vegetation*, and *Riparian and Swamp vegetation*.

## Discussion

The above reviews of the classifications of the mapping units proposed by previous workers demonstrates that identical or at least closely analogous data sets on vegetation can be rather differently represented, resulting in considerable discrepancies between the maps. It is easy

to see that the same physiognomically and floristically defined vegetation units are included in different complexes when viewed by different authors. However, the descriptions and the interpretations of the vegetation types do not agree, and it is therefore not possible simply to rearrange the mapping units of the existing classifications and maps. We have to discuss and find the best possible solutions on at least three outstanding questions.

1. The existing maps demonstrate the difficulties with the representation of complex vegetation mosaics and gradients, especially where the altitude changes drastically within a short distance. It is not realistic to have a map on a bigger scale than *c.* 1:5,000,000 for the *Flora of Ethiopia and Eritrea*. Should a new vegetation map in the *Flora of Ethiopia and Eritrea* be equivalent to, more detailed or more generalised than those previously published?
2. The representation of the lowland vegetation in the previous maps is rather different from map to map, but broadly speaking White's map has cleared up the difficulties, with the exception of the lowland forests in western Ethiopia added on the map by Friis. Is the lowland vegetation reasonably represented by a slight modification of White's ideas?
3. The plateau vegetation seems to represent the greatest unsolved difficulties. Is it possible to find a representative way to interpret this very complex system of grasslands, bushland, woodlands and forests in the highlands, taking into account the intensive farming that has been going on in these areas for hundreds or thousands of years? White (1983) has used a map unit (his no. 17, see Fig. 4) to indicate secondary vegetation following upland and montane forest in southwestern Kefa. Slightly illogically, he has not used a comparable map unit to indicate

the secondary vegetation of the plateaux. To what extent should a new vegetation map use map units for secondary vegetation types for the highlands?

With the printing of *c.* 50% of the *Flora of Ethiopia and Eritrea* completed and much more already at hand in manuscripts, it is appropriate and timely to be planning the vegetation map of Ethiopia and Eritrea, which would be part of the consolidated Volume, Vol. 8 of the Flora. The background for the need to have the vegetation map appears from the discussion above.

The characterisation of the lowland vegetation seem according to the authors rather satisfactory in White's vegetation map while the intermediate and the montane vegetation types are still incompletely characterised. The authors therefore suggested a simplification of White's vegetation map of the highlands by making them appear on the map as a mosaic of woodland (in rain shadow areas), forest (in areas receiving more rain), grassland and evergreen bushland and scrub (quite often degraded sites or areas of intensive farming for a long time).

Sebebe Demissew, second author of this paper, indicated that the 1996 vegetation map (Sebebe Demissew *et al.* 1996) was initiated as part of the report which aimed at presenting the natural resources of Ethiopia for the UN Conference held in Rio de Janeiro in Brazil in 1992 at the Secretariat office for the Conservation Strategy of Ethiopia under the Ministry of Planning. He also indicated that this vegetation map has been used since then for a number of scientific and practical purposes, but needed improvement and was hence presented here at the symposium for comments, suggestions, *etc.*

The following comments were forwarded:

Mike G. Gilbert (Natural History Museum, UK) suggested (1) to make use of the map in

Science (1984/85) for the preparation of the vegetation map; the map in Science was the maps which Kåre Lye had used for his presentation during the symposium; (2) to use satellite imagery which is based on chlorophyll productivity and also takes care of the seasonality and provide information on the growing conditions.

Tewolde Berhan Gebre Egziabher (Environmental Protection Authority, Ethiopia) indicated that the use of the satellite imagery would not be realistic, as it is difficult to decide when to use it (either at the end or at the beginning of a wet season), and exactly where the satellite image would give reliable results. He suggested instead to include information in the preparation of the map (or in separate maps) on (1) the distribution of rainfall (unimodal and bimodal) from existing sources, and (2) the evapotranspiration to supplement the rainfall data on species distribution of certain key taxa (not only woody plants), and that these species should be mapped on the present agricultural system in order to incorporate these in the vegetation types.

Zerihun Woldu (Addis Ababa University, Ethiopia) informed about the presence of vegetation map tools which can integrate information on the various environmental factors such as rainfall, evapotranspiration, *etc.*, and which can show the average of 10 years climatic events for a given season.

Sue Edwards (Ethiopian Flora Project, Ethiopia) indicated that (1) the existing map puts more emphasis to woody plants than grasses and this should be adjusted in the future, (2) wetlands are not shown and should be included; (3) the number of species used to describe vegetation types should be limited to a reasonable size, and suggested (4) the present land-use map should be taken into consideration.

Roger Polhill (RBG, Kew, UK) suggested that there could be different kinds of vegeta-

tion maps, (1) a general map for students; (2) a detailed map for the flora which shows the mosaics, and refer to subsidiary vegetation maps with more detailed information. He warned against only adopting Friis' idea of a simplified vegetation map (a map where the highlands were only indicated as a mosaic of forest, woodland, grassland and evergreen bushland), as such a map might mislead people to think that the pattern was simple.

Ib Friis repeated as a general comment what had been said earlier during discussions that the indication of the lowland vegetation types was too simplified in the 1992 map, and as a reply to Dr Polhill that a better indication of some of the vegetation types in the highlands could be achieved if a method used for the Ethiopian highlands by White was elaborated: White has used various letters to indicate patches of special vegetation in the highlands. Examples of this are "J" for Juniperus-forest, "M" for evergreen montane forest, *etc.*

Kåre Lye (Norwegian Agricultural university, Ås, Norway) informed that the present vegetation map of Norway included 125 vegetation types, and that this was very useful for nature conservation, as it could indicate which vegetation types were rare and which were widespread in Norway. However, this requires a large scale map and detailed knowledge of the vegetation, including a system that can characterise secondary vegetation types.

Kaj Vollesen (RBG, Kew, UK) indicated the use of the production of several types of maps, depending on the intended use of the maps.

Robert B. Faden (Smithsonian Institution, USA) suggested: (1) to include as much detail as possible; (2) to have as many vegetation types as could possibly be recognised.

Ensermu Kelbessa (Addis Ababa University, Ethiopia) emphasised the existence of considerable variation in vegetation and species composition in even a small restricted area in many places, thus underlining the complications that

Friis had pointed out. Ensermu cited the zonation of the vegetation around Lake Chamo in the Rift Valley as an example: Here the vegetation ranged from many types of shore vegetation surrounding the lake (for example swamps, reed swamps, swamp forest) to *Acacia* woodland close to the lake to deciduous thickets a few kms away from the lake. Dr. Ensermu also agreed with Prof. Friis in the view that the development of the scrub vegetation in the highlands is largely a result of human interference. He finally pointed out that these points need to be considered in order to come up with satisfactory vegetation types that could be mapped.

Mike G. Gilbert indicated the presence of mosaics such as the Somali-Masai region which are mainly based on geological factors and suggested the inclusion of geological information.

Tewelde Berhan Gebre Egziabher suggested that in order to improve the existing vegetation map: (1) a combination of species distribution, distribution of environmental factors and common sense needed to be used, (2) that as many sources as possible should be consulted, and (3) the work should start as soon as possible.

With the above comments, the session was concluded. At the end of the session it was understood that the suggestions presented will be looked into by the organisers of the session, Ib Friis and Sebsebe Demissew, and a report presented to the Editorial Board of the *Flora of Ethiopia and Eritrea*.

## Conclusion

The authors of this paper both feel that a fairly simple map on the scale of 1:5,000,000 (or near) will be what is needed for reproduction with the last volume of *Flora of Ethiopia and Eritrea*. We think that it would be most feasible essentially to follow the advice of Dr Tewelde Berhan Gebre Egziabher and base the outlines

of this map on climatic and altitudinal data, supplemented with existing knowledge of vegetation and data on species distribution of certain key taxa. The vegetation types mapped will have to be fairly broadly defined, with approximately fifteen mapping units. The lowland vegetation will probably be reasonably well represented by this method, and we think that the results of the application of these methods will be fairly similar to that shown by White (1983), except where vegetation types were poorly known when he made his map. For areas with complex vegetation patterns, especially in the highlands where the vegetation is much influenced by agriculture, it will probably be feasible to use an elaboration of the non-hierarchical system of White (1983). According to this, letters or other specialised conventional signs are used to indicate the presence of special mapping units of very restricted range, such as small forest patches, swamps, outcrops of particular rocks, for example gypsum, with particularly species-rich, succulent flora, *etc.* It seems a practical idea on a map of the scale of c.1:5,000,000 to indicate vegetation types which represent seral stages in a fairly well defined succession under the same heading, as was done by Breitenbach, but simpler. In some cases it may be necessary to indicate with the same conventional signs (*i.e.* the same mapping unit) phytogeographically defined vegetation complexes of small extension, for example Afroalpine or montane vegetation types, coastal mosaics, *etc.* It will be possible, and indeed very desirable, as a parallel enterprise to start compiling data of use in the production of a map on a larger scale to be produced later, especially distribution maps of more key taxa. This is likely to compensate for some of the shortcomings of the more crude vegetation map in 1:5,000,000.

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