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Atlas of the Potential Vegetation of Ethiopia

By Ib Friis, Sebsebe Demissew and Paulo van Breugel

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Atlas of the Potential Vegetation of Ethiopia

Synopsis

A new map of the potential vegetation types of Ethiopia has been produced at the scale of 1:2,000,000. It is published here as an atlas with 29 map plates. The map shows the distribution of twelve potential vegetation types that can be mapped using environmental parameters and GIS-methodology. In the accompanying text these vegetation types have been described and further divided into a number of subtypes. The types and subtypes are: (1) *Desert and semi-desert scrubland*. (2) *Acacia-Commiphora woodland and bushland* (with the subtypes (2a) *Acacia-Commiphora woodland and bushland proper* and (2b) *Acacia wooded grassland of the Rift Valley*). (3) *Wooded grassland of the western Gambela region*. (4) *Combretum-Terminalia woodland and wooded grassland*. (5) *Dry evergreen Afromontane forest and grassland complex* (with the subtypes (5a) *Undifferentiated Afromontane forest*, (5b) *Dry single-dominant Afromontane forest of the Ethiopian highlands*, (5c) *Afromontane woodland, wooded grassland and grassland*, (5d) *Transition between Afromontane vegetation and Acacia-Commiphora bushland on the Eastern escarpment*). (6) *Moist evergreen Afromontane forest* (with the subtypes (6a) *Primary or mature secondary moist evergreen Afromontane forest*, and (6b) *Edges of moist evergreen Afromontane forest, bushland, woodland and wooded grassland*. (7) *Transitional rain forest*. (8) *Ericaceous belt*. (9) *Afroalpine belt*. (10) *Riverine vegetation*. (11) *Fresh-water lakes, etc.* (with the subtypes (11a) *Fresh-water lake vegetation (open water)* and (11b) *Freshwater marshes and swamps, floodplains and lake shore vegetation*). (12) *Salt lakes, etc.* (with the subtypes (12a) *Salt lake vegetation (open-water)* and (12b) *Salt pans, saline/brackish and intermittent wetlands and salt-lake shore vegetation*). The taxonomic revision of the Ethiopian flora for the *Flora of Ethiopia and Eritrea* has been completed, and intensive field studies of the flora have been carried out over nearly the entire country, after the publication of two previous detailed vegetation maps of Ethiopia, by Pichi Sermolli in 1957 and by Frank White in 1983 – both at the scale of 1:5,000,000; this new information has been incorporated in the present map. New ideas about the classification of Ethiopian vegetation have also been put forward on maps produced on smaller scale. Here, the vegetation types used for the last two vegetation maps in 1:5,000,000 and the later maps on smaller scales are reviewed and discussed, and the definitions of most previously accepted vegetation types have been revised. Definition of a characteristic forest type, *Transitional rain forest*, in south-western Ethiopia has been completely reworked, and, for the first time, it has been attempted to classify saline vegetation on a vegetation map of Ethiopia. The vegetation atlas has been produced using a digital elevation model with a resolution of 90 x 90 metres in connection with GIS technology; it is based on information from previous literature, field experience of the authors, as well as on an analysis of information about approximately 1300 species of woody plants in the completed *Flora of Ethiopia and Eritrea*.

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Introduction

Generalised vegetation maps showing plant formations or floristically characterized associations have for long been published for Africa as a whole or for various parts of the continent. Early vegetation maps of this type were first published by German botanists by the end of the 19th Century, for example Engler's first map of the vegetation of Africa (Engler, 1882), showing the difference between the parts of Africa covered by forests (Engler's *Waldgebiet* – forest region) and those covered by woodlands and wooded grasslands (Engler's *Steppengebiet* – grassland and wooded grassland region). Engler further developed his views on the geographical distribution of African vegetation in a number of subsequent works (Engler, 1908, 1910), but his basic distinction between forest on one side and woodland, wooded grassland and grassland on the other, remained the same, and has survived to the present work.

The first vegetation map covering the Horn of Africa (comprising the present states of Eritrea, Ethiopia, Djibouti and Somalia) was published by Negri (1940) at a scale of 1:7,000,000, but that pioneer work has been completely superseded by later vegetation maps.

Need for a new vegetation map of Ethiopia realised in connection with the Ethiopian Flora project

In connection with the third International Symposium on the *Flora of Ethiopia and Eritrea* in Copenhagen in 1999, Friis and Sebsebe Demissew (2001) provided a detailed account of how the vegetation types of Ethiopia had been conceptualized by earlier authors, and how they had visualised their various ideas about generalised vegetation categories in Ethiopia. Apart from the maps by Pichi Sermolli (1955, 1957), the review dealt chiefly with the UNESCO-AETFAT-UNSO Vegetation map of Africa (White, 1983), but presented also a detailed discussion of the vegetation types of Ethiopia by Breitenbach (1963), the analyses of the forests of the Horn of Africa by Friis (1992) and a new synthesis of a generalised map of the vegetation of Ethiopia on a small scale by Sebsebe Demissew *et al.* (1996).

Since the review by Friis and Sebsebe Demissew (2001), a number of classifications and maps have been produced on a relatively small scale, for example 1:10,000,000 or smaller (CSE, 1997; Sebsebe Demissew *et al.*, 2004). This was, almost unchanged, accepted as the official classification of Ethiopian ecosystems in the first printed version of 2005 (IBC, 2005), and is still accepted, as appears from the version placed on the Internet by the Ethiopian Institute of Biodiversity Conservation and rendered here in Appendix 5 (p. 251). However, discussions at the Third International Symposium on the *Flora of Ethiopia and Eritrea* in Copenhagen in 1999 (Friis & Ryding, 2001) showed that there was a considerable interest in a new vegetation map on a bigger scale in connection with the conclusion of the Ethiopian Flora Project. It was not thought realistic to produce a map on a bigger scale than 1:5,000,000 in connection with the actual Flora volumes. A range of proposals were put forward at the symposium, particularly as to how detailed a map it would be feasible to produce, and how to tackle the problems of potential vegetation in relation to the actual Ethiopian vegetation that is deeply influenced by man.

It is not rare that large-scale vegetation maps are produced in connection with flora projects, for example a vegetation map in 1:2,500,000 of the countries (now Zambia, Malawi, Zimbabwe, Botswana and the Caprivi Strip of Namibia) covered by the Flora Zambesiaca (Wild & Grandvaux Barbosa, 1967). However, when the deadline for actual production of the general volume of the *Flora of Ethiopia and Eritrea* drew near in 2007-2008, it was not possible to consider production of a detailed vegetation map as part of the Ethiopian Flora Project itself. Instead, a brief review, with a small-scale generalised vegetation map, was produced and published in Volume 8 of the Flora (Sebsebe Demissew & Friis, 2009). This solution was somewhat unsatisfactory because it left unresolved many of the problems that had been raised and discussed by Friis and Sebsebe Demissew (2001).

The VECEA-project – "Vegetation map for land-use planning, natural resource management and conservation of biodiversity in Eastern Africa"

Taking into consideration the somewhat unsatisfactory situation for producing a vegetation map in connection with the final volume of the *Flora of Ethiopia and Eritrea* and the conclusion of the Ethiopian Flora project, it was with pleasure and relief that Sebsebe Demissew and Ib Friis accepted an opportunity for a more detailed study and the production of a new GIS-based potential vegetation map of Ethiopia. This opening turned up when the two authors were introduced to the VECEA-project, which acronym stands for *Vegetation and Climate Change in Eastern Africa: A high resolution digital vegetation map for land use planning, natural resource management and conservation of biodiversity in Eastern Africa*. The project was proposed jointly by the institute Forest & Landscape Denmark, University of Copenhagen, and scientists at World Agroforestry Centre (ICRAF), Nairobi, Kenya, and a proposal for financing by the Rockefeller Foundation was put forward by the two institutions in November 2007.

A first grant was given to the VECEA-project to cover work in the years 2008-2010, and work began in 2008, involving scientists from a range of East African countries (Ethiopia, Kenya, Uganda, Tanzania, Rwanda, Malawi and Zambia). Sebsebe Demissew is the botanist invited to represent Ethiopia. As mentioned, he and Ib Friis have previously published a critical review of previous works on the vegetation of Ethiopia (Friis & Sebsebe Demissew, 2001). The third author of this publication, Paulo van Breugel, c/o World Agroforestry Centre, ICRAF, has become involved in this work through the VECEA-project. The authors want to stress that all three have been contributing essential parts of the text and the map.

The rationale behind the VECEA-project was to mobilise existing knowledge of the distribution of vegetation types in Africa, both represented in the form of existing vegetation maps, and in the knowledge of botanists, who are familiar with the vegetation of the involved countries. The ultimate purpose of the VECEA-project is to enhance natural resource management and biodiversity conservation in the East African region now and in the future. The idea is to link occurrence of vegetation with agricultural potential, and to correlate distribution of vegetation types with spatial changes in climatic and edaphic conditions. This information will tell foresters and agronomists about likely changes in agricultural potential as a result of climate change, and help providing for design of adaptive strategies to counterbalance that change (unpublished project proposal, November 2007).

For most of the countries involved in the VECEA-project, generalised vegetation maps had been produced during the colonial period, or later in connection with more recent development projects. However, for Ethiopia the situation is different. The country has escaped colonisation, although it was invaded and partly occupied by Fascist Italy in 1935-1941. For Ethiopia no vegetation map has been produced on the basis of as detailed studies as the vegetation maps covering the East African countries further to the south. The two previous large-scaled vegetation maps of Ethiopia, both in 1:5,000,000, that produced by Pichi Sermolli (1957), part of a vegetation map of the Horn of Africa, and that by White (1983), part of a vegetation map covering the whole of Africa, showed considerable differences with regard to the vegetation types mapped and their extent.

Digitalisation of the maps by Pichi Sermolli (1957) and White (1983), and the import of these digitised maps into GIS, demonstrated clearly that the maps were largely at variance with each other when superimposed, in such a way that the extents of related vegetation types on the two maps were not congruent. Moreover, the vegetation types on the two maps, which are largely related to altitude, did not agree with the complex relief of Ethiopia, as the topography of that country is known today. The most striking example, but only one of many, is the Afroalpine vegetation on the Sanetti plateau, the highest part of the Bale mountains. This high plateau, between 20 and 30 kilometres across, is the most extensive area above 4000 metres altitude in tropical Africa, but this mountain massif had not at all been indicated on the map by Pichi Sermolli (1957). Instead, Pichi Sermolli's map had indicated continuous montane savanna for the area where the Sanetti plateau is. The Sanetti plateau is marked, but not precisely located, on the map of White (1983). Sufficiently detailed topographic maps of Ethiopia were not available to cover the need of vegetation mapping. Only modern satellite images have made available detailed topographical mapping of even the remotest parts of Ethiopia.

The current publication is a combination of the new vegetation map needed for the Ethiopian Flora Project, and at the same time an input for Ethiopia to the VECEA-project, a substitute for the previous regional vegetation maps that were never produced for Ethiopia. A new and better vegetation map of this topographically complex country is possible now, when GIS-technique has been developed and can be used with detailed digital elevation models (DEMs) that have now been produced and made publicly available.

The first DEM to be used in connection with the Ethiopian Flora Project was GLOBE (Hastings *et al.*, 1999), which had a resolution of one kilometre and was utilised, for example, in maps showing the distribution of species of *Solanum* studied for the Ethiopian Flora Project (Friis, 2006). Here we have used a model with much higher resolution, the SRTM (Shuttle Radar Topography Mission) 90 x 90 metres Digital Elevation Model, as provided by the CGIAR-CSI (The Consultative Group on International Agricultural research, Consortium for Spatial Information (CGIAR-CSI, 2008)). The data set for this DEM is freely available from the home page of CGIAR (http://csi.cgiar.org/).

In this work, the vegetation of Ethiopia has been divided into twelve major types, some of these divided into subtypes. The vegetation types are based on information from previous literature, field experience of the authors, as well as on an analysis of the information about approximately 1300 species of woody plants in the *Flora of Ethiopia and Eritrea*. It has been attempted to define simple criteria for the vegetation types and relate them to altitude and other topographical features, for example rivers and lakes, and rainfall patterns, in short such parameters that could be handled by GIS. It is clear from detailed studies of the maps by Pichi Sermolli (1957) and White (1983) that they have also used topography as an important guide in the delimitation of their vegetation types, but now it is possible to greatly refine their results. Of the vegetation types and subtypes described in the text, we have found it possible to map fifteen units that have large enough extension to appear on the map and can be defined in relation to topographic features (altitude, rivers and lakes) and rainfall.

Acknowledgements

This work is the result of the converged efforts of many projects, funding bodies and institutions, and we wish to thank them all. However, most support for this work can be grouped into two major categories, which we could call the two "legs" on which our efforts stand.

The older "leg" is the Ethiopian Flora Project, which began in 1980 in order to produce a new manual, the *Flora of Ethiopia and Eritrea*. This project has published the last two volumes of the Flora in 2009. The core support for the Ethiopian Flora Project has been provided by the Swedish Government via SIDA/SAREC (acronyms for, respectively, the Swedish International Development Cooperation Agency, and SIDA's sector department for support to research in partner countries, and research of importance for the development of these countries). The "leg" of the Ethiopian Flora Project has from Danish side been supported by grants from the Carlsberg Foundation, which has partly financed the activities of Ib Friis in Ethiopia for nearly forty years, and sometimes also the collaboration of Sebsebe Demissew. The Carlsberg grants have mainly been used for field work in remote and little known parts of Ethiopia. Other of Sebsebe Demissew's field activities were supported by the Norwegian Programme for Development, Research and Education (NUFU) and activities carried out in collaboration with Prof. Inger Nordal, University of Oslo.

The second "leg," the VECEA-project described earlier in the Introduction, has come about in 2008 due to the Forest & Landscape Denmark, University of Copenhagen, the World Agroforestry Centre (ICRAF), Nairobi, Kenya, and the Rockefeller Foundation. The authors are indebted to these institutions for support and encouragement while carrying out the present work.

Sebsebe Demissew and Ib Friis would also like to thank their universities, the Addis Abeba University and the University of Copenhagen for enabling them to work with the *Flora of Ethiopia and Eritrea* and the VECEA-project. The funding from SAREC, NUFU and the Carlsberg Foundation has been administrated through these two universities, and it would not have been possible for Sebsebe Demissew to participate in SIDA/SAREC-financed activities if the Addis Abeba University was not an official SIDA/SAREC partner. All three authors are grateful to their employers and sponsors for the support they have received in the period of data gathering for, and in the final execution of this work. The authors would also like to thank two anonymous reviewers for their suggestions, and Victoria Gordon Friis, for reading the text and proposing corrections with regard to readability and linguistic precision. She did this after having seen most of the vegetation types in the field in Ethiopia. However, the responsibility for errors in this work remains with the authors.

Last, but not least, we would like to thank the Royal Danish Academy of Sciences and Letters for publishing this atlas and the accompanying descriptive text.

Topography, geology, soil and climate of Ethiopia

Details about distribution of the potential vegetation types presented in this atlas are based on a number of parameters: altitude (also representing temperature), precipitation and a number of other factors that are mentioned or used if they have been available in a GIS-usable form, for example drainage system, presence of water bodies and flood plains, salinity and the presence of certain soil types, particularly vertisols (black cotton soils). It has been considered better to use a high-resolution digital elevation model to represent temperature than to use extrapolated temperature data from the rather few meteorological stations in the country. Other environmental factors of importance for the development of potential have not been available in a form that could be used in the GIS-analyses.

In order to make the atlas as reader-friendly as possible, this chapter presents a summary of general information about the topography of Ethiopia and additional information about environmental factors, including geology, soil types and the seasonal distribution of precipitation, some of which is has not been possible to include directly in the GIS-analyses.

Topography, place names, floristic units of the *Flora of Ethiopia and Eritrea*

Ethiopia is a land-locked country in the central part of the Horn of Africa. It shares borders with the following countries (clockwise from the north, with the approximate length of the shared borders indicated in brackets): Eritrea (approximately 910 kilometres), Djibouti (approximately 350 kilometres), Somalia (approximately 1600 kilometres), Kenya (approximately 860 kilometres), and Sudan (approximately 1600 kilometres).

Ethiopia extends from 3° 24' to 14° 53' northern latitude and from 33° 00' to 48° 00' eastern longitude. The extension of the country is approximately 1270 kilometres in the direction north-south, and approximately 1650 kilometres in the direction west-east. The area of Ethiopia is 1,104,300 square kilometres. In Africa Sudan, Algeria, the Democratic Republic of Congo, Libya, Chad, Niger, Angola, Mali and South Africa are larger than Ethiopia, but Ethiopia is larger than any country in Western Europe, covering an area approximately the combined size of France and Spain. The altitudes of Ethiopia range from 125 metres below sea level to 4533 metres above sea level, and although the mountains in Ethiopia are not as high as the highest peaks in Tanzania, Kenya, Uganda and the Democratic Republic of Congo, Ethiopia has more ground above 2000 metres altitude than any other country in Africa.

Major features of the topography of Ethiopia can be seen in Fig. 1 (p. 14), which indicates names of these features, and Fig. 2 (p. 15), which shows the general relief in more than detail than in Fig. 1. Ethiopia consists of extensive areas of highland, surrounded by lowland on all sides except to the north, where the Western highlands continue into Eritrea. The highlands are divided by the Ethiopian sector of the East African Rift Valley that runs from the Red Sea through Ethiopia and southward through eastern Africa to Mozambique (the southernmost branch of the East African Rift is the valley of the Shire tributary to the River Zambezi).

The sector of the East African Rift Valley running through central Ethiopia is marked in the north by the triangular Afar lowlands in the AF floristic region, with the widest part towards the Red Sea coast in Eritrea. The Eritrean coastal lowland, 20 to 80 kilometres wide, is separated from the Ethiopian part of the Afar lowlands by a row of volcanic peaks, the Danakil Alps. The scarce run-off towards the east from the northern part of the Western highlands and from the Danakil Alps drains into saline lakes in the Afar lowlands, from which commercial salt is extracted.

Further to the south, from approximately 9° northern latitude, the Rift Valley becomes a rather narrow

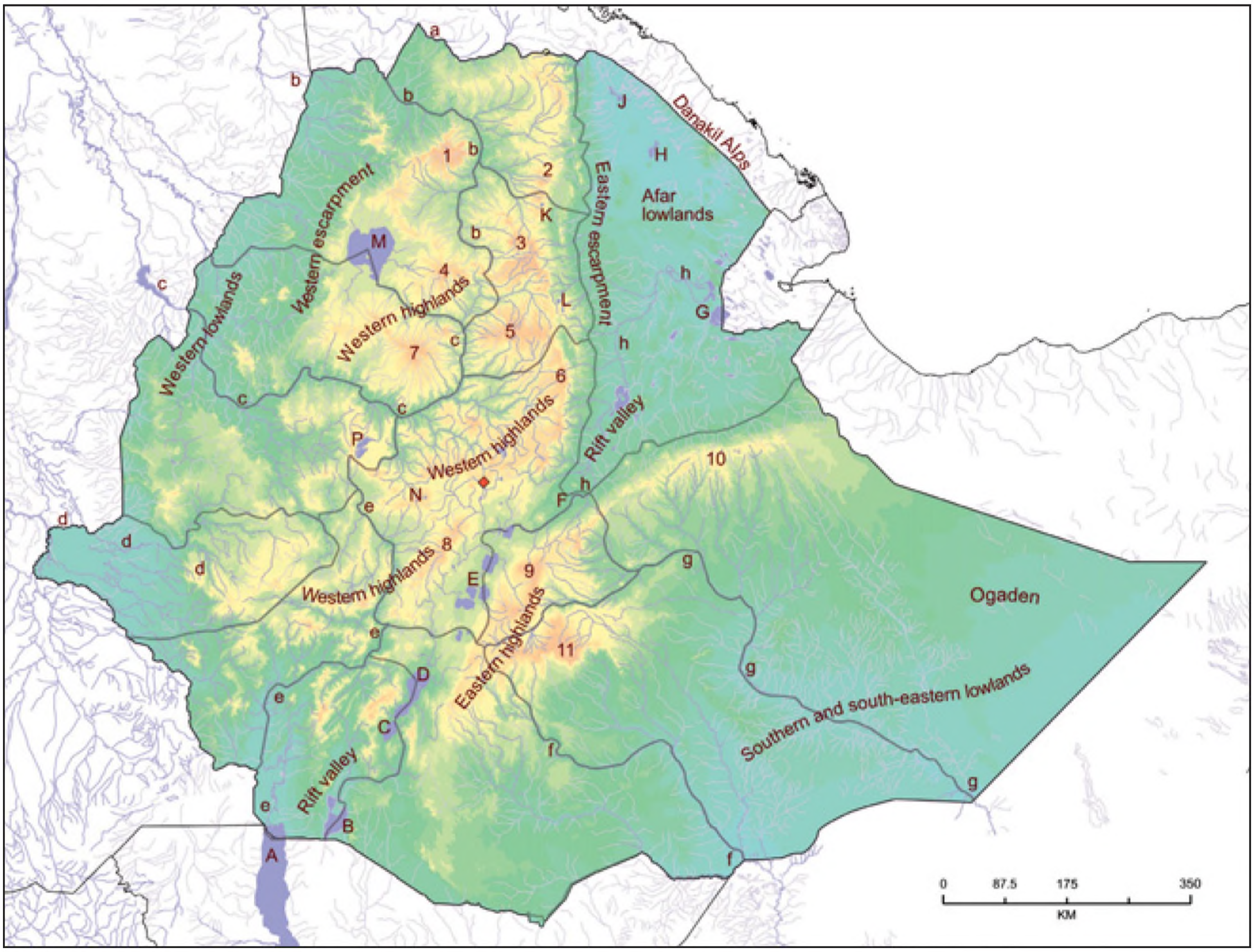


FIG. 1. Names and positions of important topographic features of Ethiopia. The solid grey lines indicate the floristic regions of the *Flora of Ethiopia and Eritrea*; see further in Fig. 3 for the standard abbreviations used for these regions used for reference in this work. Red diamond: Addis Abeba. The names of some topographic features are indicated by letters or numbers. Mountain massifs: 1 – Semien, with numerous peaks, including Ras Dejen and Bwahit. 2 – Amba-Alage. 3 – Abune Yosef. 4 – Guna. 5 – Amba Farit. 6 – Abuye Meda. 7 – Choke. 8 – Gurage. 9 – Mountains of Arsi, including Chilalo, Badda and Kaka. 10 – Gara Muleta. 11 – Bale mountains, including Batu and Tulu Dimtu; the Sanetti plateau makes up most of the brown under the number 11; the Harenna forest covers most of the southern slope to the lowland south of the number 11. Lakes and reservoirs: A – Turkana. B – Chew Bahir. C – Chamo. D – Abaya. E – Central group of Rift valley lakes, including (from south to north) the isolated Awasa, the dense cluster of Shala, Abijata, Langeno and Ziway; further to the north in the Rift Valley the Koka Dam on the Awash river. F – Metahara [Beseka]. G – Cluster of desert lakes, including Afambo, Bario, Laitaf, Gamari, and Abe. H – Afrera. J – Cluster of desert lakes with Asale, Karum and unnamed lakes in the northern part of the Afar lowlands. K – Ashange [Ashenge]. L – Hayk and Ardibo. M – Tana. N – Wonchi. P – Fincha and Chomen reservoirs. Rivers: a – Mereb. b – Tekeze. c – Abay [Blue Nile]. d – Baro, with the southern tributaries Akobo and Gilo. e – Omo, with the northern tributaries Gojeb and Gibe. f – Genale. g – Wabi Shebele. h – Awash.

and deep-sided trench that separates the Western and Eastern highlands of Ethiopia. The Rift Valley is approximately fifty kilometres wide in this part. The southern half of the Ethiopian segment of the Rift Valley is dotted by a chain of relatively large lakes, some of which hold fresh water, others contain saline water. The Rift Valley lakes are fed by small streams mainly from the east and the south.

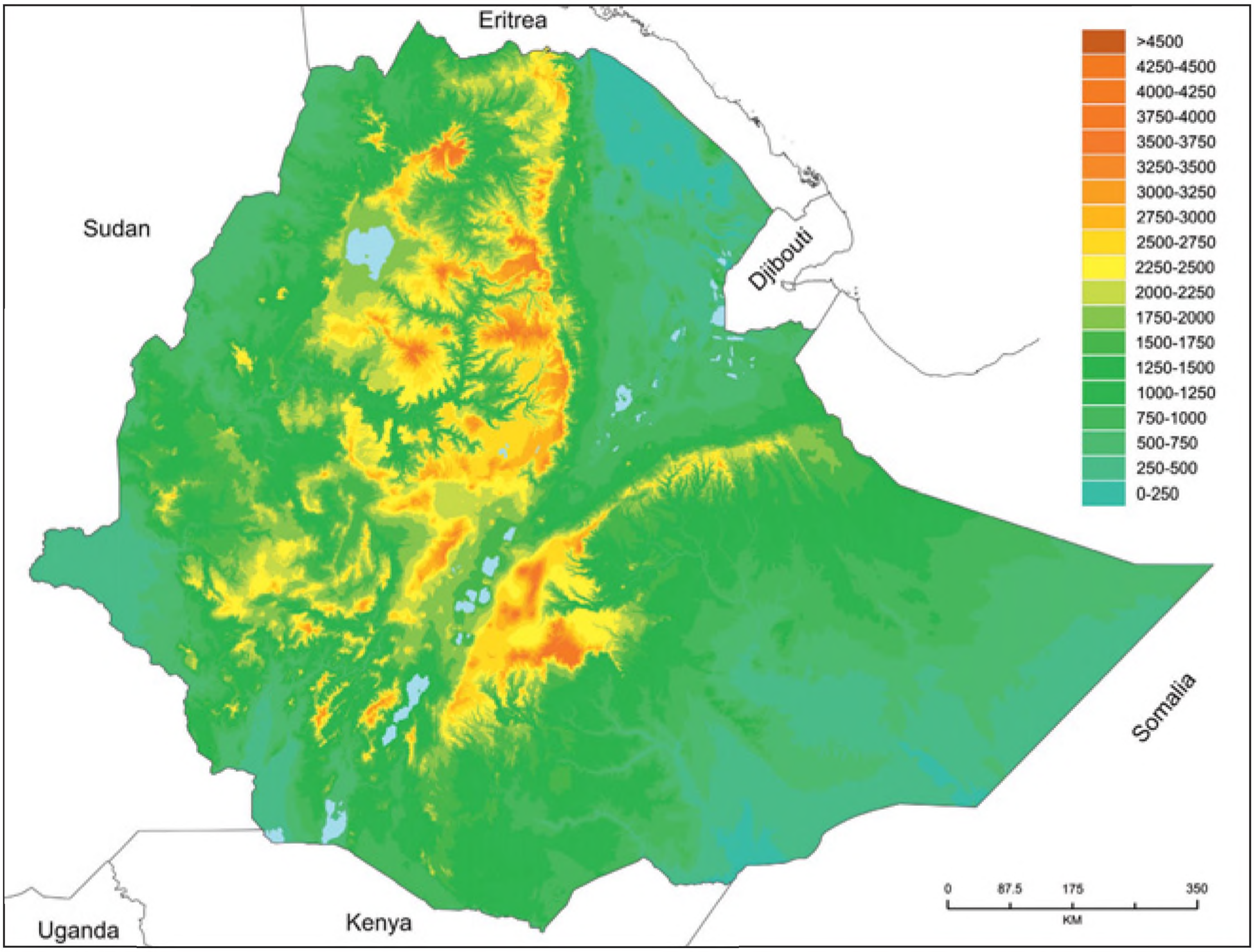


FIG. 2. Altitudes in Ethiopia indicated at intervals of 250 metres each. A small area below sea level in the Afar depression has been included with the 0-250 metres interval. The map is based on the same digital elevation model (DEM) as used for the vegetation analyses in this work, the SRTM (Shuttle Radar Topography Mission) 90 x 90 metres Digital Elevation Model. The DEM has been provided by the CGIAR-CSI (The Consultative Group on International Agricultural research, Consortium for Spatial Information (CGIAR-CSI, 2008)).

The Eastern highlands of Ethiopia slope gently towards the Southern and South-eastern lowlands that continue into Somalia and extend to the Indian Ocean; these areas range from altitudes of approximately 350 to 1500 metres. West of the Western highlands, towards the border with Sudan, is a strip of lowland, the Western lowlands, ranging from altitudes of approximately 350 to 1500 metres. The highlands of Ethiopia, on both sides of the Rift Valley, have a general elevation ranging from altitudes of approximately 1500 to 3000 metres, but most areas are below 2500 metres altitude. Scattered over the highlands are higher mountain massifs and volcanic cones that often reach altitudes over 4000 metres. Both the large massifs and the volcanic cones tend to be highest in a zone on either side of the Rift Valley. Along the western side of the Western highlands, where they meet with the Western lowlands, there is an escarpment that in this work is referred to as the Western escarpment. Along the eastern side of the Western highlands, where they meet with the Afar lowlands, there is also a steep escarpment, which in this book is referred to as the Eastern escarpment; the Eastern escarpment is generally steeper than the Western.

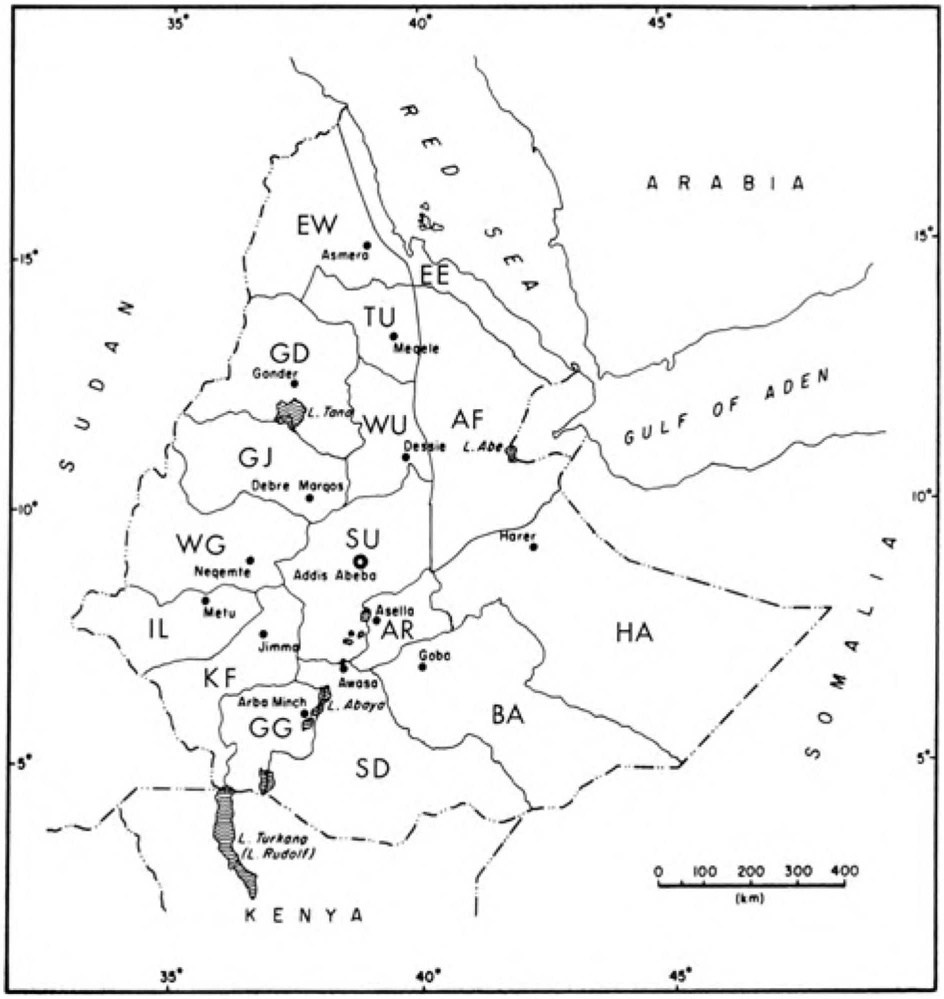


FIG. 3. Floristic regions of Ethiopia and Eritrea used for recording distributions in the *Flora of Ethiopia and Eritrea* and in this work. The floristic regions are based on the former administrative units that were used under the government of Haile Selassie I and continued to be used up to the complete reorganisation of the administrative system following the new constitution as a federal republic in 1995. Borders between traditional regions follow topographical features, while borders between the new states follow ethno-linguistic patterns. EW: western Eritrea, above 1000 metres altitude. EE: eastern Eritrea, delimited towards EW by the contour at an altitude of 1000 metres. AF: Afar, delimited towards TU, WU, SU, AR and HA by the contour at an altitude of 1000 metres, and towards EE by the old border. TU: upland Tigray; the previous Tigray region above the contour at an altitude of 1000 metres. WU: upland Welo, the previous Welo region above the contour at an altitude of 1000 metres. GD: the previous Gonder region. GJ: the previous Gojam region. SU: upland Shewa, the previous Shewa region above the contour at an altitude of 1000 metres. AR: the previous Arsi region. WG: the previous Welega region. IL: the previous Illubabor region. KF: the previous Kefa region. GG: the previous Gamo-Gofa region. SD: the previous Sidamo region. BA: the previous Bale region. HA: the previous Harerge region, modified in such a way that it is delimited against AF by the contour at an altitude of 1000 metres. Reproduced with permission from the *Flora of Ethiopia and Eritrea*.

The morphology of the Ethiopian mountains has been shaped by erosion, and most mountains are relatively steep-sided. Few of the peaks rising above the plateau are flat except for a number of level-topped mountains in the central and northern part of the country, where the original plateau form the top of mountains with eroded sides; these steep-sided, flat-topped mountains are in Ethiopia known as *ambas* (from a word in Ge'ez and Amharic, *amba*; in Tigrinya *emba* or *imba*).

The two largest and highest massifs in the Ethiopia highlands are the Semien mountains in the north and the Bale mountains in the south-east. The highest peak in the Semien mountains, and the highest point in Ethiopia, is Ras Dejen that reaches 4533 metres altitude, but there are many peaks in the Semien mountains that reach above an altitude of 4000 metres. The highest peak in the Bale mountains is Tulu Dimtu that reaches 4377 metres altitude.

The south-western part of the Western highlands is not as high as the northern section, and is cut by many wide valleys.

A list of the prominent mountain peaks with maximum heights above 3200 metres altitude has been given in Table 3 (p. 125), which has been placed near the description of the vegetation types of these peaks, the *Ericaceous belt* (EB) and the *Afroalpine belt* (AA).

Rivers have eroded deep valleys into the highlands, particularly into the Western highlands. In places the rivers now run more than 1800 metres below the level of the plateau, and the largest river gorges may be up to 30 kilometres wide. The water level in these rivers is highly fluctuation with the seasons. In the dry seasons the rivers at the bottom of the gorges may be reduced to small streams filling only a small part of the usually rocky or gravelly river bed, be dissolved into a chain of stagnant pools or be completely dried out, but during the rainy seasons the water level of these rivers rises dramatically, often within a few hours after the onset of heavy rain, and the rivers are transformed into rapid streams unsuitable for navigation and almost impossible to cross without a bridge. Due to the high rainfall in the south-western part of Ethiopia, the rivers and streams in that part of the country have a constant water supply throughout the year.

The major systems of rivers and tributaries of Ethiopia have traditionally been used to divide the country into geographical units. These units are partly identical with the floristic units used for the *Flora of Ethiopia and Eritrea* and shown in Fig. 3, with a list of the full names of the flora regions in the legend. For practical reasons the floristic units used for the *Flora of Ethiopia and Eritrea* are also used here to refer to specific parts of Ethiopia. Only the standard abbreviations of the floristic regions, each abbreviation consisting of two capital letters, are used, with an indication that the abbreviation refers to a floristic region.

Because of the general westward slope of the Western highlands, many large rivers are tributaries of the Nile system, which drains an extensive area of the central portion of the plateau. The Abay [Blue Nile], the Tekeze, and the Baro river systems are among these, and these rivers account for about half of the country's water outflow. In an increasing number of cases the potential of the rivers as sources of hydroelectric power is being utilized, and a number of man-made reservoirs are being created. The major river systems in Ethiopia have been listed in Table 4 (p. 133) together with the description of (10) *Riverine vegetation* (RV).

- The Mereb river.
- The river system of the northern part of the Afar lowlands. The rivers terminate in saline lakes in the Afar lowlands.
- The Awash river. The river terminates in large, saline lakes near the border with Djibouti.
- The Wabi Shebele river system. Most years the Wabi Shebele river does not reach the Indian Ocean, but dries out before.
- The Genale-Weyb-Dawa river system, with the Welmel and the Weyb and other rivers. At the Ethiopian border the rivers meet and form the large River Juba that flows through the South-eastern lowlands into the southern part of Somalia and meets the Indian Ocean near the town of Kisimaayo on the coast.
- The rivers of the central and southern part of the Rift Valley. The rivers terminate in the Rift Valley lakes.

- The Gibe-Omo river system, with the Gojeb river as a large tributary. The river terminates in Lake Turkana.
- The Baro-Akobo-Gilo river system. At the Ethiopian border the rivers meet and run to the White Nile in Sudan as one stream.
- The Abay [Blue Nile] river system, with the Shinfa and Dinder rivers. Several of the rivers in this system cross the Ethiopian border as individual streams and meet in Sudan before joining the White Nile at Khartoum.
- The Tekeze-Angereb-Atbara river system. Several of the rivers in this system cross the Ethiopian border as individual streams and meet in Sudan before joining the White Nile.

Lakes are scattered over the Western highlands, in the central and southern part of the Rift Valley and in the Afar lowlands. On the plateau there is one large lake, Lake Tana, and a number of smaller lakes, Lake Ashange [Ashenge], Lake Hayk, etc., as well as a number of very small lakes, many of which are volcanic crater lakes. In the central part of the Rift Valley there are two large lakes, Lake Abaya and Lake Chamo, further north there is a range of smaller lakes, for example Lake Langeno, Lake Shala, etc., and a number of small crater lakes; some of these lakes are saline. Saline and freshwater lakes exist in the Afar lowlands. Tables of freshwater lakes, Table 5 (p. 140), and of saline lakes, Table 6 (p.155), have been placed together with descriptions of the vegetation of these two kinds of habitats ((Subtype 11a) *Freshwater lakes – Open water vegetation* (FLV/OW) and (Subtype 12a) *Saltwater lakes – open water vegetation* (SLV/OW)).

Place names

Names of Ethiopian localities are often transliterated rather differently by various authors, and the position of the places they represent is not always easily traced. In order to alleviate these problems, and to help readers localising the place names, the authors have tried to refer to or cite the abbreviated names of the flora regions used in the *Flora of Ethiopia and Eritrea* wherever appropriate. See the map of the flora regions in Fig. 3.

The authors have also tried to follow a well-known map of Ethiopia in 1:2,000,000, produced by the Ethiopian Mapping Authority (Anonymous, 1997), as authority of place names and their spelling. This map has been based on similar maps from before Eritrean independence, and has been frequently reprinted also after 1997.

For the present text it has been necessary also to use a number of place names or topographic terms not indicated on this map, for example the Danakil Alps, the Semien mountains, the Bale mountains, with the Sanetti plateau and the Harenna forest, the Ogaden, etc. These names or terms can be found in Fig. 1 (p. 14), and they may also sometimes be found on maps commercially available outside Ethiopia. The authors have for such names selected a spelling that is commonly used.

The authors have also accepted commonly used designations for major geographical features, for example Western highlands, Eastern highlands, Western escarpment, Eastern escarpment, Western lowlands, Afar lowlands, Southern and South-eastern lowlands. These names are not used on the above mentioned map of Ethiopia in 1:2,000,000. The name *Rift Valley* is used for the entire rift from the border with Kenya to the border with Eritrea, which includes the Afar lowlands and the area below sea level (*Danakil depression*). Where possible, these names are indicated in Fig. 1 or explained in the legend to that figure. Place names cited from other authors that apply different spelling from the one used in this book have been identified with names on the above mentioned map of Ethiopia in 1:2,000,000, as far as this has been possible.

Geology and soils

A detailed survey of the geology of Ethiopia has been given by Mohr (1971), and a short geological history of Ethiopia is presented by Last (2009). This summary presentation is intended only as background to the biogeographical information. The oldest rocks in Ethiopia are part of the Crystalline Basement, which is pre-Cambrian in origin. The original igneous and

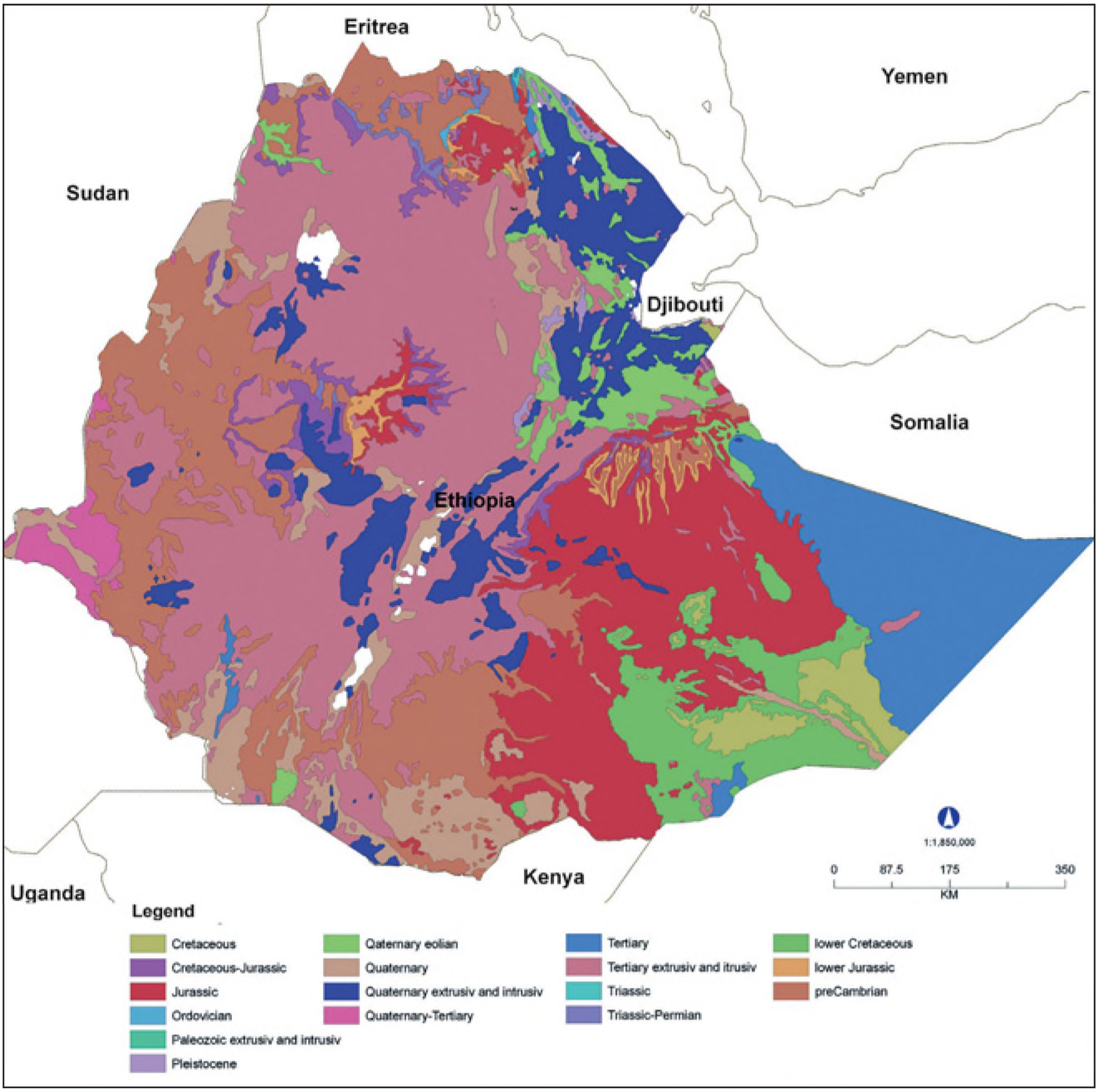


FIG. 4. Geology of Ethiopia. Map compiled by ILRI (International Livestock Research Institute).

sedimentary rocks are interbedded with schists and gneisses and subsequent igneous intrusions. The whole system is referred to as the Basement Complex.

A number of transgressions of the sea in the Mesozoic era deposited sandstones (Adigrat Sandstone) and limestones (Antalo Limestone) in the TU floristic region of northern Ethiopia. Later Mesozoic sandstones are deposited in eastern Ethiopia, particularly in the HA and SD floristic regions. The Ogaden remained covered by sea to the end of the Cretaceous period.

A dramatic uplift of the highlands marked the beginning of the Tertiary period. This was accompanied by massive outpour of lava from numerous volcanoes, resulting in the often more than one thousand metres thick basaltic shield (the Trap Series of lava deposits). The formation of the Rift Valley resulted in further uplifting of the parts of the highlands next to the Rift, and there is often a difference of more than thousand metres, sometimes up to two thousand metres, between the floor of the Rift and the surrounding edges of the highlands. Heavy rainfall and fracturing of the uplifted highlands initiated the early development of the continuously expanding river gorges still in existence on the highlands and described above. The volcanic activity continued, both in restricted areas on the highlands and throughout the entire Rift Valley system (the Aden Series of lava deposits).

A broad survey of the geology of Ethiopia is shown in Fig. 4 (p. 19). This map demonstrates the relatively uniform geological structure of the highlands dominated by Tertiary extrusive and intrusive rocks which clearly contrasts with the Palaeozoic and Mesozoic complex of the TU floristic region, the predominantly Mesozoic rocks prominent in the BA and HA floristic regions, the Precambrian and Jurassic rocks in the Abay [Blue Nile] gorge, and the many Quaternary extrusive, intrusive and eolian formations in the AF floristic region.

Pre-Cambrian rocks underlie all other rocks in Ethiopia. They form a peneplained basement of extremely folded, metamorphosed sediments and igneous intrusions. The Pre-Cambrian rocks include metamorphosed sandstone, schists, amphibole, chlorite, quartzite and quartzo-feldspathic rocks, as well as occasional intrusions of granites. These crystalline rocks are visible on the escarpments of the highlands, and they form the rock near the bottom of many of the deep river valleys.

The Mesozoic rocks of Ethiopia consist of sandstone and limestone. They appear in the deep river valleys of the central part of the Western highlands, and are visible in the much eroded TU floristic region, where Enticho Sandstone, Adigrat Sandstone, Angula Shale and Antalo Limestone are particularly prominent. Mesozoic rocks are also common on the south-eastern slope of the Eastern highlands, where limestone is common. Large areas in the eastern part of the SD floristic region, in the southern part of the BA floristic region and the Ogaden in the eastern and south-eastern parts of the HA floristic region consist of Mesozoic limestone, gypsum or geologically related rocks.

The major parts of the highlands consist of volcanic rocks dating mainly from the Tertiary (the Trap Series). The volcanic rocks include rhyolites, trachytes, tuffs, ignimbrites, agglomerates and basalts. These rocks, the major part of which is basaltic, are of considerable thickness, reaching a maximum of 3000-3500 metres in the Semien mountains, though values of 500-2500 metres are more frequent. Quite recent lava is found in the Rift Valley and in many parts of the AF floristic region.

The mosaic of soil types in Ethiopia is highly complex and dependent on the complicated topography. The soils of Ethiopia have not yet been well described in the literature, and only a very superficial impression can be given here. A broad overview of the many types of Ethiopian soils based on the FAO soil classification (http://www.fao.org/) can be seen in Fig. 5.

The FAO soil classification is based on generalizations about soils paedogenesis. It is therefore not surprising that a classification of soils in Ethiopia shows broad agreement between the division in highland and lowland and the geographical distribution of the major soil types, as well as a correlation with the patterns shown by the geological formations of the country.

A pattern with broadly defined distinction between the soils of the Western lowlands, the Western and Eastern highlands, the South-eastern lowlands and the Afar lowlands can also be generalised from Fig. 5. Red or brown Ferralsols derived from volcanic parent material are found in the highlands. Umbrisols are found chiefly in the humid parts of the highlands. Andosols are associated with recent volcanic activity in tectonically active areas, mainly in the highlands. Cambisols are soils with a beginning of soil formation or because soil formation is comparatively slow, as in cool, high altitude areas; the horizontal differentiation of cambisols is weak. Stony Leptosols are particularly associated with the escarpments and the Afar

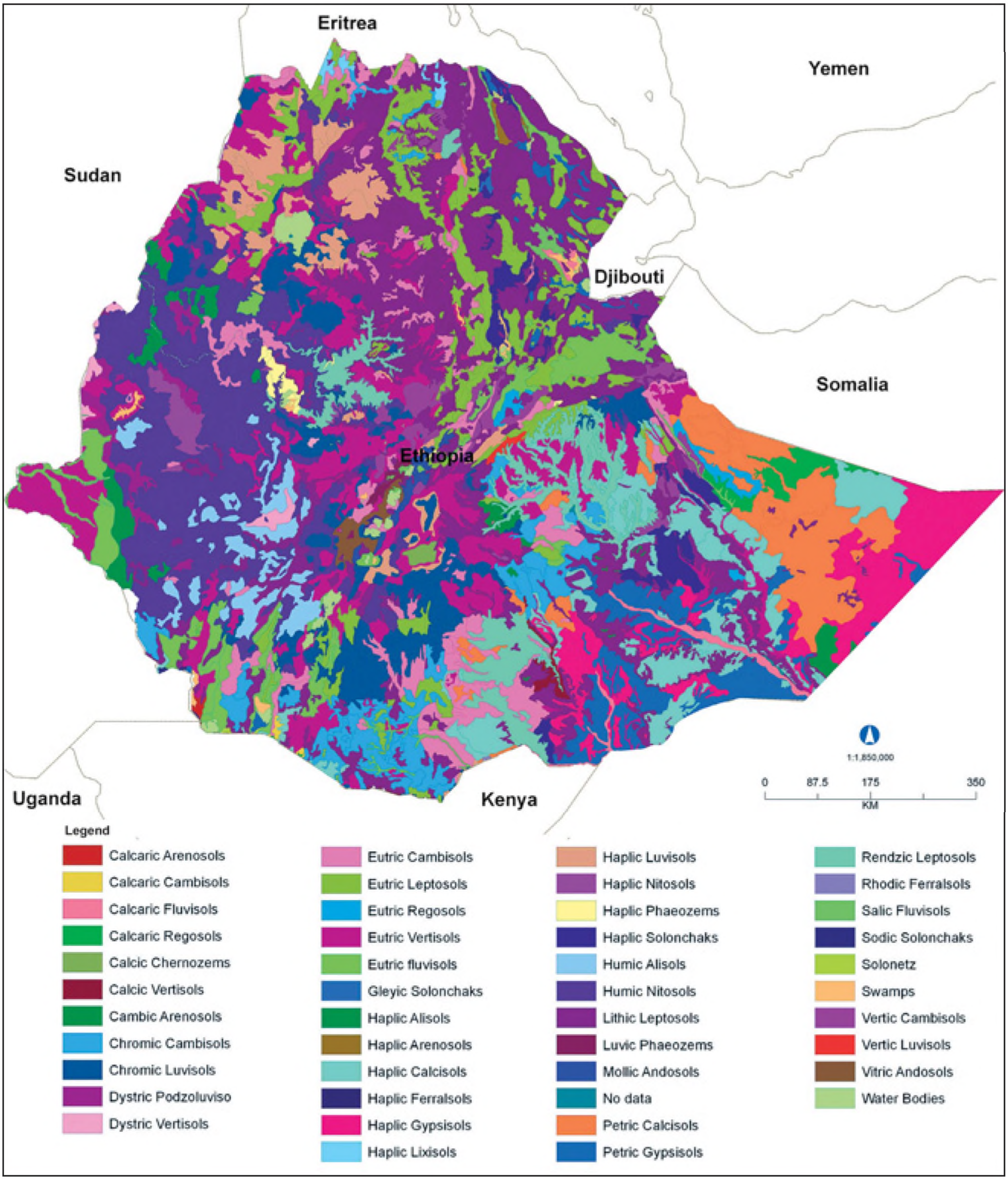


FIG. 5. Soil types of Ethiopia. Map compiled by ILRI (International Livestock Research Institute), based on the FAO classification of soil types and data from ISRIC – World Soil Information.

lowlands. Arenosols are found in arid areas of the lowlands. Calcisols are found in the areas with Mesozoic rocks in the TU floristic region and in the South-eastern lowlands. Gypsisols are restricted to the South-eastern lowlands. Black vertisols (black cotton soils) is the exception from the above mentioned rule that soil types are distributed either in the highlands or the lowlands; vertisols develop on flat ground in both highlands and lowlands.

Another broad classification, consisting of six regional soil groups, has been outline by Last (2009). The six soil groups are classified according to their geographical position and their parental rocks:

1. *The plateau soil region*. This region covers the highlands where the soils are derived from basaltic and other volcanic rocks, and the rainfall is high or relatively high. The soils are mainly red lateritic soils or black vertisol soils (Black Cotton Soils). They are usually fertile.

2. *The crystalline highlands*. These are highland soils derived from metamorphosed, crystalline rocks of the Basement Complex. These soils mainly occur at the edges of the highlands, and the soils are acid, thin, grey-brown or brown. They are usually not fertile.

3. *The desert soil region*. These soils are mainly found in the Afar lowlands, in the Ogaden and elsewhere where deserts have developed. In Afar the soil is derived from recent lava or from deposits by rivers and lakes, and some of these soils are saline or very saline. The desert soils mostly consist of withered rocks, without any humus deposited. In the Ogaden and southern desert-like regions the soils may have been formed from sedimentary rocks. The soils are more fertile than the soils of the Afar region, but are usually too dry for cultivation without irrigation. They are rich in phosphorous and potash, but low in nitrogen content.

4. *Ogaden dry steppe*. These soils have mainly been derived from sedimentary limestone rocks and are grey-brown or brown, possibly sometimes red. They have been formed under conditions with limited rainfall and have maintained the nutrient of the parent material due to only slight leaching. They are rich in carbonates and are fertile with irrigation.

5. *The Rift lakes region*. The soils here are complex in origin, some derived from recent volcanic rocks, some from sediments deposited by the previously more extensive Rift Valley lakes. The parental rocks are very varied, as some deposits come from the basaltic highlands, others from either of the flanks of the Rift Valley. Rainfall is limited. The soils are therefore only partly leached and can be fertile when water is available.

6. *Alluvial plains*. These are the plains of the large rivers. The soils are derived from material transported from the drainage area of the river, including top-soil from the highlands and may therefore be fertile.

Neither of these summaries gives an adequate description of the Ethiopian soils. Apart from the broad distinctions between lowlands and highlands and some patterns related to geology and rainfall it has not been possible to relate the soil types to the vegetation types used in the map plates in this atlas, and it has not been possible to include soil types in the GIS-based mapping of potential vegetation.

Climate

The climate of the study area is not yet well described in the literature. Only a short descriptive summary can be given here. The main emphasis has been placed on the precipitation, which varies in a less predictable way in relation to altitude, as represented in the Digital Elevation Model (DEM), than does the temperature.

The climate of Ethiopia is governed by two main topographic factors: the closeness of the Equator, with the southern boundary of the country at approximately 3° 30' northern latitude, and the complexity of the relief, which ranges from 125 metres below sea level to 4533 meters above sea level. The topography of Ethiopia is highly important for the climate, as out-

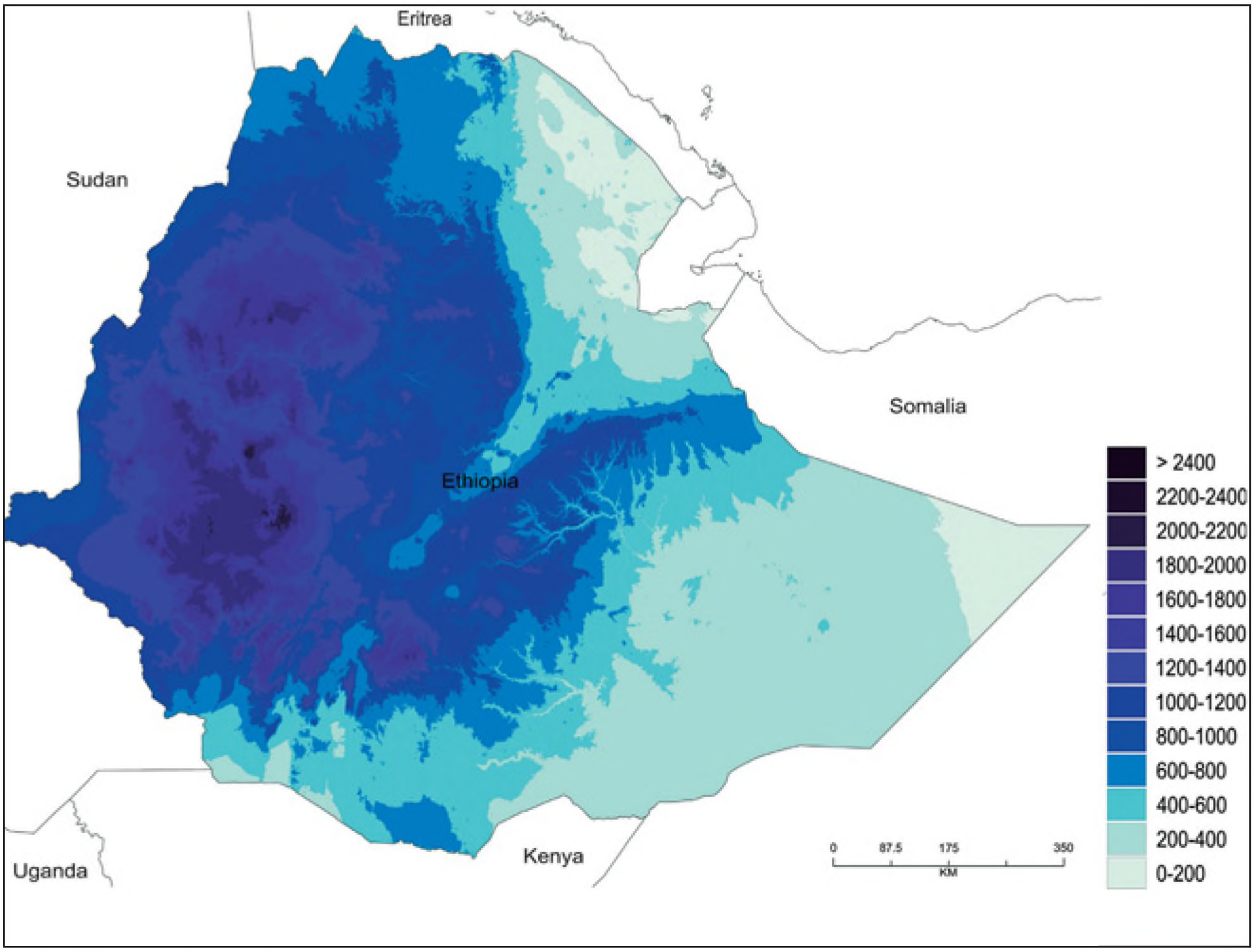


FIG. 6. Mean annual rainfall. The map has been produced from the climatic data set used for the production of this atlas, Worldclim/Bioclim with 30 arc seconds resolution (Hijmans *et al.*, 2005a).

lined by Liljequist (1986). Because of the closeness of the Equator, the monthly average temperature at a particular altitude shows little seasonal variation, approximately 2° C in the southern part of the country, and approximately 6° C in the northern part, usually with a slight minimum during the rainy season when the sky is frequently overcast. Daily variation, however, may be considerable; at Addis Abeba the daily amplitude may be as much as 17-18° C. The average annual temperature is mainly a function of the altitude, and is estimated to decrease with altitude by 0.5-0.7° C per 100 metres increase in altitude (Hahn, 1908; Liljequist, 1986).

The mean annual rainfall is shown in Fig. 6, based on the climatic data set that has been used for the production of this atlas, Worldclim/Bioclim with 30 arc seconds resolution (Hijmans *et al.,* 2005a). The following description of the factors behind the seasonal variation in rainfall is based on Liljequist (1986). The rainfall in Ethiopia depends mainly on the prevailing winds, which are governed by the movement of the intertropical convergence zone (ITCZ). However, the rainfall is much modified by local relief. Two contrasting wind systems exist, depending upon the position of the ITCZ. In the summer, from May to October, the ITCZ is north of the Equator; the prevailing wind over most of Ethiopia is south-westerly. These moisture-laden wind-systems produce rain over large areas of the escarpments and highlands. The highest rainfall is in the south-western part of the Western high-

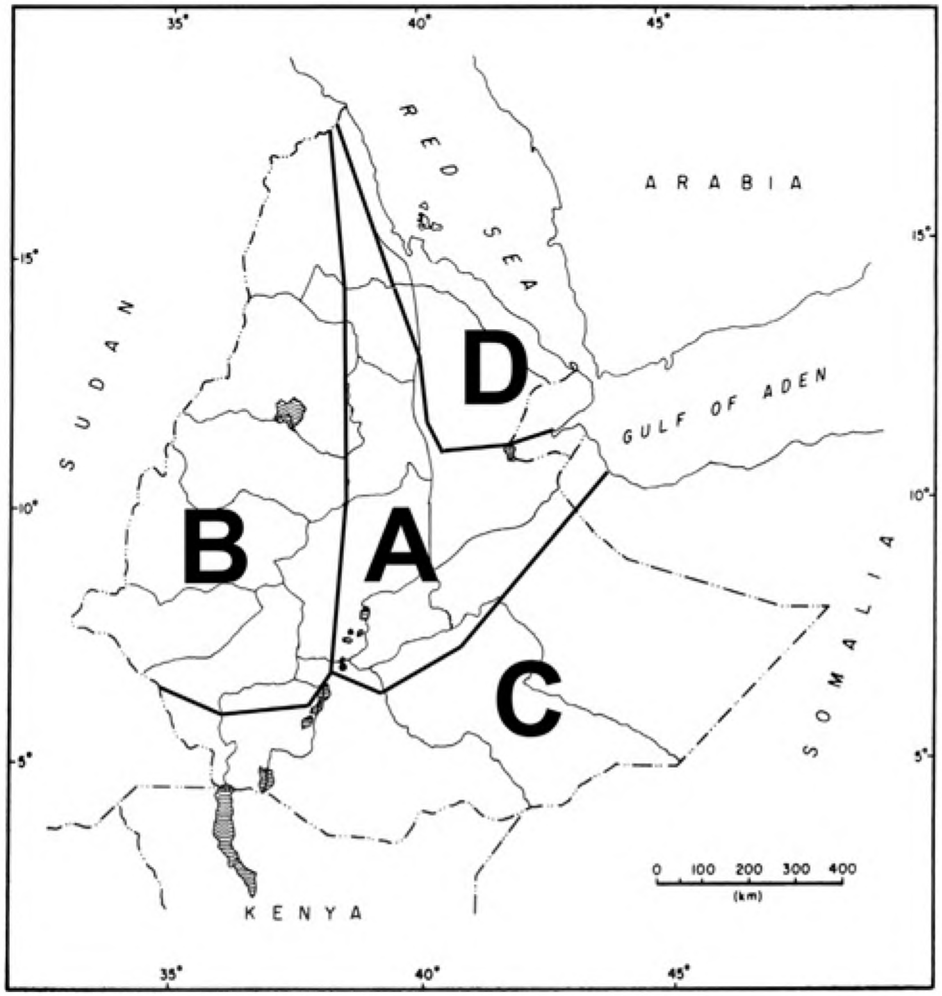


Fig. 7. Major seasonal rainfall patterns in Ethiopia and Eritrea. A – Bimodal rainfall patterns with spring and summer rains and short dry season during the early summer, particularly in June. B – Unimodal rainfall patterns with summer rains from June to September predominant, but with rain during most of the year in the southern part in the KF, IL and WG floristic regions. C – Bimodal rainfall pattern with spring and autumn rains and longer dry season during the summer than in A. D. – Scanty and erratic rainfall with winter maximum. There is no sharp boundary between pattern A and B; from the eastern part of the highlands towards the western part the bimodal pattern becomes gradually less distinctive. Redrawn and modified from Sebsebe Demissew *et al.* (2004); the modifications are mainly based on information from the climate stations shown in the *National Atlas of Ethiopia* (Anonymous, 1988).

lands, where the ascent of the wind is the steepest. The rainfall is related to the passage of the ITCZ in northern and southern direction, respectively, and there is normally a dry period in between the two rainy periods.

In the winter months, from November to April, the ITCZ is well to the south of Ethiopia and the prevailing winds are north-easterly, bringing only little moisture from the Red Sea. This moisture is soon spent over the escarpments of Eritrea and the areas around the Danakil Alps, and only little rain falls on the highlands during these months. However, due to local conditions rain may occur throughout the year in the south-western part of the Western highlands, chiefly in the KF, IL, WG and south-western GJ floristic regions, so this area has not only the highest but also the most evenly distributed rainfall in the country.

On the south-eastern slope of the Eastern highlands and in the lowlands of the Ogaden and southern Somalia there is a local convergence zone between the above-mentioned south-west monsoon over the highlands and the south-east monsoon from the Indian Ocean, causing a double system of rainy seasons, with maxima in April-May and September-October.

These changes in the position of the ITCZ and in the wind-systems result in four different areas with contrasting rainfall regimes. See Fig. 7 for an approximate representation of the rainfall regimes.

- The central and eastern parts of the highlands, from the part of the TU floristic region close to the eastern escarpment southwards through the WU and SD floristic regions to the northern parts of the SD, AR, BA, and HA floristic regions, receive a bimodal rainfall, with small spring rains between February and May, a short dry period in June and big summer rains between July and September (A in Fig. 7). The length of the dry season separating the spring and summer rains may vary in length from year to year, and the spring rains may sometimes be sporadic. The length of the rainy periods and the intensity of the rains generally decrease from the south towards the north.

- The western and south-western parts of the Western highlands and the lowlands towards Sudan, extending from the western part of the TU floristic region through the GD, GJ, WG, IL, KF, and northern part of the GG and SD floristic regions, receive a basically unimodal rainfall of varying length during the summer, typically from June to September (B in Fig. 7). The length of the rainy period and the intensity of the rains decrease markedly from the south towards the north, but throughout this part of the country the summer is the wettest period. The south-western part of this area has the highest rainfall in the country with the annual rainfall exceeding 2400 millimetres and possibility for rain throughout the year.

- The southernmost part of the highlands and the Southern and South-eastern lowlands, extending from the Western lowlands of the KF floristic region through the Southern and the South-eastern lowlands of the GG, SD, BA, and HA floristic regions and the adjacent escarpments, receive a distinctly bimodal rainfall with a wet period in the spring and early summer from March to May and in the autumn from September to November (C in Fig. 7). The dry season during the summer is therefore almost of the same length as the dry season during winter, at least in years with typical rainfall. However, one or both rainy season may fail or occasionally be longer than indicated here. The total annual rainfall in this part of the country decreases from southern SD towards the east, and there is also a very low rainfall around and to the east of the delta of the Omo river and Lake Chew Bahir.

- The Afar lowlands and the Danakil Alps have scanty rainfall with a diffuse pattern but usually with most rain in the winter (D in Fig. 7). As on the eastern escarpment of Eritrea most rain falls between November and February, but the total annual rainfall is approximately 200 millimetres or less.

Methods: sources and scale of the new vegetation map

Potential vegetation is dependent on many variables: topography (altitude above sea level, slope, north-south orientation), climate (precipitation, distribution of precipitation during the year, temperature, potential evaporation, etc.), soil conditions (chemical composition, texture, drainage, pH and salinity), and geology of the rock from which the soil has been derived. It is also dependent on a number of historical factors. Information with that degree of detail is not available for Ethiopia, and the authors of this work have therefore used what was available and could be used to produce a result that could be verified by their personal experiences. Topography (with altitude as a substitute for temperature) and precipitation have been the main factors in the characterization of the mapped vegetation types and their relation to the GIS work. Other factors are mentioned or used as they have been available in a GIS usable form or seemed relevant, for example drainage systems, salinity, flood plains and black cotton (clay) soils. It has been thought better to use a digital elevation model as a representation of temperature than to use the rather few meteorological stations that have been functioning in the country for a reasonable length of time.

Field surveys

The potential vegetation map in this publication is based on broad field surveys, mainly along the roads, by the authors (Fig. 8, p. 28), and on secondary data on altitude, rainfall and distribution of wetlands and water bodies. Together or separately, the two senior authors have covered large parts of Ethiopia with exception of the easternmost part, the Ogaden (marked in Fig. 1 , p. 14).

Resolution

The data on altitude used in the compilation of the map is derived from the digital elevation model (DEM) with 90 x 90 metres resolution, as provided by the CGIAR-CSI (2008). The rainfall data set is from WorldClim (Hijmans *et al.*, 2005a) and comes at a resolution of approximately 1 kilometre. The Global Lakes and Wetlands Database (GLWD) data layer (Lehner and Döll, 2004), which was used to delineate wetlands and lakes, also comes at a resolution of approximately 1 kilometre. The scale of the vector layer with rivers and lakes (Stankiewicz and de Wit, 2005), which was used to delineate rivers and some of the lakes, is unknown. However, the maps were manually digitized from national topographic maps (de Wit and Stankiewicz, 2006), so the scale of the source material is probably in the order of magnitude of 1:500,000 or larger.

Considering the resolutions of the input data layers, a very large-scale map, for example a map in 1:250,000, would only be true with regard to the accuracy of the basic topographic features. Vegetation boundaries defined by rainfall or boundaries of wetlands and lakes from the GLWD are considerably less precise. The same is true for the indicated man-made features such as roads or towns, which we added as background information. The precision of their location is also not more than plus or minus a few kilometres. Detailed maps of remaining forest patches in southern and south-western Ethiopia were published by Chaffey (1978a, 1978b, 1978c, 1978d, 1979) as part of the reports from the South-West Ethiopia Forest Inventory. The most detailed of these forest maps were published at the scale of 1:250,000. Chaffey's maps are based on air photography, and the forests shown are the actual remaining forest patches that can only be used as a general indicator of what the potential forest type has been over larger areas.

Boundaries between vegetation types

It is also necessary to consider the certainty and nature of the vegetation boundaries themselves. In some places transition zones between vegetation types recognized on this map may be narrow and the boundary between vegetation types sharp. Examples of sharp vegetation boundaries are readily observed when one moves from the montane vegetation of a flat plateau to the steep, rocky sides of one of the deep river gorges, certain vegetation changes along steep gradients in the high mountains or the sometimes sharp boundaries between riverine and surrounding vegetation in the arid zones. However, often the transition between two vegetation types is more blurred, with wide zones of one or several kilometres where one vegetation type is gradually replaced with the other. One moves from a vegetation of "A," through "A with admixture of B," to "B with admixture of A," and only after several kilometres from the last "pure A" the vegetation consists of "pure B." Striking examples of this can be observed when one moves from *Desert and subdesert scrub* in southern Ethiopia or in the Afar region to *Acacia-Commiphora woodland and bushland*. Often the blurred boundaries between vegetation types seem to have been caused by the activities of man, where patches of potential vegetation remain in extensively farmed areas; in such cases, as the example with Chaffey's remaining forest patches in a landscape with extensive farming, it is often not possible to locate the change in potential vegetation with accuracy greater than many kilometres.

While it has been possible to relate certain vegetation boundaries to rather well-defined changes in altitude, for example the boundaries of the *Ericaceous belt* (EB) and the *Afroalpine belt* (AA), that can be directly derived from the digital elevation model, it has in other cases been necessary to work with manually digitized boundaries based on field observations by the authors. This is the case with the border between *Acacia-Commiphora* woodland and bushland and *Combretum-Terminalia* woodland, where these two vegetation types meet in south-western Ethiopia, with the border between the *Acacia* wooded grassland of the central Rift Valley and the *Acacia-Commiphora* woodland and bushland in the Afar region, and also with parts of the boundaries of *Transitional rain forest* and *Moist evergreen Afromontane forest*. It is difficult to put any number on the accuracy of these vegetation boundaries.

The scale 1:2,000,000

In balance, considering the high possible resolution of the topographic features and the considerably lower resolution possible for vegetation and man-made features, we have decided to produce the map at a scale of 1:2,000,000 (1 centimetre = 20 kilometres) for the following reasons: (1) A scale of 1:2,000,000 will not suggest an unrealistic high degree of precision with regard to indication of vegetation boundaries and their relation to towns and roads. (2) The precision will, on the other hand, be high enough to indicate with reasonable accuracy the boundaries between high altitude vegetation types that often show fairly steep gradients, and that were not well indicated on the two previous vegetation maps of Ethiopia, which are the maps by Pichi Sermolli (1957) and White (1983).

A third and purely practical reason is that with the proposed scale it will be possible to cover the whole of Ethiopia conveniently on a limited number of pages in an atlas with broadly overlapping page coverage.

Comparisons with older maps

The vegetation types proposed by Pichi Sermolli (1957), White (1983), as well as the forest types of Friis (1992) have been reviewed, partly based on summaries provided by Friis and Sebsebe Demissew (2001).

Distributions of a range of characteristic forest trees were modelled, using the distributional data in Friis (1992) and the climatic data set Worldclim/Bioclim with 5 minutes resolution available with DIVA GIS, version 5.2. (Hijmans *et al.*, 2005b). The modelled distribution patterns, of which eight have been included in Fig. 19 (p. 71) and 27 (p. 107) in this book, were used in considering which vegetation types to accept for the forested parts of Ethiopia.

Based on the field experience of the authors, it was decided which vegetation types and subtypes would be discernable in the field. The applicability of these vegetation types and subtypes were tested with all the volumes of the *Flora of Ethiopia and Eritrea*; during this

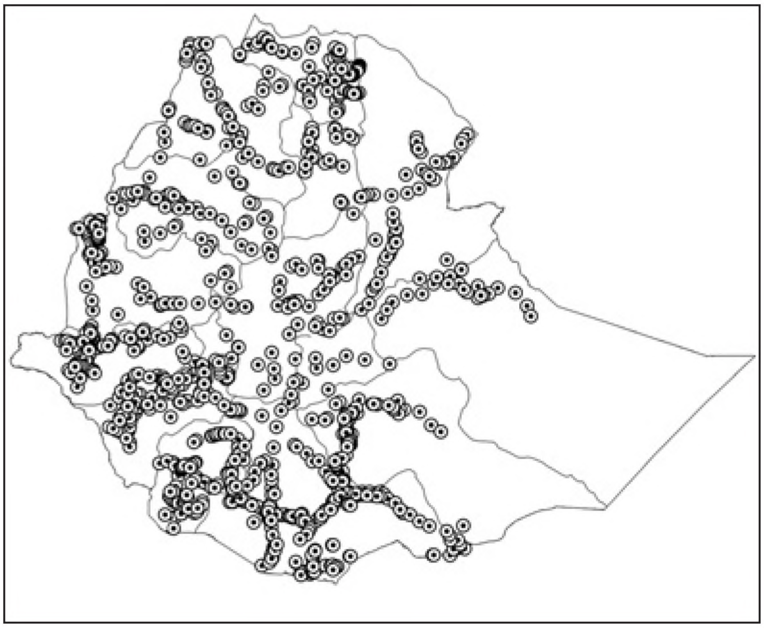


FIG. 8. Collecting localities for herbarium specimens in the series *Sebsebe Demissew* et al. and *Friis* et. al., including their joint collections. The general field observations of vegetation made by the two authors cover a wider area, but are not as easily expressed on a map as their collecting localities for herbarium specimens. The solid lines indicate borders of the flora regions used for the *Flora of Ethiopia and Eritrea* (see Fig. 3).

work, carried out by the authors, it was attempted to classify the ecological range of all woody species in the *Flora of Ethiopia and Eritrea* in the accepted vegetation types. The result of this work has been listed in Appendix 3.

Parameters and software

Subsequently it was decided which of these types and subtypes could be mapped using data sets of altitude, rainfall and the distribution and salinity of lakes and rivers; data sets for these were all available in GIS-readable formats.

Criteria relating to distribution of vegetation types and subtypes in relation to the data sets were established for all mapable types. The criteria have been listed for each vegetation type in the main text, and more detailed discussions of the use of data sets appear in the description of the workflow in Appendix 4 (p. 238-250).

The electronic version of the vegetation map project was produced by Paulo van Breugel in Nairobi, with the free, open-source GRASS GIS-software, version 6.0 (GRASS Development Team 2009). The script used to produce the electronic map in GRASS GIS is described in Appendix 4.

Final treatment in GIS of the map project was made in commercial ESRI GIS software, licensed to the University of Copenhagen (ArcMAP, version 9.3). The map was exported from ArcMAP by Ib Friis, divided into overlapping page-sized map plates and prepared for printing with ADOBE Photoshop Creative Suite, version 8.0.

Availability of data set

The data sets specified in Appendix 4 are available in electronic form from the authors on request, as well as a file in pdf-format of the entire map, which is printable on paper size A0.

Previous vegetation maps of Ethiopia and their mapping units

A full review of vegetation mapping of the area covered by Ethiopia up to ca. 1995 has been presented in Friis and Sebsebe Demissew (2001). Here only the maps of Pichi Sermolli (1957), White (1983), the forest types of Friis (1992), and the small-scale vegetation maps proposed after 2000 have been considered in relation to our present new vegetation map. The review by Friis and Sebsebe Demissew (2001) was mainly descriptive, and aimed at the comparative aspect with regard to physiognomy and floristics, while the presentation and discussion here is related to the criteria for defining the vegetation and the definitions that can be used for the new classification in this work. As it appears from the presentation, it has been necessary to considerably modify both definitions of mapping units and the areas they are presumed to cover. It has also been necessary to reject or merge some of the mapping units used on the previous maps in 1:5,000,000, as well as some used on the newer maps on smaller scale.

Mapping units used by Pichi Sermolli (1957) for vegetation in Ethiopia

It appears from Pichi Sermolli's text that he based his map (Fig. 9, p. 30) on information from all previous geographical and botanical literature dealing with the area. For his research, he studied archival material in Italian, available in Florence at various institutions responsible for research in the region during the Italian colonization of Eritrea and Somalia and occupation of Ethiopia. For the arid regions, he had particularly drawn on his own vegetation map of the Horn of Africa prepared for UNESCO and published in 1955 (Pichi Sermolli 1957, p. 15). He pointed out (p. 16) that the vegetation and flora of many parts of the area covered by the map were at that time not at all studied, and many other areas were incompletely studied. Moreover, the reports by various researchers about the same area were often conflicting. Pichi Sermolli had first-hand knowledge about parts of Eritrea, the Semien mountains, and the areas around and west of Lake Tana, but had visited no other part of the country at the time when he prepared the map.

Pichi Sermolli (1957, p. 24-26) defined the criteria for the mapping units thus: The previously published vegetation maps were compared subjectively, and all the photographs of vegetation of Ethiopia in the archives of the *Istituto Agronomico per l'Oltramare* were seen in order to establish the physiognomy of the vegetation of the localities in the photographs. Pichi Sermolli pointed out that the extremely varied topography of particularly Ethiopia and Eritrea made it difficult to make generalisations about the vegetation, and that vegetation types were often highly fragmented. Fragmentation of the vegetation made it difficult to represent the actual vegetation of the highlands on a map without making it impossible to read, a situation which is even more prevailing today.

Pichi Sermolli made it clear that he tried to map the vegetation as it looked at the time just before the map was prepared, and that he had not attempted to map the largely unknown climax vegetation, although he sometimes discussed the possible climax vegetation in his text. This means that he did not attempt to map potential vegetation types, as in this atlas. Moreover, some of his vegetation types had exceedingly restricted extension, so they were difficult to map. In such cases he tried to class them together with other related types. Also the components in mosaics and catenas had been mapped together in more comprehensive mapping units; this is, for example, the case with the vegetation types from the higher parts of the highlands. The term "savanna" was used to cover a range of slightly different vegetation types. Appendix 1 (p. 157-166), presents a systematic description and discussion of Pichi Sermolli's vegetation types recorded from Ethiopia.

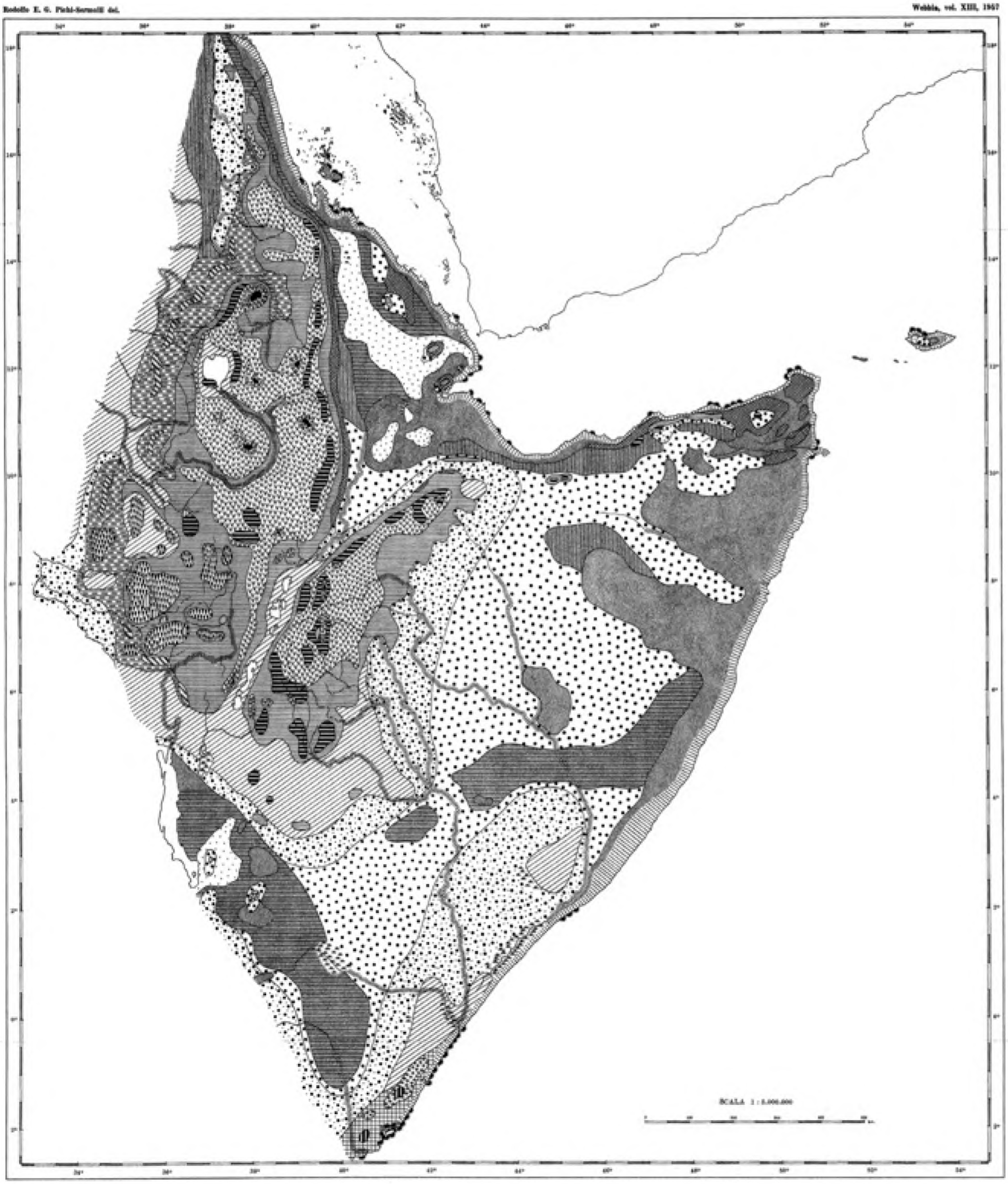
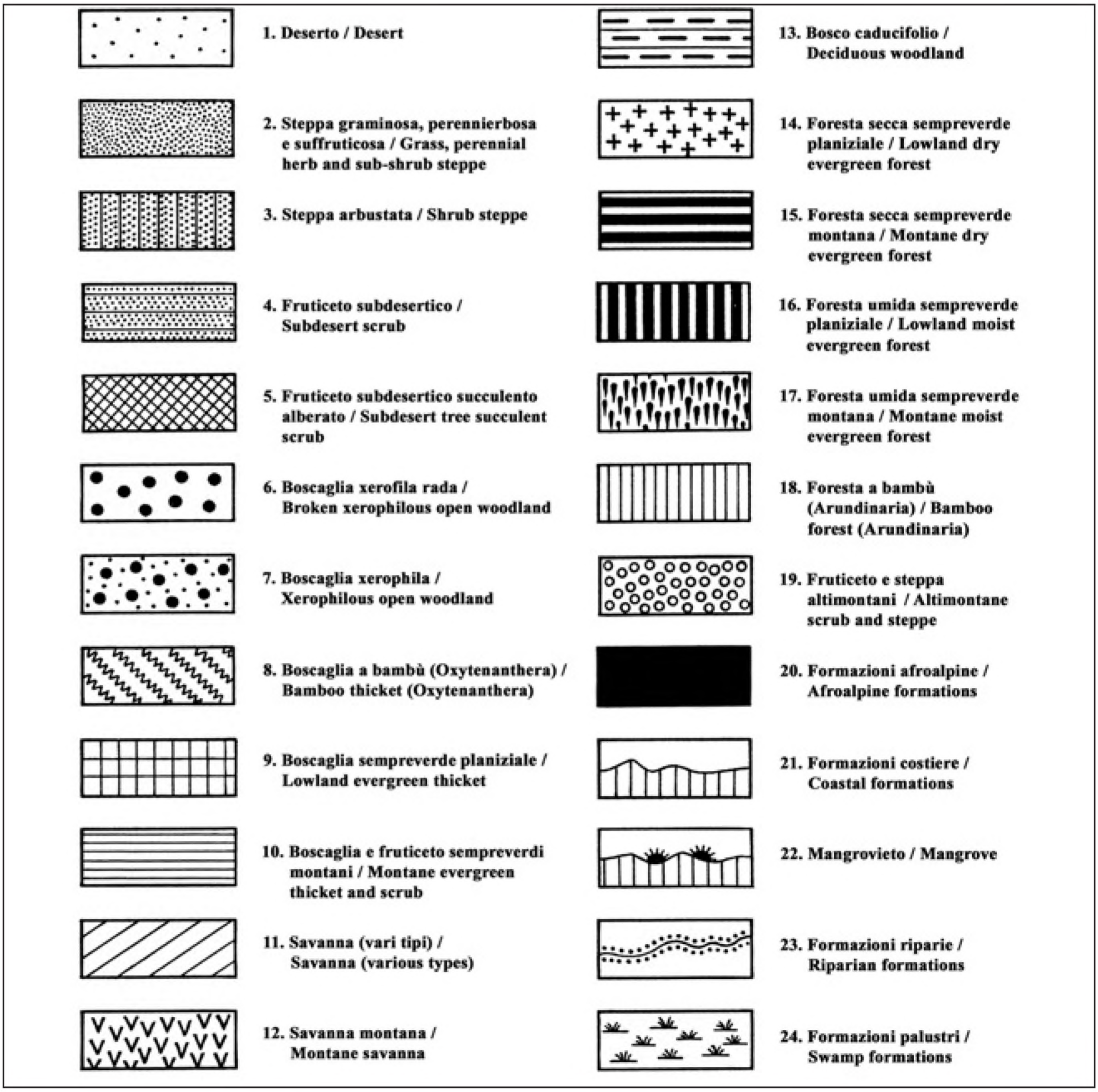


FIG. 9. R.E.G. Pichi-Sermolli's vegetation map of Eritrea, Ethiopia and Somalia (Pichi-Sermolli 1957). For legend, see adjacent page and discussion in text. The Italian names of the vegetation types are listed first, followed by translations into English. The translation is not part of the original legend. Published as appendix to *Webbia* 13 (1957). Reproduced with permission from *Webbia*.

BS 58 MAPPING UNITS USED BY PICHI SERMOLLI (1957) FOR VEGETATION IN ETHIOPIA



In spite of Pichi Sermolli's decision to map the vegetation as it appeared at the time of the mapping, he has not tried to indicate the widespread and extensively cultivated areas in the highlands, but classified the farmland with the vegetation of the surrounding, often highly anthropogenic landscape. This problem was, and is still, highly relevant because Ethiopian highland agriculture has for centuries taken new land under cultivation and abandoned other, so the limits between cultivated and fallow land are far from permanent, and nearly all land in the Ethiopian highlands has at one point been under some sort of cultivation.

Pichi Sermolli also made it clear that he was aware of the numerous narrow or broad transition zones or transitional mosaics that exist in the landscape, but that he had nevertheless decided (subjectively) to draw clear lines between the mapping units. His mapping units were based on his interpretation of the knowledge about topography, climate, physiognomy, floristic composition and anthropogenic influence, and he had allowed a certain amount of variation in all these parameters within the mapping units.

The descriptive text accompanying Pichi Sermolli's map was in Italian, as was the legend to the map and the abstract. The names for his vegetation type were throughout the publication given in Italian, apart from an English translation of the abstract, which appeared at the very end of the text. When compared with vegetation terminology for the adjacent, mainly Anglophone countries in Africa (Sudan, former British Somaliland, Kenya, Uganda) his English translations of the Italian vegetation names are not always easy to interpret and may be somewhat misleading. The original Italian names are therefore used here, with the English translations only cited in the legend to Fig. 9 (p. 30) and in the subheadings in Appendix 1 (p. 157-166) in this book, where Pichi Sermolli's vegetation types are discussed.

Pichi Sermolli's considerations have been useful for the present work, and most of his thoughts about the production of a vegetation map are as relevant today as they were in 1957. The main difference between his situation and that of the present authors is the amount of observations available from the authors' field work, the floristic information from the *Flora of Ethiopia and Eritrea,* and the data sets on topography and climate that can now be interpreted with the help of computers. Although Pichi Sermolli's vegetation types were reviewed in Friis and Sebsebe Demissew (2001), the feasibility of Pichi Sermolli's vegetation types in the present context is critically evaluated in Appendix 1. Pichi Sermolli's map of the vegetation of the Horn of Africa is reproduced here as Fig. 9. The floristic units of the *Flora of Ethiopia and Eritrea* (Fig. 3, p. 16) are used for geographical reference in the discussion.

Mapping units used by White (1983) for vegetation in Ethiopia

White (1983) enumerates 80 vegetation types and mosaics for Africa as a whole. In order of the listing in White (1983) the following 13 major vegetation types were used as mapping units for the part of his vegetation map of Africa that is present inside the borders of Ethiopia: (17) *Cultivation and secondary grassland replacing upland and montane forest in Africa*. (19a) *Undifferentiated montane vegetation (A) Afromontane* [including the subtypes *Afromontane rain forest*, *Undifferentiated Afromontane forest*, *Single-dominant Afromontane forest* [with *Juniperus procera forest*, *Hagenia abyssinica forest*, *Dry transitional montane forest*, *Afromontane bamboo*, *Part of Afromontane evergreen bushland and thicket*, *Part of Afromontane and Afroalpine shrubland*, *Part of Afromontane and Afroalpine grassland*]. (29b) *Undifferentiated [Sudanian] woodland (B) Ethiopian*. (35) *Transition from undifferentiated woodland to Acacia deciduous bushland and wooded grassland* (also including mosaic of communities dominated by *Acacia* and broad-leaved species) *(B) Ethiopian*. (38) *East African evergreen and semi-evergreen bushland and thicket*. (42) *Somalia-Masai Acacia-Commiphora deciduous bushland and thicket*. (43) *Sahel Acacia wooded grassland and deciduous bushland*. (54) *Semi-desert grassland and shrubland (B) Somalia-Masai*. (61) *Edaphic grassland in the upper Nile basin*. (62) *Mosaic of edaphic grassland and Acacia wooded grassland*. (64) *Mosaic of edaphic grassland and semi-aquatic vegetation (II) Sudanian Region*. (65) *Altimontane vegetation in tropical Africa*. And (71) *Regs, hamadas, wadis*. A part of White's map of the vegetation of Africa, showing Ethiopia and part of the surrounding countries, is reproduced here as Fig. 10. Appendix 2 (p. 167-176) of this book presents a systematic description and discussion of White's vegetation types recorded from Ethiopia. Again, the floristic units of the *Flora of Ethiopia and Eritrea* (Fig. 3) are used for geographical reference in the discussion.

Unlike Pichi Sermolli's classification, which was mainly physiognomic and contained only rather limited discussion of phytogeography, White's classification of vegetation types (White 1983) is placed in the framework of a phytogeographical classification of Africa; the area covered by Ethiopia by White is classified into the following phytochoria: (III) *The Sudanian regional centre of endemism*. (IV) *The Somalia-Masai regional centre of endemism*. (VIII/XI) *The Afromontane archipelago-like regional centre of endemism, and the Afroalpine archipelago-like region of extreme floristic impoverishment*. (XVI) *The Sahel regional transition zone* (only just found in

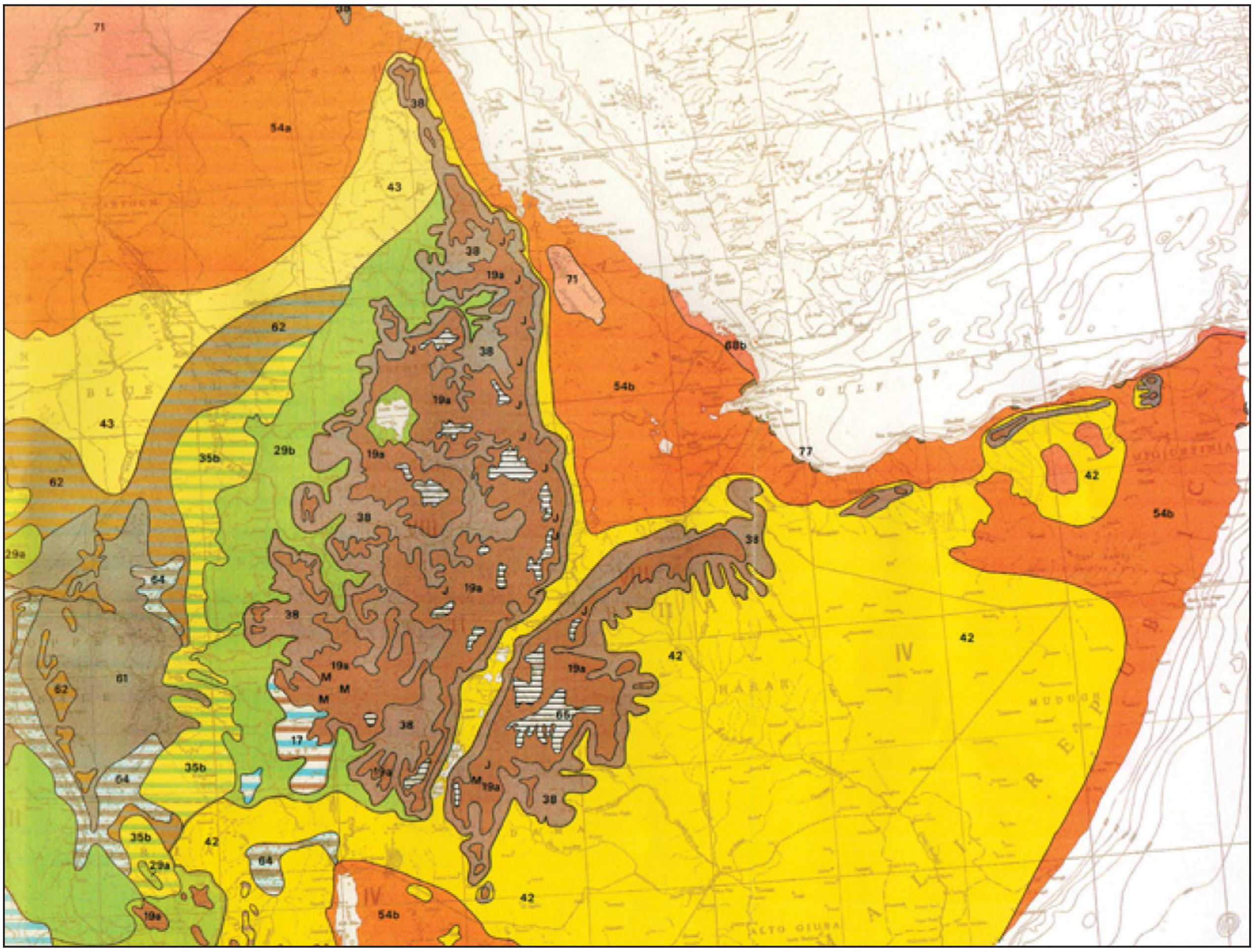


FIG. 10. Part of White's vegetation map of Africa (White 1983) covering Ethiopia. The umbers indicating vegetation types inside Ethiopia are indicated according to the legend of the map: (17) *Cultivation and secondary grassland replacing upland and montane forest – African*. (19a) *Undifferentiated montane vegetation (A) Afromontane* [with a number of subtypes specified in the text; on the map only: "J" = *Juniperus procera forest*. "M" = *Mixed forest*.]. (29b) *Undifferentiated [Sudanian] woodland (B) Ethiopian*. (35b) *Transition from undifferentiated woodland to Acacia deciduous bushland and wooded grassland (B) Ethiopian*. (38) *Evergreen and semi-evergreen bushland and thicket – East African*. (42) *Somalia-Masai Acacia-Commiphora deciduous bushland and thicket*. (43) *Sahel Acacia wooded grassland and deciduous bushland*. (54b) *Semi-desert grassland and shrubland (B) Somalia-Masai*. (61) *Edaphic grassland in the Upper Nile basin*. (62) *Edaphic grassland mosaic with Acacia wooded grassland* [in the text: *Mosaic of edaphic grassland and Acacia wooded grassland*]. (64) *Edaphic grassland mosaic with semi-aquatic vegetation* [in the text: *Mosaic of edaphic grassland and semi-aquatic vegetation (II) Sudanian*]. (65) *Altimontane vegetation in tropical Africa*. (71) *Regs, hamadas, wadis*.

See further in the text of Appendix 2 (p. 167-176), where descriptions and discussions of the relevant vegetation type recognised by White can be found. Reproduced with permission from UNESCO (UPO/D/A/2000-088 of 13 July 2000).

a few square kilometres in the extreme north-eastern part of Ethiopia, according to White). We do not object to this classification, but find it unnecessarily complicated to refer to in the present work. The main point of relevance here is that this classification is in agreement with our views that the highlands of Ethiopia, represented by White's phytochorion VIII/XI, are distinct from the lowlands, and that the Western

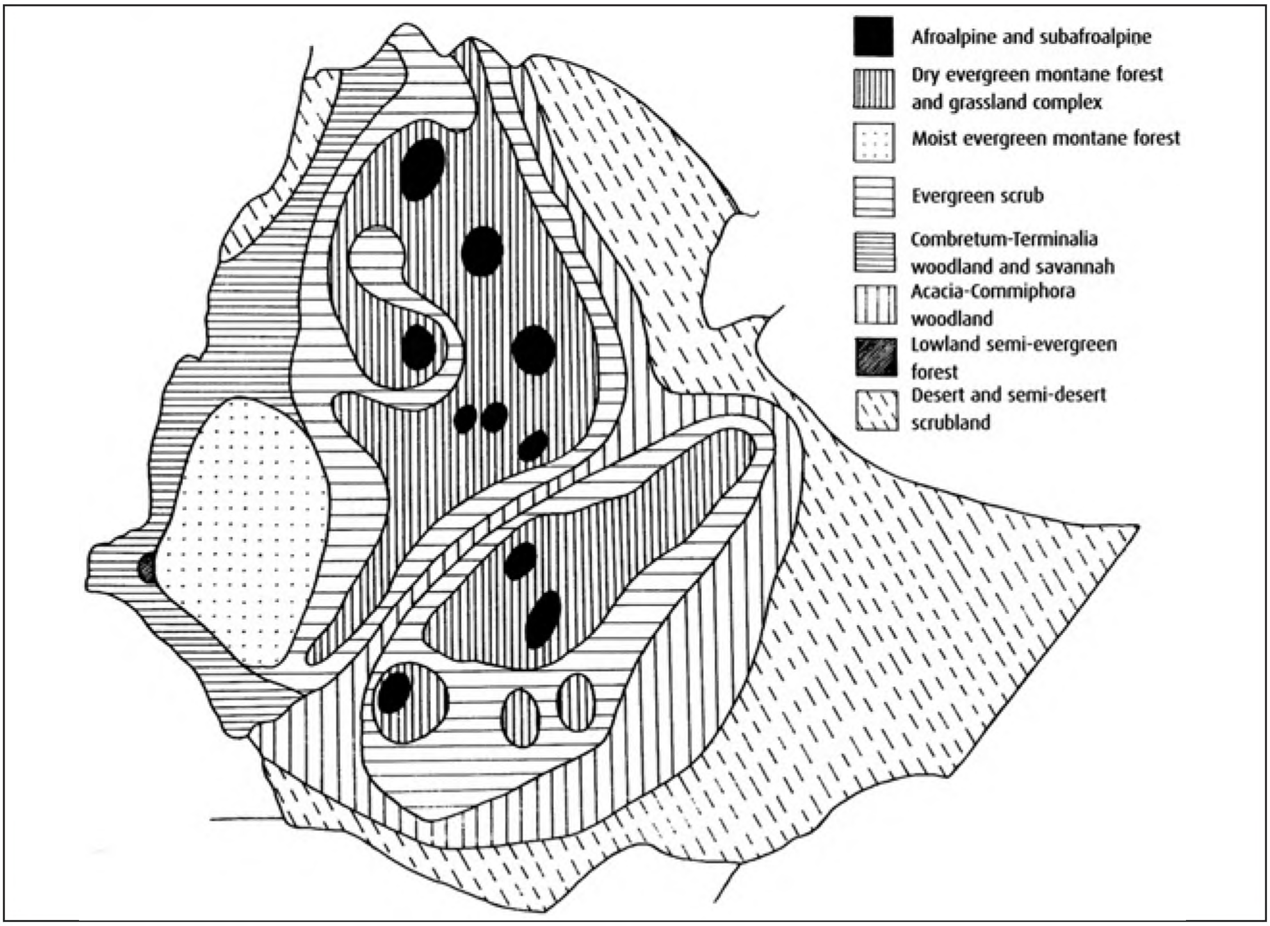


Fig. 11. Vegetation types of Ethiopia as given in Sebsebe Demissew *et al.* (1996), in CSE (1997), and in Sebsebe Demissew *et al.* (2004).

escarpment and Western lowlands, represented by White's phytochorion III, are basically different from the Eastern escarpment and Southern and South-eastern lowlands, represented by White's phytochorion IV.

Also from White's map, and particularly from the accompanying descriptive memoir, it is possible to derive valuable ideas for a modern vegetation map. It has therefore been decided to review White's mapping units in detail, and compare them with the units used in the present map. The exact position of White's vegetation types is often misleading, due to the lack of field work and the comparatively imprecise topographical maps on which White has based his vegetation map of Ethiopia.

Six of the vegetation types on the part of White's map that covers Ethiopia have largely been accepted here, although with some modifications with regard to extent and definition. Three of White's vegetation types have here been split into two major vegetation types and in one case also into a range subtypes. Other of White's vegetation types have here been split into subtypes.

New vegetation types from little-known Ethiopian forests (1970-1992)

Following the initial field work in south-western Ethiopia in 1970 and 1972-1973 Friis, Rasmussen and Vollesen continued the work with analyses of the col-

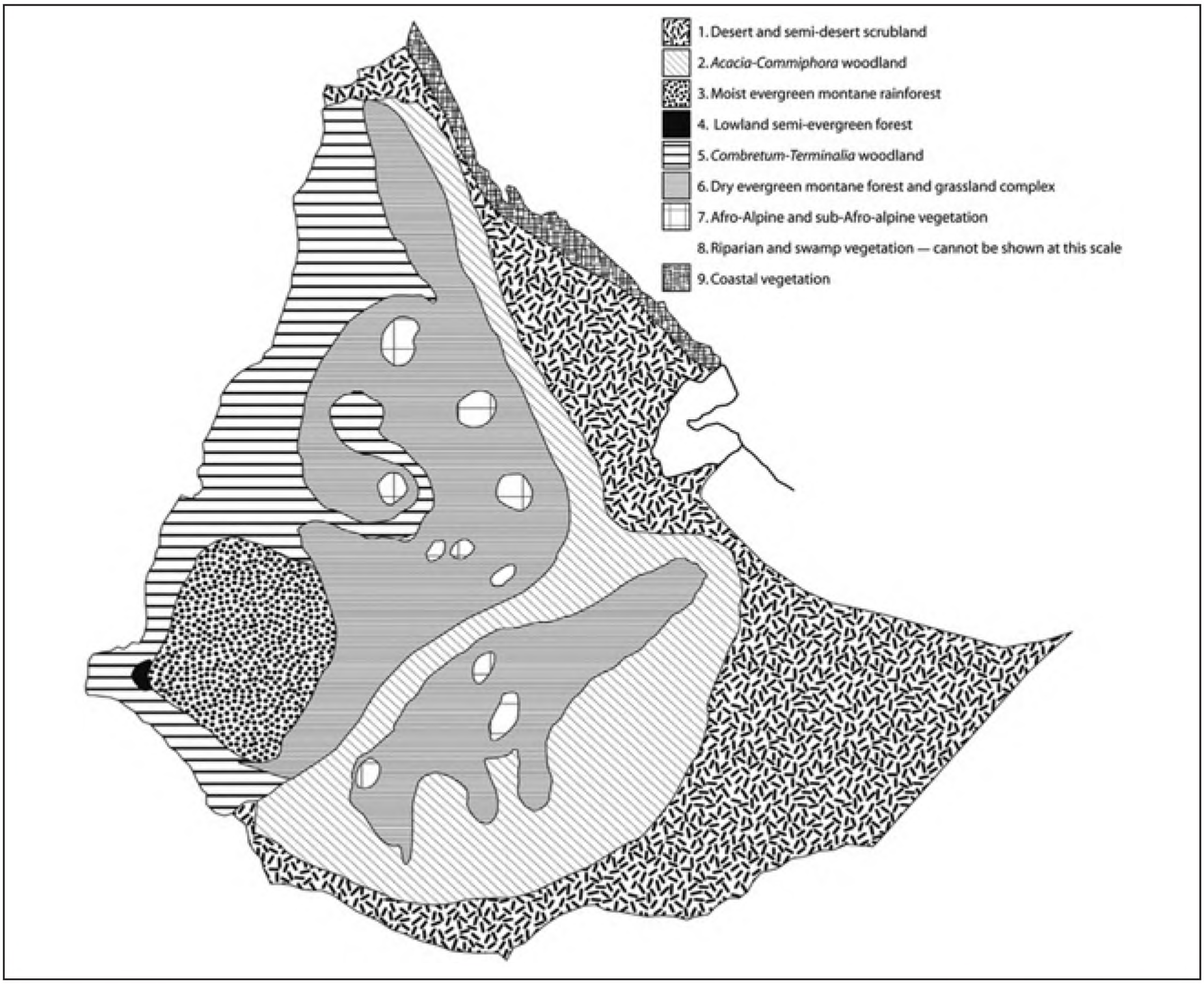


FIG. 12. Vegetation types of Ethiopia and Eritrea as given in Volume 8 of the Flora of Ethiopia and Eritrea (Sebsebe Demissew & Friis, 2009).

lected material, supplemented with studies at the Royal Botanic Gardens, Kew, and the *Erbario Tropicale*, Florence, where the Italian literature from the 1930s was also scrutinized. Also in the later half of the 1970s, and in the field in south-western Ethiopia, the South-west Ethiopia Forest Inventory Project started at the request of the Ethiopian government. The result of the former was published in a botanical monograph series (Friis *et al.*, 1982), while the latter was published as project reports with limited circulation by the British Ministry of Overseas Development, Land Resources Development Centre (Chaffey, 1978a, 1978b, 1978c, 1978d, 1979). The results of the reports by Chaffey were not available to Friis, Rasmussen and Vollesen when they drafted the text of the publication of 1982. Chaffey (1979) was known to, and cited by, White (1983), but the work came too late to have any influence on how White presented the forest types in south-western Ethiopia.

The most important results for the present Ethiopian vegetation mapping from these works are (from Chaffey, 1978a, 1978b, 1978c, 1978d, 1979) detailed mapping and floristic inventories of trees in forest patches in the SU, WG, IL, KF, SD and BA floristic regions, many of which were previously only little known and (from Friis *et al.,* 1982) information about the close floristic and successional relation between farmland, secondary woodland and evergreen bushland and forest in the KF and IL floristic regions, with an equal emphasis on trees and other life forms of plants. As the first, the Southwest Ethiopia Forest Inventory Project (Chaffey, 1979) reported on the structure and floristic composition of the tree strata in the hitherto completely unknown forests in the Western lowlands of the IL floristic region and on other little known forests below 1000 metres in the KF and IL floristic regions; the very large specimens of hitherto unrecorded forest trees, *Milicia excelsa* and *Antiaris toxicaria* (Moraceae), are first described there.

In the 1980s Friis continued the work, begun in the 1970s, with the forests of southern Ethiopia, collecting and observing during field work the forests below altitudes of approximately 1000 metres in the KF and IL floristic regions, the humid forests in the BA floristic region and the drier forests of the central Western and Eastern highlands, as well as intensifying studies at the Royal Botanic Gardens, Kew, and at the *Erbario Tropicale* in Florence in order to prepare a monograph of the forests and forest trees of the Horn of Africa, with distribution maps for all forest tree species reaching a height of 8 metres or higher (Friis, 1992). A total of 263 species, subspecies or varieties were mapped and allocated to forest types, from which they had been recorded. This work also involved the literature published in Italian and previously reviewed by Pichi Sermolli (1957), and as far as possible all species mentioned in this literature were identified to species in agreement with the taxonomic concepts current in the *Flora of Ethiopia and Eritrea* and Friis (1992).

The types of natural forest in Ethiopia comprised according to the new classification proposed by Friis (1992): (1) *Lowland dry peripheral semi-deciduous Guineo-Congolian type forest in western Ethiopia* (lowland part of the IL floristic region at 500-600 metres altitude). (2) *Transitional rain forest on the south-western escarpment of the Ethiopian highlands* (in the western KF floristic region, in the western IL floristic region above the flat lowland at 500-600 metres, and in the western WG floristic region), which is closely related to type 1 but has more humid evergreen forest species and some Afromontane species. (3) *Broad-leaved Afromontane rain forest of the Ethiopian highlands* (in the south-western WG, highland IL, KF, GG, SD, and BA floristic regions). (4) *Undifferentiated Afromontane forest* (central region of the north-western and the south-eastern highlands, north to the GD or TU floristic regions, east to highland parts of the HA floristic region), including various forest types in which *Podocarpus falcatus* is important. (5) *Dry single-dominant Afromontane forest* (in the northern parts of the Ethiopian highlands), 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* (on the eastern escarpment of the Ethiopian highlands (chiefly in the HA, BA, SD floristic regions) and in the mountain chain in northern Somalia). (7) *Riverine forests* (represented by a long range of floristic subtypes from nearly all parts of Ethiopia). The study recognized two further forest types that only occurred in Eritrea, Djibouti and Somalia. In relation to the vegetation map of White (1983), which had inspired the terminology of the forest types, the following were completely new for Ethiopia: (1) *Lowland dry peripheral semi-deciduous forest*, and (2) *Transitional rain forest*. Also the distinction between (3) *Broad-leaved Afromontane rain forest*, (4) *Undifferentiated Afromontane forest*, with *Podocarpus* and sometimes both *Podocarpus* and *Juniperus*; (5) *Dry single-dominant Afromontane forest*, with *Juniperus procera* , and (6) *Transition between dry single-dominant Afromontane forest and East African evergreen and semi-evergreen bushland and thicket*, were more strictly defined than by White, and various types of Afromontane bushland was associated with the respective forest types as typical of forest margins, or representing seral stages in the regrowth of the forests.

Mapping units used in small-scale vegetation maps of Ethiopia (1996-2009)

In a sequence of small-scale vegetation maps (Sebsebe Demissew *et al.*, 1996; CSE, 1997; Zerihun Woldu, 1999; Sebsebe Demissew *et al.,* 2004; IBC, 2005; sum-

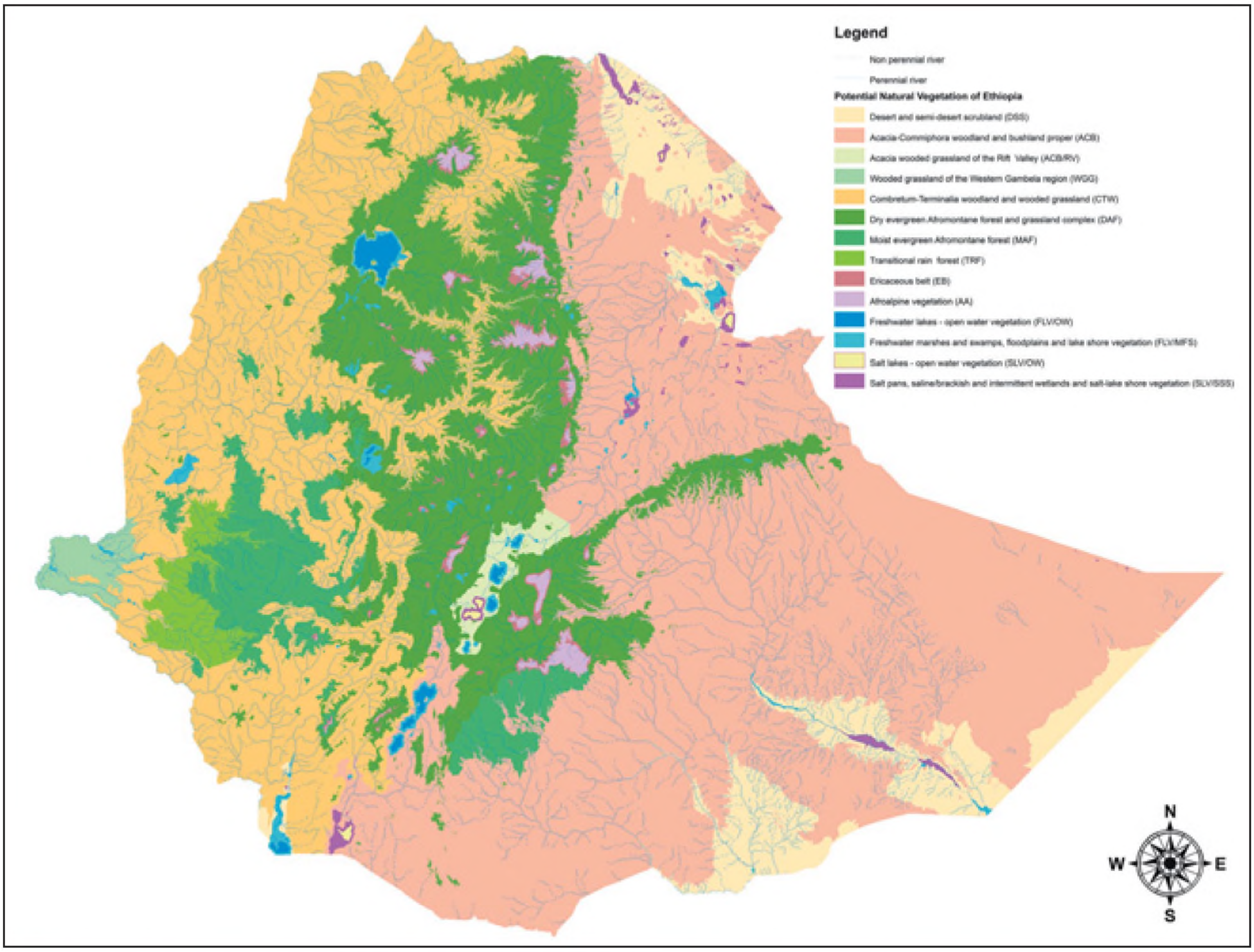


FIG. 13. Vegetation types of Ethiopia accepted in this publication. For detailed map plates in 1:2,000,000, showing also roads, towns and the boundaries of the floristic regions of the *Flora of Ethiopia and Eritrea*, see the map plates at the end of this work.

marised here in Fig. 11), the vegetation type indicated as evergreen scrub in the map and description was shown as a distinct zone surrounding the dry evergreen montane forest and grassland. These maps have, to varying extent, integrated information from White (1983) and the forest types proposed by Friis (1992), although Friis' type (2), *Transitional rain forest on the south-western escarpment of the Ethiopian highlands*, is only mentioned in Sebsebe Demissew *et al.* (2004), where it is incorporated as a subtype in *Moist evergreen forest*.

Sebsebe Demissew *et al.* (1996) accepted the following vegetation types, with distribution as indicated on maps in Sebsebe Demissew *et al.* (1996) and Sebsebe Demissew *et al.* (2004). The version presented in Sebsebe Demissew *et al.* (2004) has been accepted almost unchanged as the official classification of Ethiopian ecosystems, as presented on the Internet and rendered in Appendix 5 (p. 251-253) of this work. Sebsebe Demissew *et al.* (1996) and Sebsebe Demissew *et al.* (2004) accepted the following units:

(1) *Desert and semi-desert scrubland*. This is found in the Danakil depression in the northern part of the AF floristic region, the Ogaden, around Lake Chew Bahir and in and around the delta of the Omo river. On the map accompanying Sebsebe Demissew *et al.* (1996) this vegetation type occupies almost the entire

Ogaden, most of the Danakil depression and bends round the highlands in Eritrea and, as can be seen from the reproduction in Fig. 11 from Sebsebe Demissew *et al.* (2004), continues in the Western lowlands of Ethiopia.

(2) *Acacia-Commiphora small-leaved deciduous woodland* (in Sebsebe Demissew *et al.* (2004) called *Acacia-Commiphora woodland*). This is found in the northern, eastern, central and southern parts of the country between 900 and 1990 metres, hence the distribution is much more restricted than indicated by White (1983) for similar vegetation. This is also seen from the map accompanying Sebsebe Demissew *et al.* (1996) and Sebsebe Demissew *et al.* (2004), reproduced here as Fig. 11. The Rift Valley is also indicated as having this vegetation type, although the Rift Valley is not mentioned specifically in the text.

(3) *Moist evergreen forest*. This is found in the southern BA floristic region (chiefly on the southern slope of the Bale mountains massif), in northern Borena (the SD floristic region), in the western WG, IL and KF floristic regions (on the map accompanying Sebsebe Demissew *et al.* (1996) and Sebsebe Demissew *et al.* (2004), reproduced here as Fig. 11, no occurrence of this vegetation is indicated from SD and BA). In Sebsebe Demissew *et al.* (2004) this vegetation type has been divided into two subtypes: (1) The proper *Afromontane rainforest*, that occurs between 1500 and 2600 metres, and (2) the *Transitional rain forest*, which is equivalent with Friis' type (2), *Transitional rain forest on the south-western escarpment of the Ethiopian highlands*, and occurs at altitudes between 500 and 1500 metres on the western slopes of the WG, IL and KF floristic regions.

(4) *Lowland semi-evergreen forest*. This is restricted to areas in the lowland IL floristic region (Gambela Region) between altitudes of 450 and 600 metres. This is closely equivalent to forest type (1) *Lowland dry peripheral semi-deciduous Guineo-Congolian type forest in western Ethiopia* of Friis (1992).

(5) *Combretum-Terminalia broad-leaved deciduous woodland*. This is found on the Western escarpment, in the Western lowlands south to the lower reaches of the Omo river. In Sebsebe Demissew *et al.* (2004) it is indicated that this vegetation penetrates deeply into the Didesa valley [Dedesa valley], a tributary to the Abay [Blue Nile] river, but there is no mentioning of the main Abay [Blue Nile] valley.

(6) *Dry evergreen Montane forest and grassland complex*. This is found in much of the highlands in the northern, north-western, central and south-eastern part of the country, at altitudes between 1900 and 3400 metres, but between 1500 and 2200 metres in the south-eastern part of the country. In Sebsebe Demissew *et al.* (2004) this main vegetation type has been divided into four subtypes: (1) *Undifferentiated Afromontane forest*, rather similar to type (4) *Undifferentiated Afromontane forest* of Friis (1992). (2) *Dry single-dominant Afromontane forest of the Ethiopian highlands*, rather similar to type (5) *Dry single-dominant Afromontane forest* of Friis (1992). (3) *Afromontane woodland, wooded grassland and grassland*, which represents open woodlands and grasslands of the highlands and open, seral stage of forest regrowth of forest. (4) *Dry single-dominant Afromontane forest of the Eastern escarpment, and transition between single-dominant Afromontane forest and East African semi-evergreen bushland*, which is equivalent to the type (6) *Transition between dry single-dominant Afromontane forest and East African evergreen and semi-evergreen bushland and thicket* of Friis (1992). On the maps accompanying Sebsebe Demissew *et al.* (1996) and Sebsebe Demissew *et al.* (2004), the *Dry evergreen Montane forest and grassland complex* is surrounded by a zone of *Evergreen scrub* at the lower edge of the Afromontane vegetation, just as indicated on the map of White (1983). There is no mentioning of the *Evergreen scrub* in the text of Sebsebe Demissew *et al.* (1996), and it was not attempted to map the subtypes of Sebsebe Demissew *et al.* (2004).

(7) *Afroalpine and sub-afroalpine vegetation*. This is found on the high mountains above 3200 metres altitude, which is also indicated on the maps accompanying Sebsebe Demissew *et al.* (1996) and Sebsebe Demissew *et al.* (2004).

(8) *Riparian and swamp vegetation*. This is found along rivers, in swamps and around lakes throughout the country. The areas occupied by this vegetation are too small to be shown on the maps accompanying Sebsebe Demissew *et al.* (1996) and Sebsebe Demissew *et al.* (2004).

A brief survey of the Ethiopian and Eritrea vegetation is presented by Atkins and Edwards (2009). This survey is based on the system by CSE (1997), but elaborates the CSE-classification with regard to the forest types. The *Moist evergreen montane forest* is divided into three subtypes: A. *Humid mixed forest around the southern part of the Rift Valley and in Harerge*. This is a forest which typically has a mixture of *Podocarpus falcatus* and *Pouteria (Aningeria) adolfi-friederici* in the canopy. B. *Humid broadleaved forest of the south-western part of the plateau in southern Welega, Illubabor and Kefa*. These forests are described as differing from A by lacking *Podocarpus* in the canopy. C. *Transitional forest of the south-western escarpment*. It is characterised by a number of canopy-species otherwise only found in lowland forest. The *Dry evergreen montane forest and grassland* is divided into three types: A. *The dry forests of Eritrea and the eastern escarpment*. These forests are dominated by *Juniperus procera* and a few other species. B. *The dry evergreen montane forest of the highland plateau*. This is now a mosaic of forests dominated by *Juniperus*, in higher rainfall areas also *Podocarpus*, *Acacia abyssinica* woodland and grassland. C. *The dry forests of Sidamo, Bale and Hararghe*. These are small patches of dry and open *Juniperus procera*-dominated forest in the area with two rainy seasons.

The vegetation map in the *Flora of Ethiopia and Eritrea*, Volume 8 (Sebsebe Demissew & Friis, 2009) is shown in Fig. 12 (p. 35). The large extent of the *Desert and sub-desert scrub* in the AF floristic region and in the Ogaden has survived, but the indication of *Desert and sub-desert scrub* in western Eritrea and north-western Ethiopia has largely been replaced with *Combretum-Terminalia* woodland, which also penetrates deeply into the north-western part of the Western highlands along the Tekeze and the Abay [Blue Nile] valley. *Acacia-Commiphora woodland* is treated almost exactly as in Sebsebe Demissew *et al.* (1996) and Sebsebe Demissew *et al.* (2004), and it occupies a much smaller area than in White (1983). Incorporation of the *Transitional rain forest on the south-western escarpment of the Ethiopian highlands* with the *Moist evergreen forest* has survived.

Mapping units used here

For the preparation of this atlas it was realized that the evergreen scrub is not found in a distinct zone of its own, but rather occurs in a mosaic of vegetation types, mainly associated with dry evergreen montane forest, or as derived vegetation where moist evergreen montane forest has been destroyed. Thus, evergreen scrub is considered here to belong mostly in a seral stage subtype of the *Dry evergreen Afromontane forest and grassland complex*. The connection between evergreen bushland and moist evergreen Afromontane forest was suggested by Friis *et al.* (1982) in their description of the vegetation of south-western Ethiopia, and the major difference between the previous small scale maps and the map in the *Flora of Ethiopia and Eritrea* is that in the latter, the authors have merged *Evergreen bushland* with the *Dry evergreen montane forest and grassland complex*. The vegetation types can bee seen in Fig. 13 (p. 37) and are listed in Table 1 (p. 40).

TABLE 1. Vegetation types, subtypes and mapping units used in this work

Main Vegetation Type and Acronym	Vegetation Subtype and Acronym	Mapping units for the vegetation types and subtypes	Colour code (names; see legend to the map plates for actual colours)
1. Desert and semi-desert scrubland (DSS)		Desert and semi-desert	Pale creamy yellow scrubland (DSS)
2. *Acacia-Commiphora* woodland and bushland (ACB)	2a. *Acacia-Commiphora* woodland and bushland proper (ACB)	*Acacia-Commiphora* woodland and bushland proper (ACB)	Dusty pink
	2b. *Acacia* wooded grassland of the Rift Valley (ACB/RV)	*Acacia* wooded grassland of the Rift Valley (ACB/RV)	Palest yellow green
3. Wooded grassland of the western Gambela region (WGG)		Wooded grassland of the western Gambela region (WGG)	Neutral greyish green
4. *Combretum-Terminalia* woodland and wooded grassland (CTW)		*Combretum-Terminalia* woodland and wooded grassland (CTW)	Yellow ochre
5. Dry evergreen Afromontane forest and grassland complex (DAF)	5a. Undifferentiated Afromontane forest (DAF/U)	Dry evergreen Afromontane forest and grassland complex (DAF)	Green
	5b. Dry single-dominant Afromontane forest of the Ethiopian highlands (DAF/SD)	Dry evergreen Afromontane forest and grassland complex (DAF)	Green
	5c. Afromontane woodland, wooded grassland and grassland (DAF/WG)	Dry evergreen Afromontane forest and grassland complex (DAF)	Green
	5d. Transition between Afromontane vegetation and *Acacia-Commiphora* bushland on the Eastern escarpment (DAF/TR)	Dry evergreen Afromontane forest and grassland complex (DAF)	Green
6. Moist evergreen Afromontane forest (MAF)	6a. Primary or mature secondary moist evergreen Afromontane forest (MAF/P)	Moist evergreen Afromontane forest (MAF)	Blue green
	6b. Edges of moist evergreen Afromontane forest, bushland, woodland and wooded grassland (MAF/BW)	Moist evergreen Afromontane forest (MAF)	Blue green
7. Transitional rain forest (TRF)		Transitional rain forest (TRF)	Yellow green
8. Ericaceous belt (EB)		Ericaceous belt (EB)	Dark pink.
9. Afroalpine belt (AA)		Afroalpine belt (AA)	Paler mauve pink

10. Riverine vegetation (RV)		Perennial and non-perennial rivers below 1800 metres altitude	Darker blue (lines)
11. Freshwater lakes, lake shores, marshes, swamps and floodplains vegetation (FLV)	11a. Freshwater lake vegetation [open water] (FLV/OW)	Freshwater lakes – open water vegetation (FLV/OW)	Darker blue (areas)
	11b. Freshwater marshes and swamps, floodplains and lake shore vegetation (FLV/MFS)	Freshwater marshes and swamps, floodplains and lake shore vegetation (FLV/MFS)	Paler blue
12. Salt-water lakes, lake shores, salt marshes and pan vegetation (SLV)	12a. Salt-water lake vegetation [open-water] (SLV/OW)	Salt-water lakes – open water vegetation (SLV/OW)	Pale yellow
	12b. Salt pans, saline/brackish and intermittent wetlands and salt-lake shore vegetation (SLV/SSS)	Salt pans, saline/brackish and intermittent wetlands and salt-lake shore vegetation (SLV/SSS)	Dark mauve

Potential vegetation types in Ethiopia

Following the authors' experience with the previous small-scale vegetation maps, it has been attempted to define vegetation types that can be recognized in the field and, as far as possible, defined in terms of known environmental parameters in such a way that they can be mapped with the use of modern GIS-technology. As a consequence, the vegetation of Ethiopia has been divided into twelve major types and twelve subtypes, which combined make up a total of 19 types and subtypes shown in Table 1 (p. 40) and described in detail in the following section of the book. It was not be possible to map all 19 vegetation types and subtypes, but we have applied 15 mapping units, some of which cover several vegetation subtypes, as shown on the overview map here in Fig. 13 (p- 37) and in the detailed map plates in 1: 2,000,000 at the end of this work.

The vegetation types are, to a large extent, a further critical development of the types described in Sebsebe Demissew *et al.* (2004), but the way these vegetation types on the map plates in the atlas is quite far removed from the map in that work. The decision to merge *Evergreen bushland* with the *Dry evergreen montane forest and grassland complex*, as done by Sebsebe Demissew and Friis (2009), has been maintained in this paper.

The map plates in this atlas do not show the riverine vegetation separately, as it not possible to distinguish it graphically in print, but the rivers have been mapped, and it should be assumed that all rivers, permanent or intermittent, have some kind of associated riverine vegetation. Above an altitude of approximately 1800 metres this vegetation is normally rather similar to vegetation in the major vegetation type, for example in our vegetation type (5) *Dry evergreen Afromontane forest and grassland complex* (DAF), where the vegetation along rivers in our subtype (5c) *Afromontane woodland, wooded grassland and grassland* (DAF/WG) is rather similar to our subtype (5a) *Undifferentiated Afromontane forest* (DAF/U). This is not the case below an altitude of approximately 1800 metres, where the riverine forests are normally quite different in floristic composition from the surrounding vegetation and may contain species shared with forests at higher rainfall regimes at the same altitudes, for example with our vegetation type (7) *Transitional rain forest* (TRF), or with forests at higher altitudes, for example our vegetation type (6) *Moist evergreen Afromontane forest* (MAF), or, in a few cases, species that only occur in riverine forest.

The map plates in this work will of course not be the final vegetation map of Ethiopia, but we believe the suggestions made here, based on field observations, reflect a better and more complete picture than any of the previously published maps, and we hope that it may be useful as a research tool and for practical purposes.

The vegetation types have been tested by applying them to all woody plant species in the *Flora of Ethiopia and Eritrea*, based on information in the Flora combined with the field experience of the authors. The vegetation types to which all these species have been referred are listed in Appendix 3 (p. 177-237). It appears that, very rarely, a species occur in more than a few adjacent vegetation types, which is taken as evidence that the vegetation types are meaningful. Statistic information about the diversity of woody plants in the vegetation types, and the floristic overlap between them, has been provided in Table 2. The figures are also commented on in the descriptions of the vegetation types.

Table 2. Number of woody species, subspecies and varieties in the vegetation types

The table indicates the number of woody species, subspecies and varieties that are found in the vegetation types recognised in this atlas, as well as woody species, subspecies and varieties that are unique to or shared between combinations of vegetation types. Species, subspecies and varieties that have only been recorded with doubt from a vegetation type (indicated with a question mark in front of the vegetation type in Appendix 3) have not been counted. The same applies to all indications of distribution on subtypes.

Usually the number of species, subspecies and varieties shared between any combinations of three or four vegetation typed is low, only one or two. The cases where these numbers are higher than two have been listed in the lowermost part of the table. There is no case where species, subspecies and varieties have been recorded with certainty from five or more vegetation types. The number of the total sample is 1213, but the figures will not sum up due to the limitations mentioned. Data from Appendix 3 (p. 177-237).

	(1) DSS	(2) ACB	(3) WGG	(4) CTW	(5) DAF	(6) MAF	(7) TRF	(8) EB	(9) AA	(10) RV	(11) FLV	(12) SLV
Total numbers recorded from vegetation type	131	542	7	199	460	135	101	56	22	242	8	1
Numbers not shared with other vegetation types	10	286	1	81	128	18	47	0	1	64	0	0
Percent of total not shared with other vegetation types	7.63	52.77	14.29	40.70	27.83	13.33	46.53	0.00	4.55	26.45	0.00	0.00

Total numbers shared with one or more other vegetation types:	(1) DSS	(2) ACB	(3) WGG	(4) CTW	(5) DAF	(6) MAF	(7) TRF	(8) EB	(9) AA	(10) RV	(11) FLV	(12) SLV
(2) ACB	117											
(3) WGG	0	5										
(4) CTW	3	50	5									
(5) DAF	3	102	2	74								
(6) MAF	3	0	0	3	89							
(7) TRF	0	0	0	3	15	36						
(8) EB	0	0	0	3	56	7	0					
(9) AA	0	0	0	1	20	0	0	21				
(10) RV	10	32	0	13	102	56	30	3	0			
(11) FLV	0	0	0	0	1	0	0	0	0	8		
(12) SLV	1	1	0	0	0	0	0	0	0	0	0	

Shared between four vegetation types						Shared between four vegetation types	
AA-DAF-EB	19	ACB-DAF-RV	8	DAF-MAF-RV	34	DAF-MAF-TRF-RV	9
ACB-CTW-DAF	17	ABC-DSS-RV	5	DAF-MAF-TRF	6		
ACB-CTW-RV	5	CTW-DAF-RV	5	MAF-TRF-RV	9		
ABC-DAF-DSS	3	DAF-EB-MAF	5				

(1) *Desert and semi-desert scrubland* (DSS)

The scarce plant cover in this vegetation type consists of highly drought tolerant species. Due to external influences, such as human and animal trampling around watering points, the land can locally be completely devoid of vegetation and at times also the ground may naturally be bare, because the species are annual or geophytic. The soils are often alluvial, associated with the basins of rivers such as Awash and Wabi Shebele, but may also be derived from basaltic rocks, lava flows and limestone slopes, as is seen over large parts of the AF floristic region. In many areas with (1) *Desert and semi-desert scrubland* (DSS) there are big boulders, between which soil may accumulate and plants be protected from sun and desiccation. The salt pans in the Danakil depression in the northern part of the AF floristic region are nearly or completely devoid of vegetation.

This vegetation is found below 400 metres altitude in eastern Ethiopia. It is characterized by the presence of small trees, shrubs and herbs, which may be succulent, geophytic or annual.

Fig. 14A shows desert with sand, boulders, some shrubs and a tree among the boulders. Fig. 14B shows a sandy desert with beginning dune-formation. Fi.14C shows a desert with large, alluvial flats with annual herbs. Fig. 14D shows subdesert scrub on boulders. Fig. 14A-D are all from the Afar lowlands. Fig. 14E shows semi-desert scrubland near Dolo Odo on the border between the BA and SD floristic regions.

DIVERSITY AND FLORISTIC OVERLAP WITH OTHER VEGETATION TYPES: A total of 131 species, subspecies and varieties have been recorded to occur in (1) *Desert and semi-desert scrubland* (DSS). Of these, 10 (7.63% of the total) have only been recorded from this vegetation type; 117 have been recorded from both this vegetation type and the adjacent vegetation type (2) *Acacia-Commiphora woodland and bushland* (ACB); three have been recorded from both this vegetation type and each of the vegetation types (4) *Combretum-Terminalia woodland and wooded grassland* (CTW), which is adjacent, (5) *Dry evergreen Afromontane forest and grassland complex* (DAF), which is not adjacent, and (12) *Salt-water lakes, salt-lake shores, marsh and pan vegetation* (SLV), which is adjacent. Data from Appendix 3 (p. 177-237), Table 2 (p. 43) and Fig. 13 (p. 37).

Floristically, (1) *Desert and semi-desert scrubland* (DSS) is not a well defined vegetation type; the main characteristics are physiognomical, based on the very scarce plant cover.

CHARACTERISTIC SPECIES: The characteristic species of trees and shrubs include *Acacia ehrenbergiana* (Fabaceae subfam. Mimosoideae), *Boswellia ogadensis, Commiphora erosa, C. longipedicellata* (all Burseraceae), *Gyrocarpus hababensis* (Hernandiaceae), *Kissenia arabica* (Loasaceae), *Ochradenus baccatus* (Resedaceae), *Diceratella revoilii* (Brassicaceae); *Cadaba barbigera, C. divaricata,* (all Capparidaceae), and *Ziziphus hamur* (Rhamnaceae).

Woody species recorded only from this vegetation type include: *Acacia oliveri* (Fabaceae subfam. Mimosoideae), *Acridocarpus glaucescens* var. *ferrugineus* (Malpighiaceae), *Commiphora guidottii, C. longipedicellata, C. samharensis, C.* sp. = *Gilbert et al.* 8170, *C.* sp. = *Gilbert et al.* 8171, *C. sphaerocarpa*, *C. staphyleifolia* and *C. unilobata* (all Burseraceae).

Succulents are also characteristic, including *Euphorbia doloensis* (endemic), *E. ogadenensis, E. quadrispina* (Euphorbiaceae), *Aloe bertemariae,* and *A. citrina* (Aloaceae). Drought-tolerant grass species (Poaceae) include

FIG. 14

A: Desert with sand and boulders. Scattered shrubs of *Acacia* and tufts of grass grow in the shallow depression in foreground. A tree of *Gyrocarpus hababensis* (Hernandiaceae) grows among the large boulders of the quaternary lava flow in the background. North of Serdo along the trail to Lake Afrera. Altitude approximately 450 metres. AF floristic region. October, 2006.

B: Desert with sand dunes. Tufts of the grass *Panicum turgidum* browsed by camels in the foreground. Similar tufts are formed by *Leptadenia pyrotechnica* (Asclepiadaceae). Both kinds of tufts collect wind-blown sand and may eventually develop into dunes. North-west of Asaita. Altitude approximately 400 metres. AF floristic region. October, 2006.

A

B

FIG. 14 A-B. Views of (1) *Desert and semi-desert scrubland* (DSS).

C

D

E

FIG. 14 C-D-E. Views of (1) *Desert and semi-desert scrubland* (DSS).

FIG. 14

C: Desert with extensive sand and clay plains. The area is flooded during rains. The soils consist of fine sand or clay; the green shade represents annual species of Zygophyllaceae and Aizoaceae. A group of ostriches in search of food. North-west of Asaita. Altitude approximately 400 metres. AF floristic region. October, 2006.

D: Desert and semi-desert scrubland. In the foreground desert with small lava boulders, in the background semi-desert scrubland with rather dense growth of *Acacia*-shrubs. South-west of Eli Dar. Altitude approximately 400 metres. AF floristic region. October, 2006.

E: Semi-desert scrubland with low and open *Acacia*-dominated scrub on rocky slopes and red sand in the flat areas. West of Dolo Odo. Altitude approximately 200 metres. SD floristic region. February, 2000.

a proportionally high number of annuals, such as *Dactyloctenium aegyptium*, and relatively fewer perennials, such as *Panicum turgidum*. The grass *Panicum turgidum* and the shrub *Leptadenia pyrotechnica* (Asclepiadaceae) may grow in completely dry, sandy desert, where they stabilise drifting sand and form the core of dunes (Fig. 14B).

DISTRIBUTION: This vegetation type occurs in large parts of the AF floristic region, the Ogaden, around Lake Chew Bahir and the delta of the Omo river in GG, and in the extreme lowlands of the BA, SD and HA floristic regions. The western part of the AF floristic region has an open and depauperate type of *Acacia-Commiphora* bushland.

MAPPING: This vegetation type is indicated in the legend to the map plates of the atlas as mapping unit "*Desert and semi-desert scrubland* (DSS)." Apart from the areas taken up by salt- and freshwater vegetation, all areas below 400 metres have been mapped as this unit. Because of the scarcity of plant cover in this mapping unit there is a rather poorly marked transition zone to the surrounding terrestrial vegetation types (mapping units "*Acacia-Commiphora woodland and bushland proper* (ACB)" and "*Combretum-Terminalia woodland and wooded grassland* (CTW)"), inside which there may be vegetation that physiognomically and floristically is similar to this mapping unit.

(2) *Acacia-Commiphora woodland and bushland* (ACB)

This vegetation type is found in large areas of dry lowland to the east of the highlands and in the Rift Valley. Because of considerable differences, this complex and varied vegetation has been divided into two subtypes, one extensive subtype covering large parts of eastern and southern Ethiopia, and one restricted to part of the Rift Valley. The text here common for the two subtypes is limited because the first subtype is physiognomically varied, and has many unique species, and the second is physiognomically rather uniform and has none or only very few unique species. It therefore seems reasonable to treat the two subtypes almost as two full types. The authors have consider treating the two subtypes as independent types, but the idea was abandoned because of the limited floristic distinctiveness of the *Acacia* woodlands of the Rift Valley, where nearly all the woody species also occur in the other subtype.

DIVERSITY AND FLORISTIC OVERLAP WITH OTHER VEGETATION TYPES: A total of 565 species, subspecies and varieties have been recorded to occur in (2) *Acacia-Commiphora woodland and bushland* (ACB). Of these, 286 (52.77% of the total) have only been recorded from this vegetation type; 117 have been recorded from both this vegetation type and the adjacent vegetation type (1) *Desert and semi-desert scrubland* (DSS); 102 have been recorded from both this vegetation type and the adjacent vegetation type (5) *Dry evergreen Afromontane forest and grassland complex* (DAF); 50 have been recorded from both this vegetation type and the adjacent vegetation type (4) *Combretum-Terminalia woodland and wooded grassland* (CTW); 32 have been recorded from both this vegetation type and the adjacent vegetation type (10) *Riverine vegetation* (RV); five have been recorded from both this vegetation type and the adjacent vegetation type (3) *Wooded grassland of the western Gambela region* (WGG); one have been recorded from both this vegetation type and the adjacent vegetation type (12) *Salt-*

water lakes, salt-lake shores, marsh and pan vegetation (SLV). Data from Appendix 3 (p. 177-237), Table 2 (p. 43) and Fig. 13 (p. 37).

Floristically, (2) *Acacia-Commiphora woodland and bushland* (ACB) is the most diverse vegetation type of all in this atlas, with the highest number of species, subspecies and varieties not shared with other vegetation types. But so far relatively little is known about possible subdivisions of this large area, and the geography of such possible subdivisions can as yet only be assumed. Here, it has only been possible to distinguish two broadly defined subtypes, a fairly well defined subtype in a relatively clearly defined geographical area, the Rift Valley, and the main, extremely extensive and diverse (2) *Acacia-Commiphora woodland and bushland* (ACB).

CHARACTERISTIC SPECIES: See under the two subtypes.

DISTRIBUTION: See under the two subtypes.

MAPPING: The two subtypes are separately mapped. See further under each subtype.

(Subtype 2a) *Acacia-Commiphora woodland and bushland proper* (ACB)

This vegetation type is characterized by drought-resistant trees and shrubs, either deciduous or with small, evergreen leaves. The soils are commonly sandy, derived from Jurassic and Cretaceous limestone and other sedimentary rocks, or, in the AF floristic region, from volcanic rocks. However, black alluvial soils also occur along rivers and in places with impeded drainage.

Fig. 15A-D and 15J-K show *Acacia-Commiphora* woodland or bushland on red or brown sand during or shortly after the rainy season; there is a well-developed undergrowth of small shrubs or shrublets with annual stems from woody basal parts. Fig. 15H-K shows examples of this undergrowth, including bulbous herbs in Fig. 15K. Fig. 15D shows *Acacia-Commiphora* woodland on red or brown sand during the dry season. Fig. 15E shows an area with black cotton soil; the vegetation is grassland and wooded grassland with *Acacia drepanolobium*. Fig. 15H shows one of the climbers, *Pyrenacantha malvifolia* (Icacinaceae), with short-lived climbing stems from large, partly underground corms. Fig. 15F shows dry *Commiphora* bushland around the base of a rocky outcrop of sandstone. Fig. 15G shows *Acacia paolii* bushland on black cotton soil.

CHARACTERISTIC SPECIES: The trees and shrubs form an almost complete canopy and among the species are: *Acacia bussei, A. drepanolobium* (often dominant on black soils in places with impeded drainage), *A. hamulosa, A. ogadensis, A. prasinata* (endemic), *A. reficiens, A. tortilis, A. zizyphispina* (all Fabaceae subfam. Mimosoideae), *Boswellia microphylla, B. neglecta, Commiphora alaticaulis, C. albiflora, C. ancistrophora, C. boiviniana, C. boranensis, C. campestris, C. ciliata, C. confusa, C. coronillifolia, C. corrugata, C. cyclophylla, C. ellenbeckii, C. gowello, C. hildebrandtii, C. mildbraedii, C. myrrha, C. obovata, C. quadricincta, C. rostrata, C. serrulata, C. sphaerophylla, C. truncata* (all Burseraceae), *Balanites aegyptiaca, B. rotundifolia* (both Balanitaceae), *Boscia minimifolia*, *Cadaba ruspolii*, *C. rotundifolia*, *Capparis tomentosa* (all Capparidaceae); *Combretum aculeatum* and *Terminalia orbicularis* (both Combretaceae).

Succulents are prominent, such as *Euphorbia awashensis* (endemic), *E. monacantha* (endemic), *E. burgeri* (endemic), *E. cryptocaulis* (endemic), *E. dalettiensis* (endemic), *E. gymnocalycioides* (endemic), *E. longispina*, *E. omariana* (endemic), *E. piscidermis* (endemic), *E. robecchii*, *E. sebsebei* (endemic), *E. tescorum* (all Euphorbiaceae), *Aloe calidophila*, *A. ellenbeckii*, *A. friisii* (endemic), *A. gilbertii* (endemic), *A. mcloughlinii*, *A. otallensis* (endemic), *A. pirottae*, *A.*

FIG. 15

A: *Acacia-Commiphora* woodland and bushland with well developed understorey of subshrubs and herbs on pale red sand. Late rainy season or early dry season. Between Negele and Filtu. Altitude approximately 1600 metres. SD floristic region. September, 1972.

B: *Acacia-Commiphora* bushland on fine-grained, reddish sand. Aspect following a rainy season with much precipitation. Near Yabelo. Altitude approximately 1600 metres. SD floristic region. November, 1997.

A

B

FIG. 15 A-B. Views of (Subtype 2a) *Acacia-Commiphora woodland and bushland proper* (ACB).

C

D

E

FIG. 15 C-D-E. Views of (Subtype 2a) *Acacia-Commiphora woodland and bushland proper* (ACB).

F

G

H

FIG. 15 F-G-H. Views of (Subtype 2a) *Acacia-Commiphora woodland and bushland proper* (ACB).

I

J

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FIG. 15

C: *Acacia-Commiphora* woodland and bushland on pale, reddish gravel over limestone. Near Sof Omar on the Weyb river between Megalo and Ginir. Rainy season. Altitude approximately 1500 metres. BA floristic region. October, 1984.

D: *Acacia-Commiphora* woodland and bushland on pale red sand. The trees and shrubs are nearly all leafless and the ground bare in a dry season following after a rainy season that failed. Near Filtu. Altitude approximately 1600 metres. SD floristic region. December, 2002.

E: Grassland with scattered *Acacia drepanolobium* on black cotton soil (vertisol). To the left in the picture a denser stand of *Acacia drepanolobium*. Rainy season. South-east of Negele along the road towards Wolensu. Altitude approximately 1600 metres. SD floristic region. September, 1972.

F: Rocky outcrop in *Acacia-Commiphora* bushland. The rocks, belonging to the basement complex, withers to red sand. Early dry season. Between Wachile and El Gof. Altitude approximately 1300 metres. SD floristic region. December, 1997.

G: *Acacia-Commiphora* bushland on black cotton soil (vertisol). *Acacia paolii* is common in places with black cotton soil, together with shrubs of Capparidaceae, for example *Cadaba rotundifolia, Maerua crassifolia* and others. Dry season. Near Teltele. Altitude approximately 1500 metres. SD floristic region. December, 1997.

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FIG. 15.

H: Partly exposed tubers of *Pyrenacantha malvifolia* (Icacinaceae) in the undergrowth of *Acacia-Commiphora* bushland, here partly on black cotton soil (vertisol). Late rainy season. Near Sof Omar on the Weyb river between Megalo and Ginir. Altitude approximately 1500 metres. BA floristic region. October, 1984.

J: Open area in *Acacia-Commiphora* bushland. The low shrub with red flowers is *Satanocrater paradoxus* (Acanthaceae). Rainy season. Between Negele and Filtu. Altitude approximately 1600 metres. SD floristic region. September, 1972.

K: Subshrubs and robust bulbous herbs, including *Drimia altissima* (Hyacinthaceae), in *Acacia-Commiphora* bushland on thin, sandy soil over limestone. Rainy season. Between Negele and Filtu. Altitude approximately 1600 metres. SD floristic region. September, 1972.

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parvidens, *A. retrospiciens*, *A. rugosifolia*, *A. ruspoliana*, *A. secundiflora*, and *A. sinana* (endemic; all Aloaceae).

Lianas are not particularly prominent, but climbing species of Asclepiadaceae occur rather frequently, for example *Sarcostemma viminale* and *Pergularia daemia*. Climbing species of Convolvulaceae, for example *Ipomoea pogonantha* and *Ipomoea kituiensis*, as well as succulent-stemmed species of *Cissus* (Vitaceae), are also quite common. *Pyrenacantha malvifolia* (Icacinaceae) is a liana with relatively short-lived climbing stems from large, partly underground corms, see Fig. 15H.

Due to small leaves in the tree and shrub layers, light penetrates to the ground, which often has a rich flora. Thus, the ground-cover is rich in subshrubs, including *Satanocrater paradoxus* (Acanthaceae) and species of *Acalypha* (Euphorbiaceae), *Barleria* (Acanthaceae), and *Aerva* (Amaranthaceae). Scrambling shrubs of *Asparagus* are also common, for example *Asparagus aridicola*, *A. leptocladodius*, and *A. scaberulus* (all Asparagaceae), as well as the shrubby monocot *Xerophyta schnizleinia* (Velloziaceae). Herbaceous monocots (geophytes) are also prominent and common, such as *Chlorophytum neghellense* (endemic), *C. somaliense*, *C. pterocarpum* (endemic), *C. zavattarii* (all Anthericaceae), and *Drimia altissima* (Hyacinthaceae).

Sometimes no trees are present, and in such cases the vegetation should be referred to as *Acacia-Commiphora* bushland.

The woody species that have been recorded only from this vegetation type are numerous, almost all the 286 species, subspecies and varieties unique to the main vegetation type (2) *Acacia-Commiphora woodland and bushland* (ACB) are found in this subtype, indicating how floristically diverse the vegetation type is.[1]

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1. The woody species restricted to the ACB proper are: *Abutilon anglosomaliae; A. hirtum; Acacia condyloclada; A. etbaica* subsp. *platycarpa; A. goetzei* subsp. *microphylla; A. hamulosa; A. horrida* subsp. *benadirensis; A. nilotica* subsp. *kraussiana; A. nilotica* subsp. *leiocarpa; A. ogadensis; A. paolii; A. reficiens* subsp. *misera; A. senegal* var. *kerensis; A. senegal* var. *leiorachis; A. zizyphispina; Adenia aculeata* subsp. *aculeata; A. globosa* subsp. *globosa; A. inermis; A. venenata; Aloe gilbertii* subsp. *megalacanthoides; Anisotes involucratus; A. tanensis; A. trisulcus* subsp. *webi-schebelensis; Asepalum eriantherum; Asparagus leptocladodius; A. scaberulus; A. aspergillus; Astripomoea nogalensis; Asystasia excellens; Balanites glabra; B. rotundifolia* var. *rotundifolia; Basananthe berberoides; Bauhinia ellenbeckii; Becium ellenbeckii; Bidens hildebrandtii; Blepharispermum ellenbeckii; B. fruticosum; B. obovatum; B. villosum; Boscia minimifolia; B. mossambicensis; Boswellia microphylla; B. neglecta; Bottegoa insignis; Bourreria orbicularis; Bridelia cathartica; Buckollia tomentosa; Cadaba ruspolii; Caesalpinia dauensis; C. oligophylla; C. trothae* subsp. *erlangeri; Calyptrotheca somalensis; Carphalea glaucescens; Cephalocroton cordofanus; Chionothrix latifolia; Cissus aphyllantha; Cladostigma hildebrandtioides; C. nigistiae; Clerodendrum robecchii; Combretum contractum; C. hereroense* subsp. *parvifolium; Commiphora alaticaulis; C. albiflora; C. ancistrophora; C. boiviniana; C. boranensis; C. campestris; C. ciliata; C. confusa; C. coronillifolia; C. cyclophylla; C. hildebrandtii; C. hodal; C. horrida; C. mildbraedii; C. monoica; C. obovata; C. ogadensis; C. quadricincta; C. rostrata; C. serrulata; C. sp. = Corradii 6767, 6768; C. sp. = Friis et al. 3160; C. sp. = Glover & Gilliland 973; C. sp. = Gilbert et al. 7652; C. sphaerophylla; C. tenuis; C. terebinthina; C. truncata; C. tubuk; Cordia ellenbeckii; C. quercifolia; Cordyla somalensis; Craibia brevicaudata; Crossandra infundibuliformis* subsp. *boranensis; Croton meynhartii; C. schimperianus; C. somalense; Cynanchum lennewtonii; Cyphostemma boranense; Dalbergia commiphoroides; D. microphylla; Delonix baccal; Dichrostachys kirkii; Dicraeopetalum stipulare; Distephanus plumosus; Dombeya kirkii; Dracaena ellenbeckiana; Dregea stelostigma; Ecbolium boranense; E. gymnostachyum; Ehretia braunii; Elaeodendron aquifolium; Entada leptostachya; Erythrina burana; E. melanacantha* subsp. *melanacantha; E. melanacantha* subsp. *somala; Erythrochlamys specabilis; Erythrophysa septentrionalis; Euphorbia adjurana; E. betulicortex; E. borenensis; E. breviarticulata* var. *breviarticulata; E. breviarticulata* var. *truncuformis; E. burgeri; E. cryptospinosa; E. cuneata* subsp. *spinescens; E. dalettiensis; E. erlangeri;*

DISTRIBUTION: This vegetation type occurs in the northern, eastern, central and southern parts of the country between 400-(-900) and 1600-1800(-1900) metres altitude. It is particularly characteristic of extensive areas in the Southern and South-eastern lowlands and in the western part of the AF floristic region.

E. jatrophoides; E. kelleri var. *latifolia; E. migiurtinorum; E. nigrispina; E. robecchii; E. scheffleri; E. somalensis; E. tescorum; E. uniglans; Farsetia somalensis; Flueggea leucopyrus; Gardenia fiorii; Ghikea speciosa; Givotia gosai; Gossypium brichettii; G. somalense; Grewia arborea; G. balensis (= Gilbert & Sebsebe 8598); G. erythraea; G. forbesii; G. gillettii; G. kakothamnos; G. lilacina; G. pennicillata; G. schweinfurthii; G. tembensis* var. *ellenbeckii; G. tristis; G. villosa; Gyrocarpus angustifolius; Helinus integrifolius; Hibiscus flavifolius; H. seineri; H. sparseaculeatus; Hildebrandtia africana* subsp. *africana; H. aloysii; H. diredawensis; H. obcordata* var. *obcordata; H. obcordata* var. *puberula; H. sepalosa; Hippocratea africana* var. *richardiana; Hybanthus durus; Ichtyostoma thulinii; Indigofera binderi; I. curvirostrata; I. lupatana; I. macrantha; Ipomoea chrysosperma; I. cicatricosa; I. citrina; I. marmorata* subsp. *marmorata; I. marmorata* subsp. *somalica; I. pogonantha; I. spathulata; Jatropha dichtar; J. ellenbeckii; J. rivae* subsp. *quercifolia; J. rivae* subsp. *rivae; Justicia grisea; J. phillpsiae; J. potamophila; J. rendlei; Kirkia burgeri* subsp. *burgeri; K. tenuifolia; Kleinia negrii; K. odora; K. squarrosa; Lannea humilis; L. malifolia; Lantana viburnoides* var. *viburnoides; Leucas jamesii; Limeum fruticosum; Lippia carviodora; Loewia glutinosa; Maerua angolensis* subsp. *socotrana* var. *africana; M. boranensis; M. crassifolia; M. denhardtiorum; M. endlichii; M. gillettii; M. glauca; M. sessiliflora; M. subcordata; Maytenus putterlichoides; Megalochlamys violacea; Melia volkensii; Momordica rostrata; Moringa borziana; M. rivae* subsp *rivae; M. rivae* subsp. *longisiliqua; Ochna inermis; Ochradenus somalensis; Opilia campestris* var. *strobilifera; Ormocarpum muricatum; O. trachycarpum; O. trichocarpum; Otostegia fruticosa* subsp. *schimperi; Paederia pospischilii; Pavonia friisii (= Friis et al. 2801); Pentanopsis fragrans; Pentarrhinum somaliense; Pergularia daemia [P. tomentosa is not high enough]; Periploca visciformis; Phyllanthus borenensis; P. hildebrandtii; Platycelyphium voense; Plectranthus gillettii; P. igniarius; Premna oligotricha; P. resinosa; Psiadia incana; Psychotria kirkii* var. *tarambassica; Pyrenacantha malvifolia; Ruellia discifolia; Ruspolia hypocrateriformis; Satanocrater paradoxus; S. somalensis; Secamone parvifolia; Senna baccarinii; Sericocomopsis hildebrandtii; Sesamothamnus rivae; Sida sp. = Bally 9622 Solanum dennekense; S. hastifolium; S. somalense; S. tettense* var. *renschii; Sterculia rhynchocarpa; S. stenocarpa; Stigmatorhynchus sp. = J. de Wilde 7216; Symphyochlamys erlangeri; Terminalia basilei; T. orbicularis; T. prunioides; T. spinosa; Tinospora bakis; Triaspis erlangeri; T. niedenzuiana; Triumfetta actinocarpa; T. heterocarpa; Turraea parvifolia; Vangueria madagascariensis* var. *abyssinica; Vatovea pseudlolablab; Vepris eugenifolia; V. glomerata* var. *glabra; V. glomerata* var. *glomerata; Vernonia dalettiensis; V. hildebrandtii; Zanthoxylum chalybeum* var. *chalybeum.*

MAPPING: This vegetation subtype is marked as mapping unit "*Acacia-Commiphora woodland and bushland proper* (ACB)." The 400 metres contour marks the lower limit of this mapping unit, thus demarcating it from mapping unit "*Desert and semi-desert scrubland* (DSS)." But this sharp demarcation blurs that there is actually a broad transition zone, and that the upper limit of the mapping unit may sometimes be higher than at 400 metres altitude. Because of the low relief in most areas with this vegetation, a change in altitude of just 100 metres will result in a notable shift in the position on the map of the border between mapping units "*Desert and semi-desert scrubland* (DSS)" and "*Acacia-Commiphora woodland and bushland proper* (ACB)."

It has not been possible to define the western limit of mapping unit "*Acacia-Commiphora woodland and bushland proper* (ACB)" towards mapping unit "*Combretum-Terminalia woodland and wooded grassland* (CTW)" by simply using altitude or rainfall, although the boundary is associated with the shift from a bimodal rainy season, with rain in April-May and October-November in the areas of mapping unit "*Desert and semi-desert scrubland* (DSS)," and a primarily unimodal summer rain in the area of mapping unit "*Combretum-Terminalia woodland and wooded grassland* (CTW)." Where the mapping unit "*Acacia-Commiphora woodland and bushland proper* (ACB)" meets with "*Combretum-Terminalia* woodland and wooded grassland (CTW)" – in zone I of Fig. 36 (p. 245) in this book – a boundary has been manually defined, based on field observations of the authors.

The boundary between *Combretum-Terminalia* woodland and wooded grassland (CTW) and (2) *Acacia-Commiphora woodland and bushland proper* (ACB) is quite sharply demarcated in some places, often on steeper slopes or on deep, loamy soils, where tall grass and grass fires further the dominance of CTW, even to the east of the boundary marked in this atlas, while on flat ground and on sandy soil (2) *Acacia-Commiphora woodland and bushland proper* (ACB) may dominate, even to the west of the boundary marked in this atlas.

To the south the boundary follows the 750 metres contour, starting at the border with Sudan in the south-east corner of the GG floristic region. Further north it moves gradually to coincide with the 1250 metre contour, which it follows up to the area southwest of the mountain bridge across the Rift Valley to the south of Lake Awasa.

(Subtype 2b) *Acacia wooded grassland of the Rift Valley* (ACB/RV)

The wooded grasslands of the Rift Valley consist of a tree stratum mainly, or almost entirely, dominated by species of *Acacia* over a grass stratum. In this it resembles the *Acacia*-dominated wooded grasslands of the Gambela region, but it is distinguished from that vegetation by the nearly total absence of flooding and grass fires, and by a different composition of the tree stratum, in which *Acacia albida* and *A. tortilis* are common, while these species are rare or absent in the Gambela region. When not heavily influenced by man, the canopy of (Subtype 2b) *Acacia wooded grassland of the Rift Valley* (ACB/RV) is more closed than the canopy of the following vegetation type, (3) *Wooded grassland of the western Gambela region* (WGG), and the flat-topped species of *Acacia* in the Rift Valley form a neat stratum, not normally so well defined in the woodlands and wooded grasslands of the Western lowlands.

This vegetation type is located between northern, species-poor part of the *Acacia-Commiphora* bushland in the western part of the AF floristic region and the southern, species-rich part of the *Acacia-Commiphora* bushland in the Southern and South-eastern lowlands. But the genus *Commiphora* is almost totally absent in the major part of the Rift Valley around the northern Rift Valley lakes from Ziway to Awasa, and in wooded grasslands of the Rift Valley grasses are considerably more prominent than in the *Acacia-Commiphora* bushland proper. The wooded grasslands of the Rift Valley are therefore here placed as a separate subtype of the *Acacia-Commiphora* bushland.

Fig. 16A-C shows three examples of *Acacia* wooded grassland in the Rift Valley. Volcanic eruptions in connection with the formation of the Rift has produced rocky outcrops with lava-flows that have a flora different from the dominant *Acacia* wooded grassland. There are many succulent and other drought-tolerant species on these lava-flows, as seen in Fig. 16D.

CHARACTERISTIC SPECIES: The tree stratum consists mainly of *Acacia etbaica*, *A. seyal*, *A. albida*, *A. tortilis*, *A. senegal*, etc. (all Fabaceae subfam. Mimosoideae). Other genera are *Croton* (especially *C. dichogamus*), and a candelabra-shaped *Euphorbia* (both Euphorbiaceae). The grasses belong mainly to the genera *Hyparrhenia*, *Heteropogon*, *Setaria*, *Sporobolus* and *Panicum*.

There are also some succulents, including the widespread *Aloe trichosantha* and the endemic *A. gilbertii* subsp. *gilbertii* (both Aloaceae). Other endemic species include the succulent *Euphorbia nigrispinioides* (Euphorbiaceae) seen in Fig. 16D. However, no trees have been found to be restricted to this subtype.

DISTRIBUTION: The wooded grasslands of the Rift Valley occur from the upper part of the Awash river in the north along the Rift Valley lakes to the town of Konso in the south. On the slopes of the Rift Valley above the wooded grassland there is a range of vegetation types, in the south-western part of the Rift Valley a narrow zone of *Combretum-Terminalia* woodland, on the eastern side mainly vegetation of the Dry Afromontane forest and grassland complex.

This vegetation type might extend further north than indicated on the map plates, possibly as far north as the TU floristic region, in a zone below (5) *Dry evergreen Afromontane forest and grassland complex* (DAF). Although specimens of *Commiphora* have been observed here, they are very scattered, and a few species of *Acacia* (for example *A. mellifera* and *A. tortilis*) are the domi-

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FIG. 16

A: Early dry season aspect of open *Acacia* woodland and bushland with discontinuous ground cover. Awash National Park, near the volcano Fantale. Altitude approximately 1600 metres. SU floristic region. October, 2006.

B: *Acacia tortilis* woodland with thin ground cover of grasses. Rainy season aspect. Between Bulbula and Adami Tulu. SU floristic region. Altitude approximately 1700 metres. April, 2006. Photograph by Christian Puff, Vienna.

A

B

FIG. 16 A-B. Views of (Subtype 2b) *Acacia wooded grassland of the Rift Valley* (ACB/RV).

A

B

FIG. 16 C-D. Views of (Subtype 2b) *Acacia wooded grassland of the Rift Valley* (ACB/RV).

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FIG. 16

C: Open *Acacia tortilis* woodland with continuous ground cover of grasses. Otherwise as for (B).

D: Bushland of *Euphorbia nigrispinioides* (Euphorbiaceae), with undergrowth of annual grasses and annual and perennial herbs; early dry season aspect. East of Nazret [Adama] towards Awash. Altitude approximately 1400 metres. SU floristic region. October, 2005.

nant species in the woody component of this vegetation. See also further about the transition zone with evergreen bushland on the Eastern escarpment under (Subtype 5c) *Afromontane woodland, wooded grassland and grassland* (DAF/WG).

MAPPING: This vegetation subtype is marked as mapping unit "*Acacia wooded grassland of the Rift Valley* (ACB/RV)." It is defined as the bottom of the Rift Valley below the 1800 metres contour. With the exception of the northern link with the AF floristic region this area is surrounded by mountains with Afromontane vegetation; there is even a low bridge of mountains higher than 1800 metres that crosses the Rift Valley immediately to the south of Lake Awasa. The transitional gradient to the neighbouring vegetation types, mapping unit "*Dry evergreen Afromontane forest and grassland complex* (DAF)" on most sides except to the north, is steep and the transition zone is therefore narrow. The northern boundary towards mapping unit "*Acacia-Commiphora woodland and bushland proper* (ACB)" in the Afar region is drawn by hand and the position of this boundary is based on the observations of the authors with regard to where the typical *Acacia wooded grassland of the Rift Valley* (ABC/RV) changes into the dry and open *Acacia-Commiphora* bushland of the AF floristic region.

(3) *Wooded grassland of the western Gambela region* (WGG)

This vegetation is characterised by a tall grass stratum that burns annually, and a canopy layer of trees that can both tolerate burning and temporary flooding.

Fig. 17A shows tall grassland in the early dry season with the grass stratum dominated by the genera *Hyparrhenia* and *Oryza*. Fig. 17B shows a temporarily flooded area in the late rainy season with a clump of *Acacia seyal* and *A. nilotica* and *Balanites aegyptiaca* (Balanitaceae). Fig. 17C shows wooded grassland in the early dry season. Fig. 17D shows vey high grasses (*Hyparrhenia*) in *Acacia* wooded grassland. Fig. 17E shows an area in wooded grassland that has been flooded long enough to allow an aquatic vegetation of *Nymphaea lotus* (Nymphaeaceae), *Pistia stratiotes* (Araceae) and *Eichhornia crassipes* (Pontederiaceae) to develop.

DIVERSITY AND FLORISTIC OVERLAP WITH OTHER VEGETATION TYPES: A total of seven species, subspecies and varieties of woody plants have been recorded to occur in (3) *Wooded grassland of the western Gambela region* (WGG). Of these, one (14.29% of the total) has only been recorded from this vegetation type; five have been recorded from both this vegetation type and the adjacent vegetation type (4) *Combretum-Terminalia woodland and wooded grassland* (CTW), and 2 from both this vegetation type and (5) *Dry evergreen Afromontane forest and grassland complex* (DAF). Data from Appendix 3 (p. 177-237), Table 2 (p. 43) and Fig. 13 (p. 37).

Floristically, (3) *Wooded grassland of the western Gambela region* (WGG) has low diversity of woody plants and few species that are unique for this vegetation type. These low figures would seem to be underestimates, but the floristics of the western IL floristic region is still poorly known. Moreover, this vegetation type is mainly characterised by its physiognomy and herbaceous flora, especially the grass species, rather than by its woody species.

FIG. 17

A: Grassland with scattered trees. In the foreground *Hyparrhenia* spp., in the background areas with *Oryza* sp. dominant. West of Itang. Altitude approximately 450 metres. IL floristic region. September, 1996.

B: Partly flooded woodland with *Balanites aegyptiaca*, *Acacia seyal* and *Acacia nilotica*. West of Itang. Altitude approximately 450 metres. IL floristic region. September, 1996.

A

B

FIG. 17 A-B. Views of (3) *Wooded grassland of the western Gambela region* (WGG).

FIG. 17 C-D-E. Views of (3) *Wooded grassland of the western Gambela region* (WGG).

FIG. 17

C: Wooded grassland with medium-tall ground cover of *Hyparrhenia* spp. and other species. West of Gambela. Altitude approximately 450 metres. IL floristic region.

D: Wooded grassland with species of *Acacia* and tall grass stratum of *Hyparrhenia* spp. West of Gambela. Altitude approximately 450 metres. IL floristic region. September, 1996.

E: Partly flooded woodland. In the background *Acacia* woodland with *Hyparrhenia* spp. In the foreground large pool with *Nymphaea lotus* (Nymphaeaceae), *Pistia stratiotes* (Araceae) and *Eichhornia crassipes* (Pontederiaceae) floating on the water. East of Itang. Altitude approximately 450 metres. October 1986.

CHARACTERISTIC SPECIES: The most dominant species in the tree stratum are species of *Acacia* (Fabaceae subfam. Mimosoideae), especially *A. seyal* and *A. nilotica*. The palms *Hyphaene thebaica* and *Borassus aethiopum* may also occur, either singly or together.

In the grass stratum species of *Echinochloa*, *Setaria*, *Hyparrhenia*, *Cymbopogon* and *Sorghum* are common. In the most flooded areas there are nearly pure stands of *Oryza*, especially *O. longistaminata*. Moisture tolerant herbs are also common in the flooded areas, for example *Caperonia serrata* (Euphorbiaceae), and *Thalia geniculata* (Maranthaceae).

DISTRIBUTION: This vegetation occurs in Ethiopia only in the western part of the Gambela region. It is approximately equivalent to the continuation within Ethiopia of the extensive "Flood region" in the upper part of the Nile Valley in Sudan, and recognised as an extensive vegetation type in the southern Sudan by Harrison and Jackson (1958), but in Sudan the trees disappear as one moves towards areas of high flooding, where wooded grasslands are replaced by extensive swamps.

MAPPING: This major vegetation type is marked as mapping unit "Wooded grassland of the western Gambela region region (WGG)." Almost the whole of western Gambela region is liable to flooding in the rainy season; this almost agrees with the areas below the 450 or 500 metres contour. On the map plates in the atlas the area of (3) *Wooded grassland of the western Gambela region* (WGG) has been indicated in agreement with the areas of "Freshwater Marsh and Floodplains." in the GLWD (Global Wetlands Database; see Lehner & Döll, 2004) that are located within the IL floristic region.

(4) *Combretum-Terminalia woodland and wooded grassland* (CTW)

This vegetation type is characterized by small to moderate sized trees with fairly large deciduous leaves; species of the genera *Combretum* and *Terminalia* (Combretaceae) are characteristic, but woody species of Fabaceae other than *Acacia* (for example *Lonchocarpus laxiflorus, Pterocarpus lucens, Dalbergia melanoxylon* and *Piliostigma thonningii*) are also important. Species of *Acacia* are only prominent in a few places with special edaphic conditions, mainly on flat ground with vertisols. The grass stratum is usually well developed, many grass species, especially those belonging to the genera *Hyparrhenia*, *Panicum* and *Pennisetum* are tall, and the biomass develops well during the rainy season. In the dry season this vegetation type is strongly susceptible to burning. The grass stratum often burns several times during a dry season because the perennial grasses sprout again after burning, providing new biomass that can burn.

Figs 18A and 18C show *Combretum-Terminalia* woodland and wooded grassland at low altitude on the Western escarpment near the point where the Abay [Blue Nile] river leaves the highlands. Small individuals of *Hyphaene thebaica* (Arecaceae) can be seen, in addition to the above mentioned species of trees. Fig. 18E shows *Combretum-Terminalia* woodland and wooded grassland on the foothills of the Western escarpment between Asosa and Kurmuk. Fig. 18D-E show *Combretum-Terminalia* woodland and wooded grassland the slopes of rocky outcrops (volcanic plugs) in the foothills of the highlands near Kurmuk. Fig. 18F shows a distinct variant of *Combretum-Terminalia* woodland and wooded grassland that occurs particularly in the WG floristic region; the tree stratum is 5-8 m high, and the dominant tree is the semi-deciduous *Syzygium guineense* subsp. *macrocarpum* (Myrtaceae). Figs 18G-H show various aspects of the *Combretum-Terminalia* woodland and wooded grassland in the Tekeze valley; the deciduous trees to the left in (G) is *Boswellia papyrifera* (Burseraceae). Fig. 18J shows a flowering *Combretum collinum* (Combretaceae). Figs 18K-L show various types of *Acacia* woodland and wooded grassland inside the *Combretum-Terminalia* woodland and wooded grassland. Figs 18M-N show two aspects of the almost pure stands of the lowland bamboo (*Oxytenanthera abyssinica* (Poaceae)) that occurs within the *Combretum-Terminalia* woodland and wooded grassland.

DIVERSITY AND FLORISTIC OVERLAP WITH OTHER VEGETATION TYPES: A total of 199 species, subspecies and varieties of woody plants have been recorded to occur in (4) *Combretum-Terminalia woodland and wooded grassland* (CTW). Of these, 81 (40.70% of the total) have only been recorded from this vegetation type; 74 have been recorded from both this vegetation type and the adjacent vegetation type (5) *Dry evergreen Afromontane forest and grassland complex* (DAF); 50 have been recorded from both this vegetation type and the adjacent vegetation type (2) *Acacia-Commiphora woodland and bushland* (ACB), which meets with (4) *Combretum-Terminalia woodland and wooded grassland* (CTW) in southern Ethiopia; 13 have been recorded from both this vegetation type and the adjacent vegetation type (10) *Riverine vegetation* (RV); five have been recorded from both this vegetation type and the adjacent vegetation type (3) *Wooded grassland of the western Gambela region* (WGG); three are shared between this vegetation type and respectively the adjacent (1) *Desert and semi-desert scrubland* (DSS), the adjacent (6) *Moist evergreen Afromontane forest* (MAF), the adjacent (7) *Transitional rain forest* (TRF), the non-adjacent (8) *Ericaceous belt* (EB) and one with the non-adjacent (9) *Afroalpine belt* (AA), which is separated from (4) *Combretum-Terminalia woodland and wooded grassland* (CTW) by (5) *Dry evergreen Afromontane forest and grassland complex* (DAF) and (8) *Ericaceous belt* (EB). Data from Appendix 3 (p. 177-237), Table 2 (p. 43) and Fig. 13 (p. 37).

Floristically, the (4) *Combretum-Terminalia woodland and wooded grassland* (CTW) is a moderately diverse vegetation type, with a fairly high proportion of unique species, subspecies and varieties. The highest number of species, subspecies and varieties is shared with (5) *Dry evergreen Afromontane forest and grassland complex* (DAF).

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FIG. 18

A-B: *Combretum-Terminalia* woodland on stony soil derived from the basement complex. The palm *Hyphaene thebaica* is seen in both pictures. Foothills of the western escarpment near Bumbadi [Bumbodi], between Guba (Mankush) and El Roseires in Sudan. Altitude approximately 750 metres. GJ floristic region. October, 2008.

C: *Combretum-Terminalia* woodland with tall undergrowth of grasses, mainly *Hyparrhenia* spp. Rocky outcrop east of Kurmuk near the border with Sudan. Altitude approximately 1100 metres. WG floristic region. October, 1998.

D: *Combretum-Terminalia* woodland with undergrowth of low grasses on the steep slopes of rocky outcrop. East of Kurmuk. Altitude approximately 900 metres. WG floristic region. November, 2006.

E: Dry, regularly burnt hillside with *Lannea fruticosa* (Anacardiaceae) in the foreground, *Combretum* spp., *Cussonia arborea* and other species in the background. Between Asosa and Kurmuk. Altitude approximately 1000 metres. WG floristic region. November, 2006.

F: Woodland dominated by *Syzygium guineense* subsp. *macrocarpum* (Myrtaceae). Altitude approximately 1500 metres. Near Mendi. WG floristic region. November, 2006.

G: *Combretum-Terminalia* woodland with trees of *Boswellia papyrifera* in the foreground. Tekeze valley between Adwa and Abiy Adi [Abi Adi]. Altitude approximately 1500 metres. TU floristic region. October, 2007.

H: *Combretum-Terminalia* woodland in Tekeze valley between Inda Silase [Inda Silassie] and Togo Ber. Altitude approximately 1400 metres. TU floristic region. October, 2009.

A

B

FIG. 18. A-B. Views of (4) *Combretum-Terminalia woodland and wooded grassland* (CTW).

C

D

E

FIG. 18. C-D-E. Views of (4) *Combretum-Terminalia woodland and wooded grassland* (CTW).

F

G

H

FIG. 18. F-G-H. Views of (4) *Combretum-Terminalia woodland and wooded grassland* (CTW).

J

K

L

FIG. 18. J-K-L. Views of (4) *Combretum-Terminalia woodland and wooded grassland* (CTW).

M

M

FIG. 18. M-N. Views of (4) *Combretum-Terminalia woodland and wooded grassland* (CTW).

FIG 18

J: Flowering *Combretum collinum* in *Combretum-Terminalia* woodland. Between Bebeka coffee plantation and Dima, near the upper reach of the Akobo river. Altitude approximately 1200 metres. KF floristic region. January, 2009.

K: *Acacia polyacantha-Acacia dolicocephala* woodland and wooded grassland in Gibe gorge between Abelti and Welkite. Altitude approximately 1200 metres. KF floristic region. January, 2009.

L: Mixed *Acacia* woodland on sand near Gizen on the border with Sudan. *Acacia senegal* is the most common species. Altitude approximately 900 metres. WG floristic region. November, 2006.

M: Thicket of lowland bamboo (*Oxytenanthera abyssinica*), called Anbessa Chaka ("Lion thicket"), south of Asosa. All bamboo plants are in the stage before flowering. Altitude approximately 1400 metres. WG floristic region. November, 2006.

N: Thicket of lowland bamboo (*Oxytenanthera abyssinica*) east of Kurmuk. All bamboo plants are in the flowering stage. Altitude approximately 900 metres. WG floristic region. November, 2006.

CHARACTERISTIC SPECIES: The small to moderate sized trees with fairly large deciduous leaves characteristic of (4) *Combretum-Terminalia woodland and wooded grassland* (CTW) include *Cussonia arborea* (Araliaceae), *Boswellia papyrifera* (Burseraceae); *Anogeissus leiocarpa*, *Combretum adenogonium*, *C. hartmannianum* (near endemic), *C. molle, C. rochetianum* (near endemic), *C. collinum* (Fig. 18J), and species of *Terminalia,* for example *Terminalia laxiflora, T. macroptera,* and *T. schimperiana* (all Combretaceae); *Lonchocarpus laxiflorus, Pterocarpus lucens, Dalbergia melanoxylon, Piliostigma thonningii* (all Fabaceae subfam. Papilionoideae), *Balanites aegyptiaca* (Balanitaceae), *Stereospermum kunthianum* (Bignoniaceae), species of *Lannea,* for example *L. barteri, L. fruticosa, L. schimperi* and *L. schweinfurthii, Ozoroa insignis, O. pulcherrima, Sclerocarya birrea* subsp. *birrea* (all Anacardiaceae), *Vitex doniana* (Lamiaceae), *Acacia hockii* (Fabaceae subfam. Mimosoideae), and *Grewia mollis* (Tiliaceae). *Adansonia digitata* (Bombacaceae) is rather rare, but it does occur in the Tekeze valley and in the western parts in Benshangul-Gumuz [Benishangul-Gumuz] north to the village of Gelego, south of Metema, in the GD floristic region.

The solid-stemmed lowland bamboo *Oxytenanthera abyssinica* (Poaceae) is prominent in river valleys (and locally on the escarpment) of western Ethiopia. The ground-cover is a tall stratum of perennial grasses, including *Panicum maximum* and species of *Cymbopogon, Hyparrhenia, Echinochloa, Sorghum* and *Pennisetum.* Other characteristic monocots include *Chlorophytum herrmannii* (endemic), *C. serpens* (endemic) (both Anthericaceae); *Crinum bambusetum* (endemic), *Pancratium centrale* (both Amaryllidaceae), and *Asparagus flagellaris* (Asparagaceae).

In the tree flora of the woodlands in the deep river valleys leading westwards from the highlands are also found a small number of endemic trees, including *Boswellia pirottae* (Burseraceae), *Cussonia ostinii* and *Polyscias farinosa* (both Araliaceae).

A characteristic liana is *Tylosema fassoglensis* (Fabaceae subfam. Caesalpinioideae).

The woody species that have only been recorded from this vegetation type are less numerous than for the *Acacia-Commiphora woodland and bushland*, in fact considerably less than 100.[2] However, among the shrubby-based perennial herbs are a number of species that have a limited distribution outside this vegetation type or elsewhere in Ethiopia. These species include *Clerodendrum alatum* (Lamiaceae), *Dicoma sessiliflora* and *Ochrocephala imatongensis* (both Asteraceae).

The upper limit of the *Combretum-Terminalia* woodland in north-western Ethiopia, for example in the very broad and extensive Tekeze valley (Fig. 18G-H), is marked at almost exactly 1800 metres altitude by scattered specimens of *Anogeissus leiocarpa* (Combretaceae), *Senna singueana* (Fabaceae subfam. Caesalpinioideae) and *Acacia hecatophylla*.

In the lower part of the Tekeze valley, below 1500 metres altitude, the vegetation is dominated by *Anogeissus leiocarpa*, *Acacia hecatophylla*, *A. amythetophylla*, *Dichrostachys cinerea, Terminalia brownii, T. schimperiana, Combretum collinum*, *Lannea fruticosa* and *Stereospermum kunthianum*. Just around the river itself occur *Adansonia*

2. Only recorded from *Combretum-Terminalia* woodland and wooded grassland: *Abrus precatorius* subsp. *africanus; Acacia gerrardii; A. hecatophylla; A. hockii; Adansonia digitata; Adenia gummifera; Annona senegalensis; Anogeissus leiocarpa; Asparagus flagellaris; Barleria grandis; Boswellia papyrifera; B. pirottae; Catunaregam nilotica; Cephalocroton incanus; Cissus populnea; Clerodendrum cephalanthum; Combretum collinum* subsp. *binderianum; C. collinum* subsp. *collinum; C. collinum* subsp. *elgonense; C. collinum* subsp. *hypopilinum; C. hartmannianum; C. nigricans; C. rochetianum; Commiphora pedunculata; Crossopteryx febrifuga; Dalbergia melanoxylon; Desmodium velutinum; Dioscorea abyssinica; D. cochleari-apiculata; D. dumetorum; D. praehensilis;Dombeya buettneri; D. longibracteolata; D. quinqueseta; Entada africana; E. venenifica; Gardenia ternifolia* subsp. *ternifolia; Grewia mollis; Hymenocardia acida; Indigofera garckeana; Ipomoea shupangensis; Lannea schweinfurthii var. schweinfurthii; Lonchocarpus laxiflorus; Macrosphyra longistyla; Maerua aethiopica; Merremia kentrocaulos; M. pterygocaulos; Mucuna stans; Ochna leucophloeos; O. schweinfurthiana; Ormocarpum pubescens; Oxytenanthera abyssinica. Ozoroa pucherrima; Piliostigma thonningii; Polyscias farinosa; Protea madiensis; Pseudocedrela kotschyi; Psorospermum febrifugum; Pterocarpus lucens; Sarcocephalus latifolius; Sclerocarya birrea* subsp. *birrea; Securidaca longipedunculata* var. *longipedunculata; Strychnos henningsii; S. innocua; Taverniera schimperi; Terminalia laxiflora; T. macroptera; T. schimperiana; Tricalysia niamniamensis* var. *djurensis; Triumfetta pilosa; Tylosema fassoglensis; Vernonia cylindrica; V. thulinii; Vitellaria paradoxa; Vitex doniana.*

digitata, Tamarindus indica, Pterocarpus lucens, Flueggea virosa and *Piliostigma thonningii*.

The higher parts (1500-1700 metres altitude) of the much eroded mountainous landscape around Adi Arkay, with a drainage system leading to the Tekeze river, are dominated by *Anogeissus leiocarpa*, *Terminalia schimperiana* and *Acacia hecatophylla*. On the northern slopes of the Semien mountains these species continue up to 1800 metres altitude, but with a sporadic occurrence of Afromontane species (for example *Hypericum quartinianum* (Guttiferae), *Heteromorpha arborescens* (Apiaceae), *Rhus spp.* (Anacardiaceae)) up to 1800 metres altitude. In the valleys north-west of Gonder the border between (4) *Combretum-Terminalia woodland and wooded grassland* (CTW) and (5) *Dry evergreen Afromontane forest and grassland complex* (DAF) can also be located at 1800 metres altitude, with species like *Anogeissus leiocarpa* (Combretaceae), *Acacia hecatophylla, A. hockii* and *Calotropis procera* (Asclepiadaceae) reaching this altitudinal limit. In the valley-system there are frequently well-developed riverine forests along the rivers.

In the parts of the Western lowlands and on the Western escarpment, where the grass biomass is largest, this vegetation type has been burned annually for such a long time, presumably for millennia, that the plants show clear adaptations to fire, and must be assumed not to be adversely affected by controlled annual burning.

DISTRIBUTION: This vegetation type occurs along the western escarpment of the Ethiopian highlands, from the border region between Ethiopia and Eritrea to the western KF floristic region to Sudan and the Omo Zone. It is the dominant vegetation in large parts of what is now Gambela (Western lowlands of the IL floristic region), the Benshangul-Gumuz (western part of the GJ and WG floristic regions), the Didesa valley [Dedesa valley] in WG in Oromya extending to the lower parts of Quara to Humera (in the GD floristic region), where it occurs at 500-1900 metres altitude.

At the upper limit this vegetation frequently abuts on to the *Moist Afromontane evergreen forest* (MAF) and the *Dry Afromontane evergreen forest and grassland complex* (DAF). It penetrates into the Ethiopian highlands along the large river valleys.

The situation around Lake Tana (in the GD and GJ floristic regions) is a complication in the otherwise rather straightforward geographical distribution of the *Combretum-Terminalia woodland and wooded grassland* (CTW); the water level of Lake Tana fluctuates, but always at altitudes slightly below the limit here defined as the upper limit for the *Combretum-Terminalia* woodland and hence the lower limit for the Afromontane vegetation. Most of the area below the 1800 metres contour around Lake Tana is in fact made up by temporary floodplains, but unflooded slopes and hillsides are in fact often, according to the field observations by the authors, covered by for example *Stereospermum kunthianum* (Bignoniaceae) and other species elsewhere associated with *Combretum-Terminalia* woodland. Near Ifag and Maksegnit villages at the north-eastern point of Lake Tana the authors have observed an open woodland with *Stereospermum kunthianum* (a typical CTW-species) and *Acacia bavazzanoi* (an endemic species of (Subtype 5c) *Afromontane woodland, wooded grassland and grassland* (DAF/WG)) were observed growing together at 1850-1900 metres altitude. This would seem to confirm a transitional situation between open vegetation types (4) *Combretum-Terminalia woodland and wooded grassland* (CTW) and DAF/WG around Lake Tana.

Combretum-Terminalia woodland also occurs as a comparatively narrow zone in central, northern, south-western and eastern Ethiopia between the *Acacia-Commiphora* woodland and bushland and vegetation on the highlands. However, in these parts of Ethiopia this vegetation type is usually too insignificants to be shown on a map.

In this vegetation type, all the escarpments and some of the flatter areas are covered with *Combretum-Terminalia* woodland, and most flat areas are covered with wooded grassland. The characteristic species on the slopes are the species mentioned above; in the wooded grassland the dominant species include *Stereospermum kunthianum* (Bignoniaceae), a number of *Acacia* species and a number of grass species in the genera *Echinochloa*, *Setaria*, *Hyparrhenia*, *Cymbopogon* and *Sorghum*.

In flat sites in the *Combretum-Terminalia* woodland on the western side of the highlands there are occasionally pure stands of *Acacia seyal,* as observed in the woodlands east of Metema, in the Gibe gorge (most prominent on the side in the SU floristic region), and in locations close to the small town of Dima on the Akobo river in the KF floristic region (south-west of Mizan Teferi). In the Tekeze gorge and near Humera on the Sudanian-Ethiopian border we have observed dense stands of *Acacia hecatophylla*, *Acacia senegal,* and *Acacia mellifera* on a mosaic of sand and black cotton soil. There is very little representation of the genera *Combretum* and *Terminalia* in these habitats. Figs 18K-L show examples of *Acacia* woodland and wooded grassland within (4) *Combretum-Terminalia woodland and wooded grassland* (CTW).

Another rather distinct variant of *Combretum-Terminalia* woodland and wooded grassland with very little representation of the genera *Combretum* and *Terminalia* exists in the WG floristic region near the upper limit of the vegetation type, where it perhaps forms a transition (6) *Moist evergreen Afromontane forest* (MAF); it is dominated by the semi-deciduous tree *Syzygium guineense* subsp. *macrocarpum* (Myrtaceae), which forms a 5-8 metres high tree stratum, although the growth of the individual plants is often shrubby (Fig. 18F).

MAPPING: This major vegetation type is marked as mapping unit "*Combretum-Terminalia woodland and wooded grassland* (CTW)." It is defined as the areas between altitudes of 400 and 1800 metres that fall within zone I in Fig. 36 (the area to the west of the defined boundary between (4) *Combretum-Terminalia woodland and wooded grassland* (CTW) and ATC). However, in the IL floristic region, the Freshwater Marshes and Floodplains in the GLWD (Global Wetlands Database; see Lehner & Döll, 2004) form the lower boundary, and in the WG, IL and KF floristic regions also mapping unit "*Transitional rain forest* (TRF)," is taken out of areas between altitudes of 400 and 1800 metres.

For the situation around Lake Tana, see discussion above. It has been decided to follow the topographical parameters and mark the area around Lake Tana that is below the 1800 metres contour as mapping unit "*Combretum-Terminalia woodland and wooded grassland* (CTW)," after the areas covered by marches and floodplains have been taken out. See further about the swamps, marches and floodplains around Lake Tana under (Subtype 11b) *Freshwater marches and swamps, floodplains and lake shore vegetation* (FLV/MFS).

For definition of the boundary between (4) *Combretum-Terminalia woodland and wooded grassland* (CTW) and (2a) *Acacia-Commiphora* woodland and bushland (ACB), see above under (Subtype 2a) *Acacia-Commiphora* woodland and bushland proper (ACB).

(5) *Dry evergreen Afromontane forest and grassland complex* (DAF)

This vegetation type represents a complex system of successions involving extensive grasslands rich in legumes on heavy black clay soils and periodically inundated areas, shrubs and small to large-sizes trees to closed forest with a canopy of several strata on the slopes. Thousands of years ago Ethiopian highland agriculture developed largely inside areas covered by this vegetation complex, and particularly the northern part of the *Dry evergreen Afromontane forest and grassland complex* (DAF) has been intensely utilised by man ever since, with the result that the forests have diminished in area, and are replaced by bushland in most areas. In this process, soils have, in many areas previously covered by forest, become shallow as a result of intensive soil erosion (Friis *et al.,* 1982; Zerihun Woldu, 1999).

DIVERSITY AND FLORISTIC OVERLAP WITH OTHER VEGETATION TYPES: A total of 460 species, subspecies and varieties of woody plants have been recorded to occur in (5) *Dry evergreen Afromontane forest and grassland complex* (DAF); of these 128 (27.83% of the total) have only been recorded from this vegetation type; 102 have been recorded from both this vegetation type and the adjacent vegetation type (10) *Riverine vegetation* (RV); 102 have been recorded from both this vegetation type and the adjacent vegetation type (2) *Acacia-Commiphora woodland and bushland* (ACB); 89 have been recorded from both this vegetation type and the adjacent vegetation type (6) *Moist evergreen Afromontane forest*

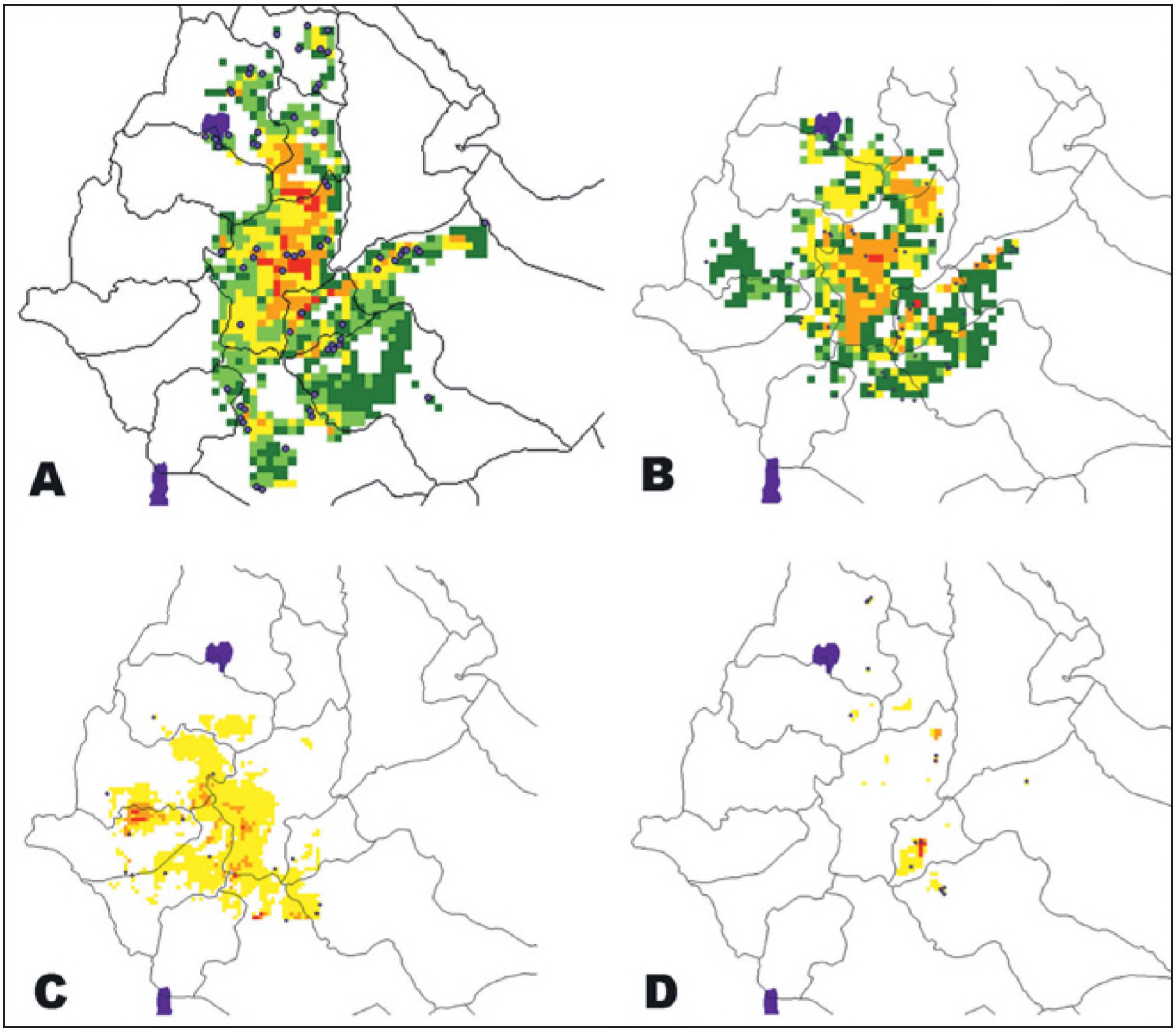

FIG. 19. The recorded and modelled distributions of four species characteristic of (5) *Dry evergreen Afromontane forest and grassland complex* (DAF), (6) *Moist evergreen Afromontane forest* (MAF) and (9) *Afroalpine belt* (AA). A. *Juniperus procera*, important species in (5) *Dry evergreen Afromontane forest and grassland complex* (DAF). B. *Podocarpus falcatus*, important species in (5) *Dry evergreen Afromontane forest and grassland complex* (DAF), present in drier parts of (6) *Moist evergreen Afromontane forest* (MAF). C. *Pouteria adolfi-friederici*, important species in (6) *Moist evergreen Afromontane forest* (MAF). D. *Lobelia rhynchopetalum*, important species in (9) *Afroalpine belt* (AA). The small dots indicate observed records. The colouring indicates the modelled distribution, using rainfall and temperature from the version of WorldClim provided with DivaGIS. The full colour code: red: areas with high suitability; orange: areas with high suitability; yellow: suitable areas; pale green: areas with moderate suitability; dark green: areas with relatively low suitability; no colouring: areas not suitable. In species with few records the full colour scale has not been utilised by the programme. Original data based on herbarium material from Friis (1992) and later field observations by the authors.

(MAF); 74 have been recorded from both this vegetation type and the adjacent vegetation type (4) *Combretum-Terminalia woodland and wooded grassland* (CTW); 56 have been recorded from both this vegetation type and the adjacent vegetation type (8) *Ericaceous belt* (EB); 20 are shared between this vegetation type and the vegetation type (9) *Afroalpine belt* (AA) that is separated from this vegetation type by the vegetation type (8) *Ericaceous belt* (EB); 15 have been recorded from both this vegetation type and the adjacent vegetation type (7) *Transitional rain forest* (TRF); three are shared between this vegetation type and the non-adjacent vegetation type (1) *Desert and semi-desert scrubland* (DSS) that is separated from this vegetation type by the vegetation type (2) *Acacia-Commiphora woodland and bushland* (ACB); two are shared between this vegetation type and the non-adjacent vegetation type (3) *Wooded grassland of the western Gambela region* (WGG), which is separated from this vegetation type by (7) *Transitional rain forest* (TRF) and (4) *Combretum-Terminalia woodland and wooded grassland* (CTW); one has been recorded from both this vegetation type and the adjacent vegetation type (11) *Fresh-water lakes, lake shores, marsh and floodplain vegetation* (FLV). Data from Appendix 3 (p. 177-237), Table 2 (p. 43) and Fig. 13 (p. 37).

Floristically, (5) *Dry evergreen Afromontane forest and grassland complex* (DAF) is the second richest vegetation type after (2) *Acacia-Commiphora woodland and bushland* (ACB), but the number of species, subspecies and varieties unique to this vegetation type is lower than for (2) *Acacia-Commiphora woodland and bushland* (ACB). However, this must be assumed to be partly due to overlap with the rather high number of adjacent vegetation types, both wetter vegetation types, especially (6) *Moist evergreen Afromontane forest* (MAF) and (10) *Riverine vegetation* (RV), vegetation types at higher altitudes, especially (8) *Ericaceous belt* (EB), and drier vegetation types, especially (2) *Acacia-Commiphora woodland and bushland* (ACB).

DISTRIBUTION: Throughout the highlands above 1800 metres and below 3000 metres from the border with Eritrea to scattered areas with high ground in the south; avoiding higher rainfall areas in the western and south-eastern parts of the highland, where it is replaced by vegetation type (6) *Moist evergreen Afromontane forest* (MAF). A broad outline of the distribution of (5) *Dry evergreen Afromontane forest and grassland complex* (DAF) is indicated by the modelled distribution of *Juniperus procera* (Cupressaceae), which can be seen in Fig. 19A. In contrast, both the established and the modelled distribution of *Podocarpus falcatus* (Podocarpaceae) transgresses the western boundary of this vegetation type into the area of (6) *Moist evergreen Afromontane forest* (MAF), as can be seen in Fig. 19B.

MAPPING: This major vegetation type is marked as mapping unit "*Dry evergreen Afromontane forest and grassland complex* (DAF)". Areas between altitudes of 1800 and 3000 metres have here been marked as this mapping unit, with certain exceptions outlined in Appendix 4. The actual lower limit of this major vegetation type may vary from the general boundary of 1800 metres altitude used for the mapping. The same applies to the upper limit, which may differ from the altitude of 3000 metres used for the mapping; see further under descriptions of the subtypes and of the limit for (8) *Ericaceous belt* (EB), which is the adjacent vegetation type above (5) *Dry evergreen Afromontane forest and grassland complex* (DAF).

Five distinct subtypes have been recognized (Friis, 1992; Friis & Sebsebe Demissew, 2001). However, it has not been possible to define these based on parameters as altitude or rainfall, nor to draw boundaries between them manually, based on personal observations.

(Subtype 5a) *Undifferentiated Afromontane forest* (DAF/U)

The forests on the highlands can be seen as a gradient from wet to dry types, and generally the vegetation on the highlands appears now 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 was wooded grassland, woodland or deciduous bushland (see subtype 5c). Canopy views of examples of this forest type are seen in Figs 20A-C; a view of an understory in this type of forest is seen in Fig. 20J.

The undifferentiated Afromontane forests are either *Juniperus-Podocarpus* forests, or tend towards single dominant *Podocarpus* or *Juniperus* forests, both with an element of broad-leaved species. They occur especially on the highlands in the floristic regions of SU, WG, WU, SD, BA and HA at altitudes between 1500 and 2700 metres, with annual rainfall between 700 and 1100 millimetres. The Anabe and Denkoro forests (2100-2200 metres altitude) in the WU floristic region seem to be the northernmost examples of this forest type in existence today.

CHARACTERISTIC SPECIES: Today, the few larger patches still remaining appear widely separated by areas of cultivation and wooded grassland. The canopy is usually dominated by *Juniperus procera* (Cupressaceae), *Podocarpus falcatus* (Podocarpaceae; Fig. 20G-H), *Olea europaea* subsp. *cuspidata* (Oleaceae), *Croton macrostachyus* (Euphorbiaceae), and *Ficus* spp. (Moraceae). The tallest trees are 20-30 metres high.

There is usually a rather well-developed stratum of small to medium-sized trees, for example *Allophylus abyssinicus* (Sapindaceae), *Apodytes dimidiata* (Icacinaceae), *Bersama abyssinica* (Melianthaceae), *Cassipourea malosana* (Rhizophoraceae), *Celtis africana* (Ulmaceae), *Chionanthus mildbraedii* (Oleaceae), *Dovyalis abyssinica* (Flacourtiaceae), *Dracaena steudneri* (Dracaenaceae), *Ekebergia capensis* (Meliaceae), *Erythrina brucei* and *Millettia ferruginea* (both endemic; both Fabaceae subfam. Papilionoideae), *Lepidotrichilia volkensii* (Meliaceae), *Maytenus undata* (Celastraceae), *Olinia rochetiana* (Oliniaceae), *Prunus africana* (Rosaceae), *Teclea nobilis* and *Vepris dainellii* (endemic; both Rutaceae). Smaller individuals of *Olea europaea* subsp. *cuspidata* (Oleaceae) than in the canopy may also be common in this stratum.

Other small trees and shrubs are *Carissa spinarum* (Apocynaceae), *Discopodium penninervium* (Solanaceae), *Dombeya torrida* (Sterculiaceae), *Halleria lucida* (Scrophulariaceae), *Lobelia giberroa* (Lobeliaceae), *Myrsine africana* (Myrsinaceae), *Pittosporum viridiflorum* (Pittosporaceae), *Ritchiea albersii* (Capparidaceae), *Solanecio gigas* (Asteraceae), and *Sideroxylon oxyacanthum* (Sapotaceae; Fig. 20D). Endemic shrubs like *Acanthus sennii* (Acanthaceae) occur in this vegetation zone.

Scrambling species of *Rubus,* for example *R. steudneri* (Rosaceae; Fig. 20E), are common, together with true lianas, for example *Urera hypselodendron* (Urticaceae).

Epiphytes include species of *Peperomia*, for example *P. abyssinica* (Piperaceae), ferns and orchids.

The ground-cover is rich in ferns, grasses, sedges, and small herbaceous dicotyledons. The small terrestrial orchid genus *Holothrix* has the majority of its species in this habitat and in the single dominant Afromontane forests.

At the upper limit of this type of forest, between 3000 and 3400 metres, overlapping in part with (8) *Ericaceous belt* (EB), there is often a more open type of woodland or evergreen bushland with *Erica arborea* (Ericaceae), *Gnidia glauca* (Thymelaeaceae), *Hagenia abyssinica* (Rosaceae), *Hypericum revolutum* (Guttiferae;

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FIG. 20.

A-C: Undifferentiated Afromontane forest with canopy of *Podocarpus falcatus* and *Juniperus procera*. Other species of forest trees in the lower strata. Chilimo forest, north of Ginchi. Altitude 2500-2600 metres. SU floristic Region. September, 2005.

D: Undifferentiated Afromontane forest with *Sideroxylon oxyacanthum* (Sapotaceae) in the lower strata. Chilimo forest, north of Ginchi. Altitude 2500 metres. SU floristic Region. January, 2009.

E: Undifferentiated Afromontane forest with scrambling *Rubus steudneri* (Rosaceae) in the lower strata. Chilimo forest, north of Ginchi. Altitude 2500 metres. SU floristic Region. January, 2009.

A

B

FIG. 20 A-B. Views of (Subtype 5a) *Undifferentiated Afromontane forest* (DAF/U). Both *Podocarpus falcatus* (Podocarpaceae) and *Juniperus procera* (Cupressaceae) are present in the canopy of these forests. Forest dominated by *Hagenia abyssinica* (Rosaceae) and/or *Hypericum revolutum* (Guttiferae) may occur near the upper edge of these forests.

C

D

E

FIG. 20 C-D-E. Views of (Subtype 5a) *Undifferentiated Afromontane forest* (DAF/U). Both *Podocarpus falcatus* (Podocarpaceae) and *Juniperus procera* (Cupressaceae) are present in the canopy of these forests. Forest dominated by *Hagenia abyssinica* (Rosaceae) and/or *Hypericum revolutum* (Guttiferae) may occur near the upper edge of these forests.

F G

H J

FIG. 20 C-D-E. Views of (Subtype 5a) *Undifferentiated Afromontane forest* (DAF/U). Both *Podocarpus falcatus* (Podocarpaceae) and *Juniperus procera* (Cupressaceae) are present in the canopy of these forests. Forest dominated by *Hagenia abyssinica* (Rosaceae) and/or *Hypericum revolutum* (Guttiferae) may occur near the upper edge of these forests.

FIG. 20

F-G: Undifferentiated Afromontane forest with *Podocarpus falcatus*. (F): Part of trunk and crown. (G): Closer view of branches. Chilimo forest, north of Ginchi. Altitude 2800 metres. SU floristic Region. January, 2009.

H: Undifferentiated Afromontane forest with *Hypericum revolutum* in the lower strata. Chilimo forest, north of Ginchi. Altitude 2800 metres. SU floristic Region. September, 2005.

J: Undifferentiated Afromontane forest with canopy of *Podocarpus falcatus* and *Juniperus procera*. Other species of forest trees in the lower strata. Menagesha forest on the slopes of Wechecha [Wuchacha mountain], west of Addis Abeba. Altitude approximately 2700 metres. SU floristic region. September, 1972.

Fig. 20H), *Jasminum stans* (Oleaceae), *Morella salicifolia* (Myricaceae), *Myrsine africana* (Myrsinaceae), *Myrsine (Rapanea) melanophloeos* (Myrsinaceae), *Nuxia congesta* (Loganiaceae), and *Rosa abyssinica* (Rosaceae). If classified according to physiognomy, this would be referred to as evergreen bushland with occasional trees of *Hagenia abyssinica* (Rosaceae) and *Hypericum revolutum* (Guttiferae) as emergents.

Clumps of the mountain bamboo, *Arundinaria alpina* (Poaceae) may occur, but a distinct bamboo zone is not developed. On the highlands woodlands or forests, where the canopy is mixed with species such as *Albizia gummifera, Albizia schimperiana, Acacia abyssinica*, mountain bamboo features on forest margins or indicates serial stages in forest regeneration.

Other characteristic monocots include endemic aloes, *Aloe debrana*, *A. monticola*, *A. percrassa*, *A. steudneri* and *A. trigonantha* (all Aloaceae); *Gladiolus lithicola* (Iridaceae), and *Asparagus africanus* (Asparagaceae).

Lianas and a ground-cover of partly moisture-loving herbs may occur.

In the two northern examples of this subtype, the Anabe and Denkoro forests (2100-2200 metres altitude) in the WU floristic region, the canopy is dominated by *Podocarpus falcatus* with *Juniperus procera*. The lower stratum is poorer than in the forests further south; *Croton macrostachyus* (Euphorbiaceae), *Ficus* spp. (Moraceae), *Olea europaea* subsp. *cuspidata* (Oleaceae), *Trema orientalis* (Ulmaceae), and *Maesa lanceolata* (Myrsinaceae) occur as understorey trees. *Ekebergia capensis* (Meliaceae), and *Acacia abyssinica* (Fabaceae subfam. Mimosoideae) also occur as relics or recolonizers in a dispersed manner, adjacent to these forest patches.

The mixture of *Juniperus-Podocarpus* dominated forest and *Hagenia abyssinica-Hypericum revolutum* woodland or scrub near the upper limit of the Undifferentiated Afromontane forest seems to be characteristic of the Ethiopian forests. In East Africa (Kenya, Uganda and Tanzania) Hedberg (1951) has defined a *Hagenia-Hypericum* zone on the Virunga volcanoes, the Aberdares and Mt. Kenya, but not on Ruwenzori, Kilimanjaro and Mt. Meru, where the situation is more like in Ethiopia. *Hagenia-Hypericum* woodland forms a continuous transition to Afromontane forest on the Imatong mountains in southern Sudan (Friis & Vollesen, 2005), and Jackson (1956) has hypothesised that the *Hagenia-Hypericum* woodland is a seral stage in the regrowth of the Afromontane forest. This may also be the case near the upper limit of (Subtype 5a) *Undifferentiated Afromontane forest* (DAF/U) on the Ethiopian mountains.

MAPPING: This vegetation subtype could not be mapped.

(Subtype 5b) *Dry single-dominant Afromontane forest of the Ethiopian highlands* (DAF/SD)

According to Friis (1992), this forest occurs especially on the highlands in the TU, GD, WU and HA floristic regions at altitudes between (1600-) 2200 and 3200 (-3300) metres with annual rainfall between 500 and 1500 millimetres. The typical dominant species in the upper storey of these forests is *Juniperus procera* (Fig. 21C), with *Olea europaea* subsp. *cuspidata* (Fig. 21E) and a number of other species below. Sometimes the juniper trees can be rather scattered, and the vegetation is then better characterized as *Juniperus* woodland with discontinuous evergreen undergrowth. This vegetation type shows transition to subtype 5a, as mentioned above, but it is the prominent forest type in large parts of the Ethiopian plateau north of Lake Tana and the forest patches in WU mentioned under subtype 5a.

Canopy views of these forests are shown in Fig. 21A and, near the upper limit and mixed with a few trees of *Hagenia abyssinica*, in Fig. 21B. A view along a road inside a forest of this type is seen in Fig. 21D.

CHARACTERISTIC SPECIES: As mentioned above, the characteristic species of canopy tree of this forest type is *Juniperus procera*, with *Olea europaea* subsp. *cuspidata* in the lower storey.

Smaller trees and shrubs recorded from the northern forests include *Acokanthera schimperi* (dominant species), *Carissa spinarum* (both Apocynaceae), *Calpurnia aurea* (Fabaceae subfam. Papilionoideae), *Clausena anisata* (Rutaceae), *Clutia abyssinica* (Euphorbiaceae), *Discopodium penninervium* (Solanaceae), *Euclea racemosa* subsp. *schimperi* (Ebenaceae), *Grewia ferruginea* (Tiliaceae), *Maesa lanceolata* (Myrsinaceae), *Morella salicifolia* (Myricaceae), *Psydrax schimperianum* (Rubiaceae), *Teclea (Vepris) nobilis* (Rutaceae), and *Rhus natalensis* (Anacardiaceae).

There are comparatively few lianas, for example *Urera hypselodendron* (Urticaceae), epiphytes, shrubs and forest floor herbs, apart from some species of grasses.

In eastern Tigray, north of the Amba-Alage massif, the rocks are made up of various kinds of sandstone. In these areas it seems that the *Juniperus-Olea* forest may normally have been restricted to areas with deeper soil, although this statement is currently difficult to ascertain, as the areas with deeper soil over limestone are now almost everywhere cultivated. A notable exception to this rule can be seen in places near the top of the escarpment. In such places there may be much condensation of dew and oreographic rain, and in these places, for example at the escarpment east of Mekele (between Atzbi and Berahile (Berhale)), where there are remnants on rocky ground of *Juniperus-Olea* forest with dense undergrowth of *Tarchonanthus camphoratus*, *Cadia purpurea*, *Acokanthera schimperi*, etc.

The upper limit of (5) *Dry evergreen Afromontane forest and grassland complex* (DAF) in the TU floristic region is not well defined. *Hagenia abyssinica* and *Hypericum revolutum* seem both to be rare or absent from the higher altitudes of TU and northern GD floristic region, and *Erica arborea* is extremely rare or absent in the TU floristic region. On the mountains west of Adigrat open *Juniperus-Olea* forest was observed to at least 3100 metres altitude, giving way to low vegetation with short grasses and perennial herbs.

MAPPING: This vegetation subtype could not be mapped.

FIG. 21

A: *Juniperus procera* dominated dry single-dominant Afromontane forest. Entoto mountains above Gulele (Addis Abeba). A few planted trees of the species *Eucalyptus globulus* (Myrtaceae; introduced from Australia) are growing up through the trees of *Juniperus*. Altitude approximately 3000 metres. SU floristic Region. October, 2009.

B: *Juniperus procera* dominated dry single-dominant Afromontane forest, with a tree of *Hagenia abyssinica* in the foreground. Upper edge of Chilimo forest, north of Ginchi. Altitude approximately 3000 metres. SU floristic Region. September, 2005.

A

B

FIG. 21. A-B. View of (Subtype 5b) *Dry single-dominant Afromontane forest of the Ethiopian highlands* (DAF/SD). *Podocarpus falcatus* is absent from the canopy of these forests that occur at higher altitudes or under lower rainfall than (Subtype 5a) *Undifferentiated Afromontane forest* (DAF/U).

FIG. 21. C-D-E. View of (Subtype 5b) *Dry single-dominant Afromontane forest of the Ethiopian highlands* (DAF/SD). *Podocarpus falcatus* is absent from the canopy of these forests that occur at higher altitudes or under lower rainfall than (Subtype 5a) *Undifferentiated Afromontane forest* (DAF/U).

FIG. 21

C: *Juniperus procera* dominated dry single-dominant Afromontane forest. In the foreground clearing with *Kniphofia foliosa*. Northern slopes of Bale mountains above Goba. Altitude approximately 2800 metres. BA floristic region. September, 2005.

D: *Juniperus procera* dominated dry single-dominant Afromontane forest; a core-area with typical and tall *Juniperus* forest, surrounded by transition to *Acacia-Commiphora* bushland (see Fig. 23). Near Arero. Altitude approximately 3000 metres. SD floristic Region. October, 2002.

E: Remnant of dry single-dominant Afromontane forest with some old trees of *Olea europaea* subsp. *cuspidata* left in cultivated and fallow land with thin soil. Along road between Wikro (Wukro; in the highlands) and Berahile (Berhale; in the Afar lowlands). Altitude approximately 2800 metres. TU floristic region. October, 2009.

(Subtype 5c) *Afromontane woodland, wooded grassland and grassland* (DAF/WG)

This includes the primary and secondary woodlands, wooded grasslands and grasslands of the highlands. The tree stratum in the primary woodlands consists mainly of species of *Acacia* (Fabaceae subfam. Mimosoideae), for example *A. abyssinica, A. lahai, A. negrii, A. pilispina, A. bavazzanoi, A. origena* and *A. venosa* (the latter five species endemic) in the highlands. The secondary woodlands contain a long list of tree species that also occur in the two previous subtypes, (Subtype 5a) *Undifferentiated Afromontane forest* (DAF/U) and (Subtype 5b) *Dry single-dominant Afromontane forest of the Ethiopian highlands* (DAF/SD). The modifications of this vegetation subtype with trees and other woody plants occur on well drained sites, while the edaphic grasslands without trees occur on areas with black cotton soil which may be flooded during the rains. Thus it must be assumed that before the influence of man the vegetation type has formed a mosaic with the forests and evergreen bushland vegetation of the highlands.

These pure or almost pure edaphic grasslands are frequently seen in the central part of the Western highlands, particularly in GJ, but also in GD and SU floristic regions. In the Eastern highlands similar grasslands are seen in the AR floristic region between Arsi Robi and Seru, and in the north-western part of the BA floristic regions, for example between the small towns of Kofele in AR and Adaba in BA. Much of the edaphic Afromontane wooded grassland and pure grassland is now under intensive cultivation. Particularly extensive use has been made of the grasslands in the AR and north-western BA floristic regions, where the grasslands have been almost completely converted into large, mechanized farms producing cereal crops. Elsewhere in the farmland derived from this subtype, there remain scattered trees and clumps of bushland, in which for example species of the genus *Maytenus* are prominent. Also associated with the grasslands and bushland are the several endemic species of *Echinops* (Asteraceae).

Figs 22A, 22C-E show secondary woodlands, wooded grasslands from relatively moist habitats, with species of trees that also occur in forest. Fig. 22B shows an example of almost pure *Acacia abyssinica* woodland. Figs 22F-G show edaphic grasslands. Figs 22H-K show woodlands or bushlands from drier habitats than Figs 22A-D. Fig. 22M shows open wooded grassland near the upper limit of *Juniperus-Podocarpus* forest, with plants of the giant lobelia of lower altitudes, *Lobelia achrochilus.*

CHARACTERISTIC SPECIES: The Afromontane wooded grassland, with *Acacia abyssinica* and the above mentioned range of endemic *Acacia* species, is common in the central and northern-central part of the Western highlands. The ground cover in the primary wooded grasslands is rich in grasses and sedges. Small herbs, for example species of the genus *Trifolium*, are also common. A number of ground orchids, for example species of the genera *Habenaria*, *Disa* and *Satyrium,* occur in open and damp places in this habitat.

The secondary wooded grasslands have many of the same tree species as in the forest of the same region, for example *Podocarpus falcatus* (Fig. 22A-B) or species of *Maytenus* (Fig. 22D). On well-drained slopes with moderate grazing there is frequently several metres tall bushland with species of *Maytenus* and *Rhus*, as well as *Acanthus polystachius* (Acanthaceae), *Buddleja polystachya* (Loganiaceae), *Clerodendrum myricoides* (Lamiaceae), *Grewia ferruginea* (Tiliaceae), *Heteromorpha arborescens* (Apiaceae), *Myrsine africana* (Myrsinaceae), *Nuxia congesta* (Loganiaceae), *Osyris quadripartita* (Santalaceae) and *Protea gauguedi* (Proteaceae). *Croton macrostachyus* (Euphorbiaceae) is very common as a secondary invader in these habitats, representing an early stage in their return to forest. Lianas in these habitats include *Helinus mystacinus* (Rhamnaceae) and *Jasminum abyssinicum* (Oleaceae). The ground cover is very similar to that of the natural Afromontane woodlands.

In the dry wooded grasslands in the TU and northern GD floristic regions *Acacia lahai* and *A. abyssinica* may occur as co-dominant in some paces. In such areas remnants of *Juniperus-Olea* forest may be seen on the mountain ridges above the *Acacia* woodland.
On the northern side of the Abay [Blue Nile] gorge between Addis Abeba and Debre Markos the lower limit for *Acacia abyssinica* woodland seems to be around 1800 metres altitude. Below that altitude, *Acacia abyssinica* is replaced by other species of *Acacia* and *Dichrostachys cinerea*, with *Boswellia papyrifera* on the limestone strata.

The most frequent vegetation in (Subtype 5c) *Afromontane woodland, wooded grassland and grassland* (DAF/WG) on sandstone and limestone in Tigray is an evergreen type of bushland dominated by *Acacia etbaica* and *Euclea,* usually with numerous individuals of the acaulescent leaf-roset succulent *Aloe elegans* in the ground cover. Here and there on the rocky outcrops and slopes around Mekele and with interruptions in similar places northwards to Adigrat the *Acacia etbaica* bushland is replaced by *Acacia abyssinica* woodland or with woodland with other species of *Acacia* (*A. sieberiana, A. albida* or elsewhere *A. lahai*). *Acacia lahai* and *A. abyssinica* may occur as co-dominant in some paces. In such areas remnants of *Juniperus-Olea* forest may be seen on the mountain ridges above the *Acacia* woodland. *Euclea* is absent or relatively less common in the areas with other species of *Acacia* than *A. etbaica* (Fig. 22H-J).

In dry and rocky areas near the Eastern escarpment in the TU floristic regions east of Adigrat (on the trail to the monastery Gunda Gundo) the forest and woodland is replaced by a 0.5-1 metre high open bushland dominated by *Becium, Solanum adoense* and *Macowania abyssinica* with *Aloe* in the scarce ground cover (Fig. 22K-L).

Included here is also the upland evergreen bushland associated with the *Dry evergreen Afromontane forest*

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FIG. 22

A: Degraded dry evergreen Afromontane forest with single canopy trees of the forest left in cultivated and fallow land. The photograph shows a number of old trees of *Podocarpus falcatus* that in this area have been left in the woodland, indicating that the area has previously been covered by forest. Between Gedo and Fincha. Altitude approximately 2400 metres. SU floristic region. January, 2009.

B: *Acacia abyssinica* woodland near Kosober, between Debre Markos and the Abay [Blue Nile] gorge. Altitude approximately 2400 metres. GJ floristic region. October, 2009.

C: As for (A).

D: Degraded dry evergreen Afromontane forest with single canopy trees of the forest left in cultivated and fallow land. Some planted *Eucalyptus globulus* (Myrtaceae) can bee seen in the photograph. West of Guder. Altitude approximately 2200 metres. SU floristic region. January, 2009.

E: Degraded dry evergreen Afromontane forest with single canopy trees of the forest left in cultivated and fallow land. *Maytenus obscura* (Celastraceae) particularly common in this area. East of Gedo. Altitude approximately 2400 metres. SU floristic region. January, 2009.

F: Afromontane edaphic grassland near Sheno, southwest of Debre Berhan. *Andropogon amethystinus* completely dominating, together with species of *Trifolium*, *Ranunculus*, *Uebelinia* (according to recent studies part of the widespread temperate genus *Lychnis*), and other genera of herbs with wide temperate distribution. Altitude approximately 2700 metres. SU floristic region. October, 2009.

A

B

FIG. 22. A-B. Views of (Subtype 5c) *Afromontane woodland, wooded grassland and grassland* (DAF/WG).

C

D

FIG. 22. C-D. Views of (Subtype 5c) *Afromontane woodland, wooded grassland and grassland* (DAF/WG).

E

F

FIG. 22. E-F. Views of (Subtype 5c) *Afromontane woodland, wooded grassland and grassland* (DAF/WG).

G

H

J

FIG. 22. G-H-J. Views of (Subtype 5c) *Afromontane woodland, wooded grassland and grassland* (DAF/WG).

K

L

M

FIG. 22. K-L-M. Views of (Subtype 5c) *Afromontane woodland, wooded grassland and grassland* (DAF/WG).

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FIG. 22

G: Afromontane edaphic grassland between Debre Markos and Dejen. Altitude approximately 2400 metres. GJ floristic region. October, 2009.

H: Bushland with *Acacia lahai* and evergreen shrubs, including *Dodonaea angustifolia* (Sapindaceae) and *Euclea racemosa* subsp. *schimperi* (Ebenaceae). Near Wikro [Wukro]. Altitude approximately 2200 metres. TU floristic region. October 2009.

J: Bushland with *Acacia lahai* and evergreen shrubs, including *Dodonaea angustifolia* (Sapindaceae) and *Euclea racemosa* subsp. *schimperi* (Ebenaceae). North-east of Mekele on the road to Wikro [Wukro]. Altitude approximately 2300 metres. TU floristic region. October 2009.

K-L: Bushland with *Acacia lahai* and evergreen shrubs near the monastery of Gunda Gundo. Altitude (K) approximately 2500 metres and (L) 2600 metres. TU floristic region. October 2009.

M: High altitude Afromontane wooded grassland with tall, scattered *Juniperus procera* in the background and flowering specimens of the low-altitude giant lobelia, *Lobelia achrochilus*, in the foreground. East of Dinshu. Altitude approximately 2900 metres. BA floristic region. September 2005.

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and grassland complex (DAF). Although natural upland evergreen bushland may exist in some places, and form an ecotone between the dry evergreen Afromontane forest and vegetation types with montane woodland and grassland, with species of *Rhus* (Anacardiaceae), *Euclea* (Ebenaceae), *Erica arborea* (Ericaceae), and even endemic species of shrubs, like *Rosa abyssinica* (Rosaceae) and *Jasminum stans* (Oleaceae), etc., the authors are convinced that nearly all the current upland evergreen bushland in the highlands now represents a grazing-cultivation complex following destruction of the forest, in the regrowth of which it seems to form a seral stage (Friis *et al.*, 1982). Often stunted species of trees and shrubs from the *Juniperus procera* forest occur in the bushland for example *Olea europaea* subsp. *cuspidata*. The ground-cover in this vegetation is dominated by grasses, most species of which also occur in various types of Afromontane grasslands, but near the upper limit of this vegetation type there is also a species of giant lobelia (*Lobelia achrochilus*; Fig. 22H). The authors have made particularly many observations of what seems to agree with White's *Evergreen bushland* on the Eastern escarpment. Here, the vegetation may seem to form a transition zone of varying width between (5) *Dry evergreen Afromontane forest and grassland complex* (DAF) and (2) *Acacia-Commiphora woodland and bushland* (ACB). The border between these two zones seems to be well defined at 1800 metres altitude, but may be blurred by the presence of large areas of evergreen scrub. On the Eastern escarpment below Korem there are many evergreen bushes (of the genera *Dodonaea, Euclea, Zizyphus,* and *Rhus*) scattered in the (5) *Dry evergreen Afromontane forest and grassland complex* (DAF) just above 1800 metres altitude, and these bushes may also be quite frequent in the upper part of (2) *Acacia-Commiphora woodland and bushland* (ACB), chiefly between 1500 and 1800 metres altitude. Bushes of the genera *Dodonaea* and *Zizyphus* seem occasionally to continue even to lower altitudes. From Korem and northwards *Acacia etbaica* has locally been the dominant species near the lower edge of (5) *Dry evergreen Afromontane forest and grassland complex* (DAF), at least where the authors have been able to make observations.

MAPPING: This vegetation subtype could not be mapped.

(Subtype 5d) *Transition between Afromontane vegetation and Acacia-Commiphora bushland on the Eastern escarpment* (DAF/TR)

This vegetation is complex and scattered. It includes a range of physiognomic types, but these are connected by the presence of characteristic and unusual species, such as *Barbeya oleoides* (belonging to the monotypic and isolated family Barbeyaceae), *Cadia purpurea* (Fabaceae subfam. Papilionoideae) and *Pistacia aethiopia* (Anacardiaceae). The subtype is rich in endemic species, and ranges from open forest (for example at Arero and Negele, both in the SD floristic region) to evergreen scrub with dispersed trees (on the escarpment of the Ethiopian highlands), or even clumps of evergreen bushland in deciduous *Acacia-Commiphora* bushland, but even more typical in adjacent parts of Somalia). The subtype has been described from localities in the HA floristic region by Gillett (1941) and from a locality in the BA floristic region (Ellot mountain, at ca. 6° N, 42° E, in the "paese dei Gherire." This is described in a unpublished manuscript by G. Benardelli, *Cenni monografici sul Paese dei Gherire*, based on field work in 1937 and deposited in Florence).

Floristically the whole range of patches of this vegetation subtype is connected. The forest-like types exist scattered on the Eastern escarpment, from the border with Eritrea to the Awash valley, and on the northern escarpment of the highlands in the HA floristic region from the Awash valley to the border with Somalia; on these escarpments the bushland-like types with trees occur scattered.

The vegetation subtype is also found on the southeastern slopes of the Eastern highlands extending along the mountain chain into northern Somalia. Throughout its range this forest type occurs on rocky ground with unimpeded drainage at altitudes between 1500 and 2400 metres, and with an annual rainfall of between 400 and 700 millimetres.

Fig. 23A shows a fairly well preserved example of this vegetation type. Fig. 23B shows a stand of *Dracaena ombet* subsp. *ombet* (Dracaenaceae) at the lower limit of the vegetation shown in Figs 23A and 23D-E. Fig. 23C shows a tree of *Barbeya oleoides* left in *Acacia-Commiphora* bushland in an area that has previously dry *Juniperus* forest. Figs 23D-E shows regrowth of *Tarchonanthus camphoratus* and *Cadia purpurea* after the destruction of *Juniperus* forest.

CHARACTERISTIC SPECIES: The dry juniper forests of SD with floristic elements from this vegetation occur at altitudes between 1500 and 2000 (-2200) metres with an annual rainfall between 400 and 700 millimetres. In an open stratum of smaller trees the following species occur: *Acokanthera schimperi* (Apocynaceae), *Barbeya oleoides* (Barbeyaceae; Fig. 23C), *Berchemia discolor* (Rhamnaceae), *Cadia purpurea* (Fabaceae subfam. Papilionoideae; Fig. 23E), *Cladostigma dioicum* (Convolvulaceae), species of *Pistacia* (*Pistacia aethiopica* and *Pistacia falcata*), *Rhus* (both Anacardiaceae), *Olea europaea* subsp. *cuspidata* and *Schrebera alata* (both Oleaceae), *Sideroxylon oxyacanthum* (Sapotaceae), and *Tarchonanthus camphoratus* (Asteraceae; Fig. 23D).

In its northernmost examples, for example on the escarpment near the border with and in Eritrea, this vegetation is characterised by the presence of *Barbeya oleoides, Cadia purpurea* and *Pistacia aethiopia,* together with *Sideroxylon oxyacanthum* and *Tarchonanthus camphoratus* at the edge of *Juniperus procera-Olea europaea* subsp. *cuspidata* forest. In these places *Dracaena ombet* subsp. *ombet* (Dracaenaceae; Fig. 23E) may occur at the lower edge of this vegetation.

East of Mekele there are remnants of *Juniperus-Olea* forest with dense undergrowth of *Tarchonanthus camphoratus*, *Cadia purpurea*, *Acokanthera schimperi*, etc. and just below the forest a rather dense woodland of *Dracaena ombet* subsp. *ombet.*

Further to the south other understorey shrubs are present in this vegetation, for example *Berberis holstii* (Berberidaceae), and *Cladostigma dioicum* (Convolvulaceae); these have rather restricted distribution in Ethiopia.

Parts of the open dry juniper forests of the SD floristic region (at the town of Mega, and partly at the towns of Yabelo, Arero and Negele) are so open that it is rather a *Juniperus* woodland over a layer of evergreen scrub, and form the southern extension of this type. Other characteristic species besides the ones al-

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FIG. 23

A: Remnant of *Juniperus procera* forest forming transition to *Acacia-Commiphora* bushland. Near Arero. Altitude approximately 1800 metres. SD floristic region. September, 2002.

B: Stands of *Dracaena ombet* subsp. *ombet* (Dracaenaceae) in *Acacia*-dominated bushland below remnants of *Juniperus procera* forest. Between Wikro (Wukro; in the highlands) and Berahile (Berhale; in the Afar lowlands). Altitude approximately 1700 metres. TU floristic region. October, 2009.

A

B

FIG. 23. A-B.Views of (Subtype 5d) *Transition between Afromontane vegetation and Acacia-Commiphora bushland on the Eastern escarpment* (DAF/TR). This represents the driest vegetation type in which *Juniperus procera* occurs.

C

D

E

FIG. 23. C-D-E. Views of (Subtype 5d) *Transition between Afromontane vegetation and Acacia-Commiphora bushland on the Eastern escarpment* (DAF/TR). This represents the driest vegetation type in which *Juniperus procera* occurs.

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FIG. 23

C: Single evergreen tree of *Barbeya oleoides* (Barbeyaceae) left in *Acacia-Commiphora* bushland near remnant of *Juniperus procera* forest. Close to Kersa Dek and Curre Liban, east of Negele. Altitude approximately 1650 metres. SD floristic region. October, 2000.

D-E: Remnant of *Juniperus procera* forest forming transition to *Acacia-Commiphora* bushland. Hardly any trees of *Juniperus procera* left after cutting and fires. (D) shows regrowth of *Tarchonanthus camphoratus* (Asteraceae). (E) shows regrowth of *Cadia purpurea* (Fabaceae subfam. Papilionoideae). Between Wikro (Wukro; in the highlands) and Berahile (Berhale; in the Afar lowlands). Altitude approximately 2000 metres. TU floristic region. October, 2009.

ready mentioned are (in the HA floristic region) *Dracaena ellenbeckiana* (Dracaenaceae), *Barbeya oleoides* (Barbeyaceae) (in the BA and SD floristic regions), *Buxus hildebrandtii* (Buxaceae) (in the HA and BA floristic regions), *Catha edulis* (in the SD floristic region, perhaps the original habitat for this now widely cultivated plant), *Olea europaea* subsp. *cuspidata*, *Pistacia aethiopica* (Anacardiaceae), *Pittosporum spp.* (Pittosporaceae) and *Schrebera alata* (Oleaceae). Other small trees and shrubs are *Acokanthera schimperi*, *Carissa spinarum* (both Apocynaceae.), *Cussonia holstii* (Araliaceae), *Dodonaea angustifolia* (Sapindaceae), *Dracaena ellenbeckiana*, *Euclea divinorum*, *Euclea racemosa* subsp. *schimperi* (Ebenaceae), *Fagaropsis hildebrandtii* (Rutaceae), *Heteromorpha arborescens* (Apiaceae), *Pappea capensis* (Sapindaceae), *Sideroxylon oxyacanthum* and *S. mascatense* (both Sapotaceae), *Tarchonanthus camphoratus* (Asteraceae), and *Tinnea somalensis* (Lamiaceae).

MAPPING: This vegetation subtype could not be mapped. The few remaining patches of this vegetation subtype are restricted in extension, and there are no environmental parameters that can exactly predict where they can be found.

(6) *Moist evergreen Afromontane forest* (MAF)

In most cases this vegetation type is characterized by one or more closed strata of evergreen trees that may reach a height of 30 to 40 metres. Sometimes only the lower stratum remains, due to human activity involving the removal of the tallest trees. Previously this vegetation type was considered to consist of two subtypes (see for example Sebsebe Demissew *et al.*, 2003, 2004; Sebsebe Demissew & Friis, 2009): (subtype 1) *Afromontane rainforests*, where the forests with wild coffee are found, and (subtype 2) *Transitional rain forest*, bordering the *Combretum-Terminalia* woodlands on the western escarpment of the Ethiopian highlands in the floristic regions IL and KF. The latter subtype has now been considered a distinct vegetation type, and it includes what was (also by Sebsebe Demissew *et al.* (2003, 2004) and Sebsebe Demissew & Friis (2009)) considered the *Lowland semi-evergreen forest.*

According to Friis (1992), the moist evergreen Afromontane forest occurs mainly in the Western highlands between (1500-) 1800 and 2600 (-3000) metres, with an annual rainfall between 700 and 2000 millimetres (or more). The Harenna forest on the southern slopes of the Bale mountains is the easternmost example of this forest. The northernmost examples are patches of this type of forest in WG floristic region, such as the Wembera forest. There are patchlike examples of this forest type in the surroundings of the small town of Wendo Genet on the border between the SU and SD floristic regions.

Views of the canopy of this forest type is shown in Figs 25A-C; a view of an understory in this type of forest is seen in Fig. 25D. Figs 25E-F show views of nonflowering and flowering mountain bamboo (*Arundinaria alpina*). Figs 25G-H show other types of single-species stands inside (6) *Moist evergreen Afromontane forest* (MAF); Fig. 25G shows a stand of *Phoenix reclinata* (Arecaceae) in a permanently damp spot; Fig. 25H shows a rocky slope with a stand of *Euphorbia ampliphylla* (Euphorbiaceae). Fig. 25 J shows a tree trunk with epiphytic ferns, and Fig. 25K a stand of the tree fern *Cyathea manniana* (Cyatheaceae).

DIVERSITY AND FLORISTIC OVERLAP WITH OTHER VEGETATION TYPES: A total of 135 species, subspecies and varieties of woody plants have been recorded to occur in (6) *Moist evergreen Afromontane forest* (MAF); of these 18 (13.33% of the total) have only been recorded from this vegetation type; 89 have been recorded from both this vegetation type and the adjacent vegetation type (5) *Dry evergreen Afromontane forest and grassland complex* (DAF); 56 have been recorded from both this vegetation type and the adjacent vegetation type (10) *Riverine vegetation* (RV); 36 have been recorded from both this vegetation type and the adjacent vegetation type (7) *Transitional rainforest* (TRF); seven have been recorded from both this vegetation type and the non-adjacent vegetation type; three have been recorded from both this vegetation type and the adjacent vegetation type (4) *Combretum-Terminalia woodland and wooded grassland* (CTW). Data from Appendix 3 (p. 177-237), Table 2 (p. 43) and Fig. 13 (p. 37).

Floristically, (6) *Moist evergreen Afromontane forest* (MAF) is a moderately diverse vegetation type, with a low number of unique woody species, subspecies and varieties. The highest number of woody species, subspecies and varieties is shared with (5) *Dry evergreen Afromontane forest and grassland complex* (DAF), (10) *Riverine vegetation* (RV) and (7) *Transitional rainforest* (TRF).

CHARACTERISTIC SPECIES: These forests predominantly contain broad-leaved evergreen species in the multilayered canopy. *Podocarpus falcatus* may occur in the eastern- and northernmost of these forests, but *Podocarpus* is never prominent (and it may occasionally only be present due to human introduction). *Podocarpus* becomes gradually more infrequent towards the southwest in KF (see Fig. 19B), while *Pouteria adolfi-friederici* (Sapotaceae) seems to become more prominent in the same direction, although this statement is now difficult to verify due to the profound human influence on the forests. The climatic condition for this species is presumably high in parts of the IL floristic region, and that the northernmost outpost is in the south-western GJ floristic region (Fig. 19C). The drier parts of these forests are floristically somewhat similar to those in the humid parts of the central highlands, and the transition between subtype 5a and this forest type is therefore gradual, which could cause difficulties with the classification of the forests in the WG and GJ floristic regions, but due to the low frequency or absence of *Pouteria adolfi-friederici* most of the forests of WG and GJ are here classified as (5) *Dry evergreen Afromontane forest and grassland complex* (DAF).

However, the other important conifer in Ethiopia, *Juniperus procera* (Cupressaceae) does not occur in this type of moist evergreen forest, as in clearly seen from Fig. 19A. In the BA floristic region *Juniperus procera* occurs in areas with suitable habitats around the areas here marked as (6) *Moist evergreen Afromontane forest* (MAF) (see also Fig. 19A).

The most characteristic type of this forest occurs widely in upland parts of the southern WG, IL (excluding the lowlands), and KF floristic regions. It is found in areas between 1500 and 2500 metres, with an annual rainfall between 1500 millimetres and more than 2000 millimetres, with rain all the year round. The absolute maximum of rainfall in the area is uncertain, but the estimated maximum of 2600 millimetres/year is thought to be reached in an area north of the town of Tepi.

The large Harenna forest on the southern side of the Bale mountains is floristically closely related to the south-western Ethiopian Afromontane rain forest. Near its lower limit, however, the canopy of this forest contains large specimens of *Podocarpus falcatus*. It would be worthwhile to note if it occurs with the characteristic species mentioned above, or occupies a distinct lower zone of its own.

A typical transect is shown in Fig. 24. There is only one emergent species from the 20-30 metres high canopy: *Pouteria adolfi-friederici*.

The 10-30 metres high main canopy consists of *Albizia gummifera, A. schimperiana, A. grandibracteata* (predominant at lower altitudes; all Fabaceae subfam. Mimosoideae), *Cassipourea malosana* (Rhizophoraceae), *Celtis africana* (Ulmaceae), *Sapium ellipticum, Macaranga capensis* var. *kilimandscharica, Croton macrostachyus, Euphorbia ampliphylla* (most common in clearings at forest margins and in secondary forest, may form monospecific stands (Fig. 25H); all four Euphorbiaceae), *Ekebergia capensis* (Meliaceae), *Ficus sur, F. ovata, F. thonningii*

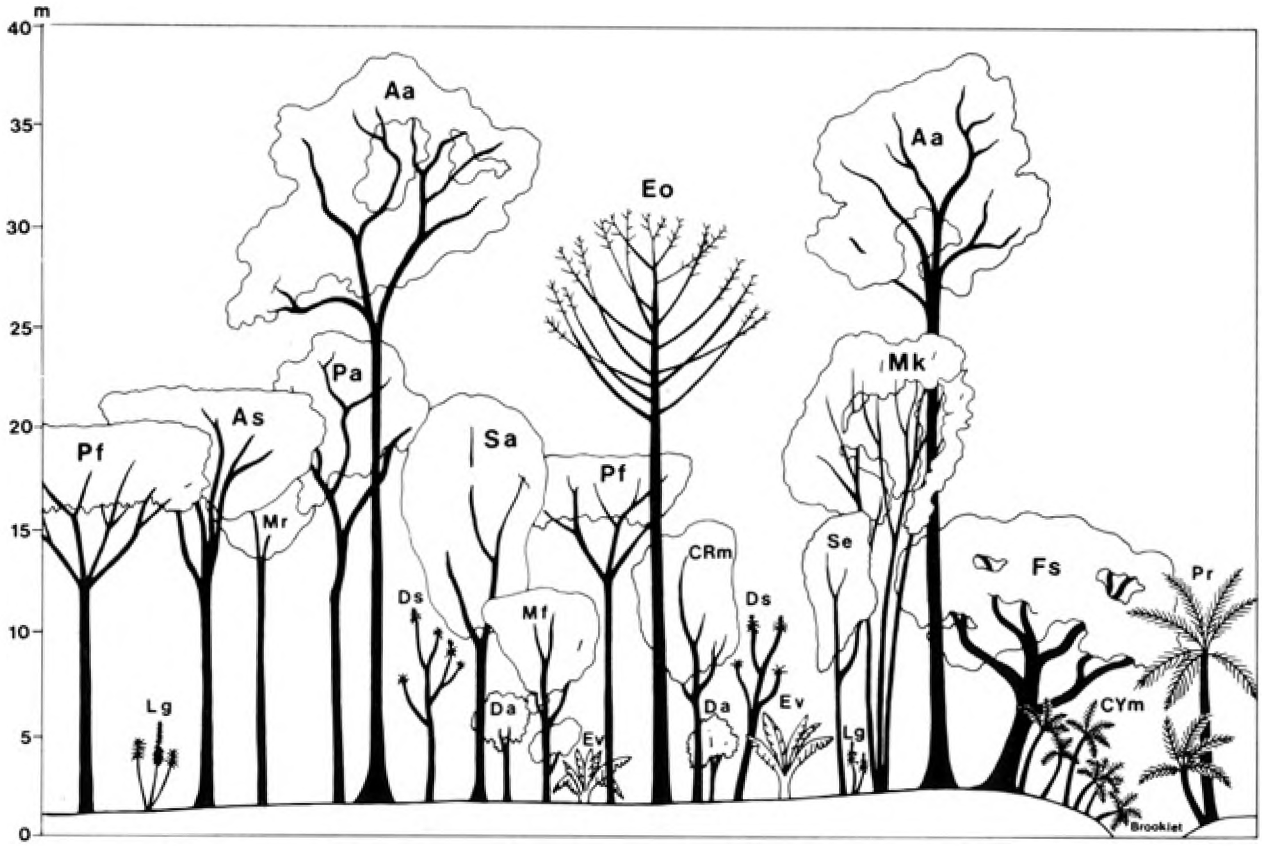

FIG. 24. Transect of (Subtype 6a) *Primary or mature secondary moist evergreen Afromontane forest* (MAF/P). Generalised representation based on observations made in old secondary forest at approximately 1700 metres altitude south of Gore, IL floristic region. Although this locality is situated just below the altitudinal limit used for mapping (6) *Moist evergreen Afromontane forest* (MAF) no species restricted to (7) *Transitional rain forest* (TRF) were observed, but a few species, for example *Hallea rubrostipulata,* are known from both vegetation types. The abbreviated names for the species stand for: Aa: *Pouteria (Aningeria) adolfi-friederici*. As: *Albizia schimperiana*. CRm: *Croton macrostachyus*. CYm: *Cyathea manniana*. Da: *Dracaena afromontana*. Ds: *Dracaena steudneri*. Eo: *Euphorbia ampliphylla*. Ev: *Ensete ventricosum*. Fs: *Ficus sur*. Lg: *Lobelia giberroa*. Mf: *Millettia ferruginea*. Mk: *Macaranga capensis* var. *kilimandscharica*. Mr: *Hallea (Mitragyna) rubrostipulata*. Pa: *Prunus africana*. Pf: *Polyscias fulva*. Pr: *Phoenix reclinata*. Sa: *Schefflera abyssinica*. Sa: *Sapium ellipticum*. Drawn by Victoria C. Friis. Reproduced from Friis *et al.* (1982).

(all Moraceae), *Hallea rubrostipulata* (predominant at lower altitudes, Rubiaceae), *Ilex mitis* (Aquifoliaceae), *Ocotea kenyensis* (Lauraceae), *Olea welwitschii (Oleaceae), Polyscias fulva, Schefflera abyssinica* (both Araliaceae), *Prunus africana* (Rosaceae), and *Syzygium guineense* subsp. *afromontanum* (Myrtaceae).

A discontinuous lower canopy of smaller trees (less than 10 metres high) includes *Allophylus abyssinicus, Deinbollia kilimandscharica* (both Sapindaceae), *Apodytes dimidiata* (Icacinaceae), *Bersama abyssinica* (Melianthaceae), *Brucea antidysenterica* (Simaroubaceae), *Erythrina brucei* (endemic), *Calpurnia aurea, Millettia ferruginea* (the latter endemic, all three Fabaceae subfam. Papilionoideae), *Galiniera saxifraga* (at higher altitudes), *Canthium oligocarpum, Coffea arabica, Rothmannia urcelliformis, Oxyanthus speciosus* subsp. *stenocarpus, Psychotria orophila* (all Rubiaceae), *Chionanthus mildbraedii* (Oleaceae), *Clausena anisata, Teclea nobilis, Vepris dainellii* (the latter endemic, all Rutaceae), *Cyathea manniana* (Cyatheaceae), *Dracaena afromontana, D. fragrans* (at lower altitudes), *D. steud-*

neri (all Dracaenaceae), *Ehretia cymosa* (Boraginaceae), *Lepidotrichilia volkensii, Turraea holstii* (both Meliaceae), *Lobelia giberroa* (Lobeliaceae), *Nuxia congesta* (Loganiaceae), *Oncoba routledgei* (Flacourtiaceae), *Phoenix reclinata* (Arecaceae; Fig. 25G), *Pittosporum viridiflorum* (Pittosporaceae), *Ritchiea albersii* (Capparidaceae), *Solanecio gigas, S. mannii* (both Asteraceae), and *Trema orientalis* (Ulmaceae). The giant herb *Ensete ventricosum* (Musaceae) also belongs in this stratum.

The discontinuous shrub stratum includes: *Acanthus eminens* (Acanthaceae), *Maytenus* spp. (Celastraceae), *Phyllanthus limmuensis* (Euphorbiaceae), and *Whitfieldia elongata* (mainly at lower altitudes; Acanthaceae). A characteristic feature of this vegetation type, at least in its moister forms (but not yet observed in the Harenna forest), is the dense stands of tree ferns, *Cyathea manniana* (Cyatheaceae; Fig. 25K), that occurs in ravines and on moist slopes. Tree ferns do not occur in any of the adjacent forest types.

Lianas are common in this type of forest, and about 25 species have been recorded, including *Tiliachora troupinii* (endemic, Menispermaceae). Climbing species of *Acacia,* incl. *A. pentagona*, are also frequent here.

Epiphytes are also numerous, and include many species of ferns (Fig. 25J), especially of the family Polypodiaceae and Hymenophyllaceae and the genus *Asplenium*, lycopods, including the large species *Huperzia dacrydioides* hanging from large branches in the canopy of the forests, orchids, including many species of the genera *Aerangis*, *Angraecopsis*, *Bulbophyllum*, *Diaphananthe*, *Liparis*, *Microcoelia*, *Oberonia*, *Polystachya,* and *Stolzia*, several species of *Peperomia*, including *P. abyssinica* and *P. fernandopoiana* (Piperaceae), and the endemic *Scadoxus nutans* (Amaryllidaceae).

The ground-cover is rich where light is sufficient; more than 110 species have been recorded from this stratum. Other characteristic monocots in the lower stratum or at the forest edge include *Chlorophytum filipendulum* (Anthericaceae), *Aloe kefaensis* (endemic; Aloaceae), and *Asparagus asparagoides* (Asparagaceae). *Phoenix reclinata* occurs at moist places in the forest or forms dense stands in areas that are too waterlogged to support tall forest (Fig. 25G).

The mountain bamboo *Arundinaria alpina* (Poaceae) is patchy, but not uncommon at higher altitudes in these forests, as seen in the areas around the two small towns Gecha and Masha in the south-western forest-area in IL and in Harenna forest in the south-eastern forest-area in BA. The mountain bamboo may form big and dense stands (Fig. 25E-F), but in many places it occurs only locally. Nowhere in Ethiopia the mountain bamboo seems to form an altitudinally distinct bamboo zone, as described by Hedberg (1951) from certain mountains in East Africa, where it occurs between the forest zone and the *Hagenia-Hypericum* zone. Hedberg has recorded a distinct mountain bamboo zone from the Virunga volcanoes, Ruwenzori, Mt. Elgon, Aberdare, Mt. Kenya and Mt. Meru, but not on Kilimanjaro. Although *Arundinaria alpina* is common on the Imatong mountains, a distinct zone is lacking (Jackson, 1956; Friis & Vollesen, 2005). In Ethiopia the mountain bamboo is much used for the construction of houses in this area, small clumps have therefore often been planted at the edge or in clearings in forest, and it is therefore difficult to estimate the natural size of the populations of *Arundinaria alpina*.

The status of the moist evergreen forests around and on the islands in Lake Tana is not yet clear. The moist climate caused by the lake seems to account for the presence of species of trees and shrubs otherwise only known from this type in south-western Ethiopia, but it has yet to be decided if the forests in general belong here or to the *Dry evergreen Afromontane forest and grassland complex* (DAF). It has been mapped as (5) *Dry evergreen Afromontane forest and grassland complex* (DAF) on the current vegetation map.

The *Moist evergreen Afromontane forest* is only intact in rather limited areas, mainly forest reserves. There are woody and herbaceous species that occur only in intact forest, species that occur both in intact and secondary forest, species that occur in closed forest, along forest margins and in the mosaic of farmland, evergreen bushland, woodland and grassland that has now in many places replaced the *Moist evergreen Afromontane forest*. The complex of *Moist evergreen Afromontane forest* and its various derived subtypes was studied by

Friis *et al.* (1982). It is possible to allocate species of woody plants to the various categories of derived vegetation, but for the purpose of checking the vegetation types in this work only two categories have been used: For this reason two subtypes are proposed here and have been applied in Appendix 3 (p. 177-237), one subtype including the primary or mature secondary forests and another subtype representing the forest edges, clearings and the mosaic of farmland, evergreen bushland, woodland and grassland that have in many places replaced the forest.

In the KF, IL and SD floristic regions there are extensive areas of (6) *Moist evergreen Afromontane forest* (MAF) which have been modified by man into semi-natural "coffee forests," where coffee is gathered or harvested. The natural canopy is nearly intact or thinned. The strata with small trees and shrubs has been almost completely cleared and shrubs of coffee (*Coffea arabica*) planted instead. All possible transitions may be found between almost natural forest with coffee and plantations, where there is only a thin canopy left over regularly planted rows of coffee shrubs or trees. The indigenous forest flora often survives well in these "coffee forests."

DISTRIBUTION: Two major blocks of this vegetation type exist in the highlands over 1800 metres. One south-western block has its main distribution in the KF, IL and WG floristic regions and relatively small outlying patches in the GJ and GG floristic regions. Another block exists in the southern part of the BA floristic region and in the northern part of the SD floristic region.

MAPPING: This major vegetation type is marked as mapping unit "*Moist evergreen Afromontane forest* (MAF)." The general rules used to define this unit are that the vegetation type occurs at areas between altitudes of 1800 and 3000 metres and at annual rainfall greater than 1700 millimetres. Field observations, and the above-mentioned difficulty with the classification of forests in the GJ floristic region, have resulted in a number of areas with an annual rainfall lower than 1700 millimetres which have also been classified as this mapping unit (see Appendix 4 and Fig. 13). Field studies of the boundary between mapping unit "*Moist evergreen Afromontane forest* (MAF)" and mapping unit "*Transitional rain forest* (TRF)" have resulted in a limit at the 1800 metres contour in the south-western part of Ethiopia as the lower boundary of mapping unit "*Moist evergreen Afromontane forest* (MAF)" in the south-west (plus some additional small areas, see Appendix 4 (p. 238-250) and Fig. 13 (p.37). The boundary between mapping units "*Transitional rain forest* (TRF)" and "*Combretum-Terminalia woodland and wooded grassland* (CTW)" in the west and south of Ethiopia may, according to the field observations of the authors, be somewhat fluctuating. But an average limit at the 1800 metres contour seems generally satisfactory, especially because mapping unit "*Transitional rain forest* (TRF)" forms a wide, dividing zone in most areas. This is not the case in south-eastern Ethiopia, where the mapping unit "*Moist evergreen Afromontane forest* (MAF)" meets with the "*Acacia-Commiphora* woodland and bushland (ACB)," only in places separated by a zone rich in species of *Combretum* and *Terminalia*, which, however, is too narrow to be mapped. In south-eastern Ethiopia, on the southern slope of the Bale mountains, etc., the mapping unit "*Transitional rain forest* (TRF)" has been defined to include all forest between the 1600 and the 3000 metres contours, irrespective of annual rainfall (see further in Appendix 4 and Fig. 13). This is the only way in which the Harenna forest, which floristically is close to the moist forests of south-western Ethiopia, can be included in mapping unit "*Moist evergreen Afromontane forest* (MAF)."

The vegetation type can be subdivided into two not particularly distinct subtypes. The first subtype represents the closed, mature forest; the second type is represented in climax vegetation forest margins, clearings and areas where local edaphic or topographic conditions have favoured the development of evergreen bushland, woodland, wooded grassland and grassland.

(Subtype 6a) *Primary or mature secondary moist evergreen Afromontane forest* (MAF/P)

This is basically the forest type described above.

CHARACTERISTIC SPECIES: A limited number of woody species are restricted or nearly restricted to this vegetation subtype: *Alangium chinense* (Alangiaceae), *Allophylus macrobotrys* (Sapindaceae), *Cissampelos owariensis* (Menispermaceae), *Cyathea manniana* (Cyatheaceae), *Erythrococca trichogyne* (Euphorbiaceae), *Ocotea kenyensis* (Lauraceae), *Phyllanthus limmuensis* (Euphorbiaceae), *Piper guineense* (Piperaceae), *Pittosporum viridiflorum* (Pittosporaceae), and *Sericostachys scandens* (Amaranthaceae).

Most species of mature moist evergreen Afromontane forest in Ethiopia can survive as isolated trees in farmland; even canopy species such as *Pouteria adolfi-friederici* (Fig. 26D) and *Olea welwitschii* (Fig. 26E) have been observed by us to flower and fruit under these conditions. They must therefore be expected to be able to act as recolonising species under favourable conditions.

MAPPING: It has not been possible to map this subtype separately. The extent of the remaining patches of primary or mature secondary moist evergreen Afromontane forest is dependent on human activity, and cannot be related to environmental parameters.

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FIG. 25

A: Margin of moist evergreen Afromontane forest (MAF). Between Bonga and Masha. Altitude approximately 1850 metres. KF/IL floristic region. September 2002.

B-C: Two views of canopy of moist evergreen Afromontane forest (MAF). North of Masha. Altitude approximately 1950 metres. IL floristic region. (B) September 2002; (C) September, 2005.

D: Understorey of moist evergreen Afromontane forest (MAF). Between Gore and Masha. Altitude approximately 1800 metres. IL floristic region. January 2009.

E-F: Edge of thicket of Afromontane bamboo (*Arundinaria alpina*). Near Masha. Altitude approximately 2300 metres. IL floristic region. (E): Before bamboo mass-flowering, September 2005. (F): During bamboo mass-flowering, January 2009.

G: Stand of *Phoenix reclinata* (Arecaceae) in naturally open, waterlogged area in the forest. East of Tepi. Altitude approximately 1600 metres. IL floristic region. January 2009.

H: Stand of *Euphorbia ampliphylla* (Euphorbiaceae) on rocky slope. Between Arjo and Bedele, north of the Didesa valley [Dedesa valley]. Altitude approximately 1800 metres. WG floristic region. January 2009.

J: Lower part of trunk of canopy tree, *Syzygium guineense* subsp. *afromontanum* (Myrtaceae), with epiphytic ferns, mainly species of *Asplenium* (Aspleniaceae) and *Arthropteris* (Oleandraceae). Harenna forest. Altitude approximately 2500 metres. BA floristic region. September 2005.

K: Stand of the tree fern *Cyathea manniana* (Cyatheaceae). North of Tepi. Altitude approximately 1900 metres. IL floristic region. September 2005.

A

B

FIG. 25. A-B. Views of (Subtype 6a) *Primary or mature secondary moist evergreen Afromontane forest* (MAF/P). *Podocarpus falcatus* is almost absent and *Juniperus procera* is completely absent from these forests.

C

D

FIG. 25. C-D. Views of (Subtype 6a) *Primary or mature secondary moist evergreen Afromontane forest* (MAF/P). *Podocarpus falcatus* is almost absent and *Juniperus procera* is completely absent from these forests.

E

F

FIG. 25. E-F. Views of (Subtype 6a) *Primary or mature secondary moist evergreen Afromontane forest* (MAF/P). *Podocarpus falcatus* is almost absent and *Juniperus procera* is completely absent from these forests.

G

H

FIG. 25. G-H. Views of (Subtype 6a) *Primary or mature secondary moist evergreen Afromontane forest* (MAF/P). *Podocarpus falcatus* is almost absent and *Juniperus procera* is completely absent from these forests.

J K

FIG. 25. J-K. Views of (Subtype 6a) *Primary or mature secondary moist evergreen Afromontane forest* (MAF/P). *Podocarpus falcatus* is almost absent and *Juniperus procera* is completely absent from these forests.

(Subtype 6b) *Edges of moist evergreen Afromontane forest, bushland, woodland and wooded grassland* (MAF/BW)

This is an analogous vegetation type to the Subtype 5c "Afromontane woodland, wooded grassland and grassland" of the *Dry evergreen Afromontane forest and grassland complex*. As mentioned above under the drier types, the upland evergreen bushland associated with the Moist evergreen Afromontane forest represents a grazing-cultivation complex following destruction of the forest, in the regrowth of which it seems to form a seral stage following various forms of woodland, and it is closely associated with communities that occur at forest edges (Friis *et al.*, 1982). Figs 26A-B show examples of vegetation at the edges of (6) *Moist evergreen Afromontane forest* (MAF). Fig. 26C shows a liana, *Combretum panniculatum* (Combretaceae), growing over trees; lianas are frequent in this open vegetation subtype. Figs 26D-E show two canopy species from the mature forest, left after forest clearing; Fig. 29D shows trees of *Pouteria adolfi-friederici* (Sapotaceae) and Fig. 29E shows an isolated tree of *Olea welwitschii* (Oleaceae).

CHARACTERISTIC SPECIES: The forest regeneration may follow two courses, either through montane woodland and wooded grassland, often dominated by *Acacia abyssinica* (Fabaceae subfam. Mimosoideae), *Allophylus abyssinicus* (Sapindaceae), *Cordia africana* (Boraginaceae), *Croton macrostachyus* (Euphorbiaceae), *Dombeya torrida* (Sterculiaceae), various species of *Ficus* (Moraceae), etc., or through a bushland with species that also occur in the lower strata of the moist Afromontane forest, for example *Bersama abyssinica* (Melianthaceae), *Maesa lanceolata* (Myrsinaceae), *Rhamnus staddo* (Rhamnaceae), *Clausena anisata* (Rutaceae), *Calpurnia aurea* (Fabaceae subfam. Papilionoideae), *Carissa spinarum* (Apocynaceae), and *Pittosporum viridiflorum* forma *ripicola* (Pittosporaceae), etc.

Lianas are frequent and may sometimes completely cover the scattered trees or shrubs. The species are nearly all the same as in the closed forest, but they dominate more in the open habitats, as can be seen from Fig. 26C.

Like with the evergreen bushlands associated with (5) *Dry evergreen Afromontane forest and grassland complex* (DAF), the undergrowth in bushlands associated with (6) *Moist evergreen Afromontane forest* (MAF) consists mainly of grasses and other herbaceous species that are known from grasslands in the same complex, or from open places in forest.

MAPPING: It has not been possible to map this subtype separately. As for subtype 6a, the extent of this subtype is dependent on human activity, and cannot be related to environmental parameters.

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FIG. 26

A: Edge of Beleta forest, a moist evergreen Afromontane forest, and surrounding woodland and evergreen bushland. To the right *Ensete ventricosum* (Musaceae). The land is cultivated or fallow. Between Jima and Bonga. Altitude approximately 1850 metres. KF floristic region. January, 2009.

B: Regrowth with large trees of *Ficus sycomorus* (Moraceae) and *Albizia* cf. *schimperiana* (Fabaceae subfam. Mimosoideae) and low evergreen scrub. East of Beleta forest. Altitude approximately 1900 metres. KF floristic region. January, 2009.

C: Secondary scrub covered by the red-flowered climber *Combretum panniculatum* (Combretaceae). East of Beleta forest. Altitude approximately 1900 metres. KF floristic region. January, 2009.

D: Group of canopy trees from moist evergreen Afromontane forest, left in farmland and surrounded by shrubs of *Vernonia* spp. The central tree, more than 30 metres high, is *Pouteria (Aningeria) adolfi-friederici* (Sapotaceae). Between Fincha and Shambu, north-west of Fincha reservoir, where (6) *Moist evergreen Afromontane forest* (MAF) seems to have been in close contact with (5) *Dry evergreen Afromontane forest* (DAF) before the forests were cleared. Altitude approximately 2350 metres. WG floristic region. February, 2009

E: Single canopy tree (*Olea welwitschii* (Oleaceae)) in early flowering stage at the edge of the Wushwush tea plantation west of Bonga. Altitude approximately 1800 metres. KF floristic region. January, 2009.

A

B

FIG. 26. A-B. View of (Subtype 6b) *Edges of moist evergreen Afromontane forest, bushland, woodland and wooded grassland* (MAF/BW).

C

D

E

FIG. 26. C-D-E.View of (Subtype 6b) *Edges of moist evergreen Afromontane forest, bushland, woodland and wooded grassland* (MAF/BW). Note person in lower right corner of Fig. 26E.

(7) *Transitional rain forest* (TRF)

This forest type has previously been considered as a subtype of the *Moist Afromontane Forest* of Sebsebe Demissew *et al.* (2003, 2004), and is identical with the *Dry peripheral semi-deciduous Guineo-Congolian forest* of Friis (1992). It was first recognised as an independent vegetation type by Chaffey (1978a, 1978b, 1978c, 1978d, 1979) in the reports from the South-West Ethiopia Forest Inventory. In those reports, the vegetation was referred to as "*Lowland broadleaved forest*," and the most characteristic large trees listed.

Figs 28A-B show canopy views of this vegetation type near its upper limit. Fig. 28D shows the sharp edge of the forest where a village has been established by slash-and-burn near the lower limit of the forest. Figs 28C and 28H show the fluted bases of trunks of (Fig. 28C) *Alstonia boonei* (Apocynaceae) and *Pouteria altissima* (Sapotaceae). Fig. 28E shoes an epiphytic fern (*Platycerium elephantotis* (Polypodiaceae)); with large and drought-resistant fronds it is well suited to the fluctuating humidity and high temperatures of the habitat. Figs 28F-G show a characteristic, near-endemic understorey-tree, *Baphia abyssinica* (Fabaceae subfam. Papilionoideae). Fig. 28J shows an isolated tree of a frequent canopy species, *Trilepisium madagascariense* (Moraceae).

DIVERSITY AND FLORISTIC OVERLAP WITH OTHER VEGETATION TYPES: A total of 101 species, subspecies and varieties of woody plants have been recorded to occur in (7) *Transitional rain forest* (TRF). Of these, 47 (46.52% of the total) have only been recorded from this vegetation type; 36 have been recorded from both this vegetation type and the adjacent vegetation type (6) *Moist evergreen Afromontane forest* (MAF); 30 have been recorded from both this vegetation type and the adjacent vegetation type (10) *Riverine vegetation* (RV); 15 have been recorded from both this vegetation type and the non-adjacent vegetation type (5) *Dry evergreen Afromontane forest and grassland complex* (DAF), which is separated from this vegetation type by (6) *Moist evergreen Afromontane forest* (MAF); three have been recorded from both this vegetation type and the adjacent vegetation type (4) *Combretum-Terminalia woodland and wooded grassland* (CTW). Data from Appendix 3 (p. 177-237), Table 2 (p. 43) and Fig. 12 (p. 37).

Floristically, (7) *Transitional rain forest* (TRF) is only moderately diverse, with a number of woody species, subspecies and varieties lower than in (6) *Moist evergreen Afromontane forest* (MAF), but with a relatively high number of unique woody species, subspecies and varieties. The proportion of unique woody species, subspecies and varieties is only second to that found in (2) *Acacia-Commiphora woodland and bushland* (ACB).

CHARACTERISTIC SPECIES: The canopy of (7) *Transitional rain forest* (TRF) includes *Manilkara butugi*, *Pouteria (Aningeria) altissima* (Fig. 28H), *Pouteria (Malacantha) alnifolia* (all Sapotaceae), *Anthocleista schweinfurthii* (Loganiaceae), *Antiaris toxicaria*, *Ficus mucuso*, *F. exasperata*, *Milicia excelsa*, *Morus mesozygia*, *Trilepisium madagascariense* (all Moraceae; the latter species is shown in Fig. 28J), *Alstonia boonei* (Apocynaceae; Fig. 28C), *Croton sylvaticus* (Euphorbiaceae), *Celtis toka*, *C. zenkeri*, *C. gomphophylla* (all Ulmaceae), *Diospyros abyssinica* (Ebenaceae), *Zanha golungensis*, *Lecaniodiscus fraxinifolius* (both in Sapindaceae), *Strychnos mitis* (Apocynaceae), *Trichilia dregeana* (Meliaceae), *Zanthoxylum leprieurii* (Rutaceae), *Albizia schimperiana*, and *A. grandibracteata* (Fabaceae subfam. Mimosoideae), all of which either form or emerge from the main canopy. Some of these trees are mapped in Fig. 27.

Baphia abyssinica (Fabaceae subfam. Papilionoideae; Figs 28F-G) forms a more or less continuous lower canopy, particularly at lower altitudes and below the large species of Sapotaceae and Moraceae.

From the lower strata of small trees or large shrubs have been recorded *Gomphia* sp. = *Mooney* 9249 (name used in the *Flora of Ethiopia and Eritrea*, referred to as *Campylospermum bukobense* in Friis (1992); Ochnaceae), *Celtis philippensis* (Ulmaceae), *Dracaena fragrans* (Dracaenaceae), *Elaeodendron buchananii* (sometimes a canopy tree; Celastraceae), *Eugenia bukobensis* (Myrtaceae), *Metarungia pubinervia* (Acanthaceae), and *Rinorea friisii* (Violaceae). [3]

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3. The following woody species have been recorded only from Transitional rainforest: *Acacia pentagona; Acalypha acrogyne;*

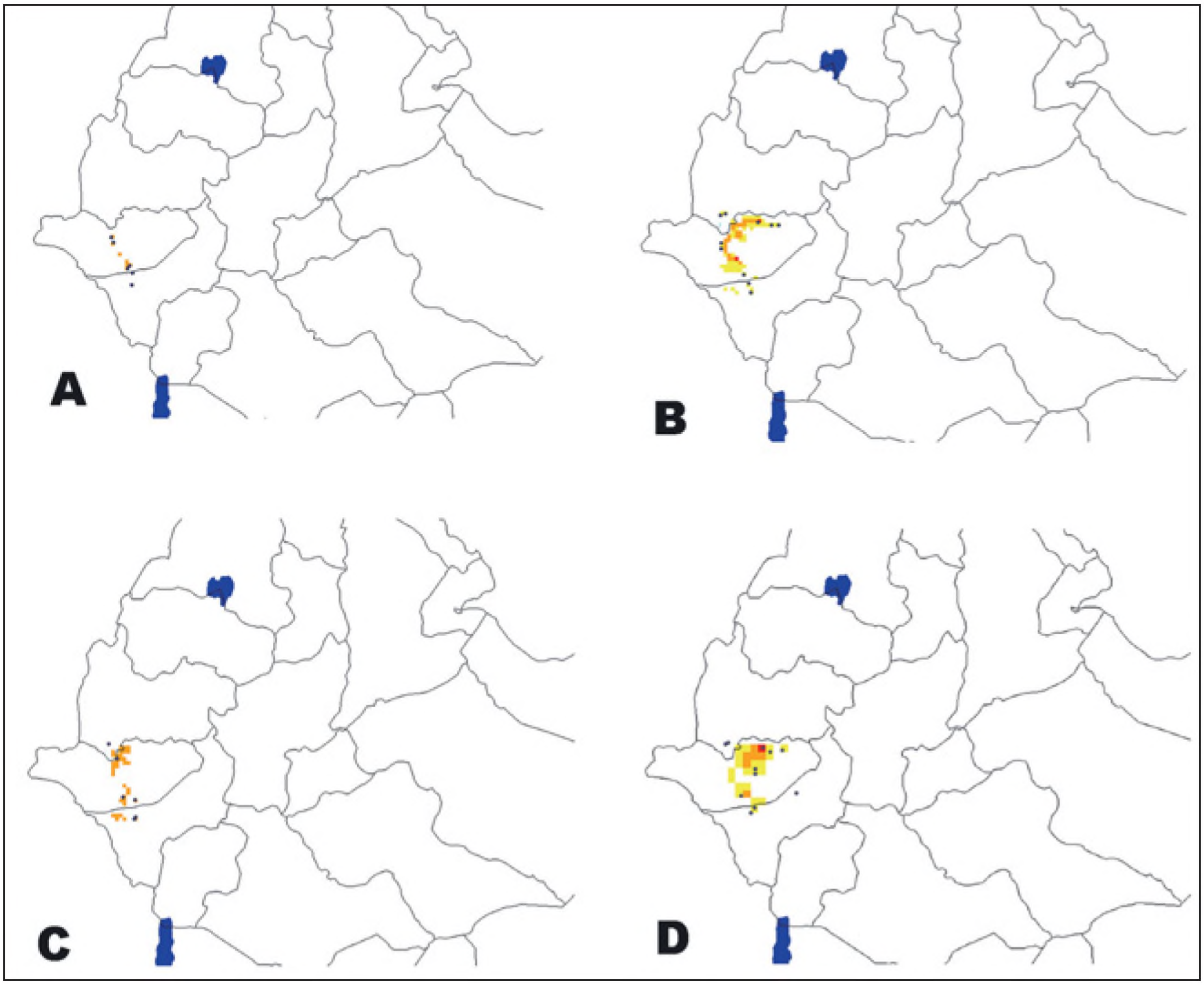


FIG. 27. The recorded and modelled distributions of four tree species characteristic of (7) *Transitional rain forest* (TRF). A. *Alstonia boonei*. B. *Morus mesozygia*. C. *Pouteria altissima*. D. *Trilepisium madagascariense*. The small dots indicate observed records. The colouring indicates the modelled distribution, using rainfall and temperature from the version of WorldClim provided with DivaGIS. The full colour code: red: areas with rather high suitability; orange: areas with high suitability; yellow: suitable areas; no colouring: areas not suitable. All four species are represented with few records, and the full colour scale has therefore not been utilised by the programme. Original data based on herbarium material from Friis (1992) and later field observations by the authors.

Alchornea laxiflora; Alstonia boonei; Anthocleista schweinfurthii; Antiaris toxicaria subsp. *welwitschii* var. *welwitschii; Argomuellera macrophylla; Byttneria catalpifolia* subsp. *africana; Ceiba pentandra; Celtis gomphophylla; C. zenkeri; Chazaliella abrupta; Clerodendrum johnstonii; Ficus asperifolia; F. dicranostyla; F. mucuso; F. platyphylla; F. umbellata; Flabellaria paniculata; Gomphia sp. = Mooney 9249; Hippocratea parvifolia; Lannea welwitschii* var *welwitschii; Milicia excelsa; Morus mesozygia; Ochna bracteosa; Oxyanthus lepidus* var. *lepidus; O. lepidus* var. *unyorensis; O. speciosus* subsp. *globosus; Pisonia aculeata; Pouteria altissima; Psychotria sp. = Mooney 9252; Pyrenacantha sylvestris; Raphiostylis beninensis; Rinorea friisii; R. ilicifolia* subsp. *ilicifolia; Solanum welwitschii; Tetracera stuhlmanniana; Trichilia prieuriana; Trilepisium madagascariense; Urera trinervis; Uvaria schweinfurthii; Ventilago diffusa; Xylopia parviflora; Zanthoxylum leprieurii.*

The lianas *Urera trinervis* (Urticaceae) and *Ventilago diffusa* (Rhamnaceae) are characteristic of this forest type.

The epiphytes are mostly drought-resistant ferns, *Phymatosorus scolopendria*, *Microsorum punctatum* and *Platycerium elephantotis* (all Polypodiaceae, the latter species is shown in Fig. 28E). Epiphytic species of orchids and *Peperomia* occur, but are not prominent.

The forests are highly threatened because of the high value of the timber from these tree species. In addition, the areas covered by these forests are highly suitable for development as coffee- and tea-plantations. Also the increasing population of the area, resulting in more shifting cultivation and burning of the big trees, presents major problems for the preservation of this vegetation type in south-western Ethiopia.

These forests were previously, at their lower limit in the Western lowlands in the IL floristic region and neighbouring Sudan, referred to as "*Lowland semi-evergreen forest*." These forests were recorded from altitudes between 450 and 650 metres on sandy soils, but usually with a high groundwater table, with average maximum temperatures of 35-38°C, mean annual temperatures of 18-20°C, and annual rainfall between 1300 and 1800 millimetres. Friis (1992) distinguished these forests from altitudes between 450 and 650 metres as a separate vegetation type by and named them *Dry peripheral semi-deciduous Guineo-Congolian forest*.

The forests at altitudes between 450 and 650 metres are semi-deciduous, with a 15-20 metres tall, more or less continuous canopy of *Baphia abyssinica* (endemic to south-western Ethiopia and adjacent areas of Sudan), mixed with less common species such as *Celtis toka* (= *C. integrifolia;* Ulmaceae), *Diospyros abyssinica* (Ebenaceae), *Lecaniodiscus fraxinifolius* (Sapindaceae), *Pouteria* (*Malacantha*) *alnifolia* (Sapotaceae), *Trichilia prieureana* (Meliaceae), *Trilepisium madagascariense* (Moraceae), *Zanha golungensis* (Sapindaceae), and *Zanthoxylum leprieurii* (Rutaceae). Some species emerge high above the main canopy: *Alstonia boonei* (Apocynaceae), *Antiaris toxicaria* (Moraceae), *Celtis gomphophylla* (Ulmaceae), and *Milicia excelsa* (= *Chlorophora excelsa;* Moraceae).

Below the closed canopy of *Baphia* is a more or less continuous stratum of small trees, especially *Acalypha neptunica* (Euphorbiaceae), *Erythroxylum fischeri* (Erythroxylaceae), *Tapura fischeri* (Dichapetalaceae), *Ziziphus pubescens* (Rhamnaceae), and *Xylopia parviflora* (Annonaceae). The shrub layer is sometimes dense, and includes: *Alchornea laxiflora*, *Argomuellera macrophylla* (both Euphorbiaceae), *Mimulopsis solmsii* (Acanthaceae), *Oncoba spinosa* (Flacourtiaceae), *Chazaliella abrupta*, *Oxyanthus speciosus* (both Rubiaceae), *Rinorea ilicifolia* subsp. *ilicifolia* (Violaceae), and *Whitfieldia elongata* (Acanthaceae). Tall lianas are not prominent, but the lower strata of the forest are often densely mixed with woody lianas, some of which (species of *Capparis*; Capparidaceae) are thorny and make walking in the forest difficult. There is no record of any epiphytic species. The ground is mostly covered by thick litter, and there are apparently few species of forest floor herbs, one being the widespread forest grass *Streptogyna crinita* (Poaceae).

As already pointed out by Chaffey (1979), these forests of the Western lowlands have considerable similarity with the forests at higher altitudes. However, some genera of the family Moraceae (*Milicia excelsa* and *Antiaris toxicaria*) seem to be more common among the emergent species than at higher altitudes. The forests at altitudes between 450 and 600 metres also seem to have some characteristic species that do not occur at higher altitudes and are rare, and do not at all occur elsewhere in Ethiopia. This is the case with the rubiaceous understorey shrub *Chazaliella abrupta*, which is sometimes dominant in the undergrowth of the lowland forests, and *Tapura fischeri* (Dichapetalaceae), which also occurs up to altitudes of approximately 1000 metres in the lower part of Omo valley and the

FIG. 28

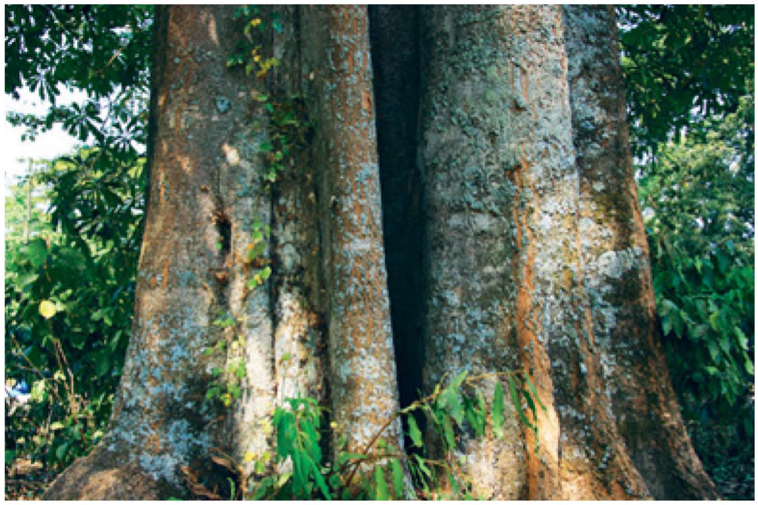
A-B: Two aspects of canopy and forest margins of Transitional rain forest. In (B) the understorey has been partly cleared and replaced with regularly planted shrubs of *Coffea arabica* (Rubiaceae). Bebeka coffee plantation. Altitude approximately 1200 metres. KF floristic region. January 2009.

A

B

FIG. 28. A-B. Views of (7) *Transitional rain forest* (TRF).

C



D

E

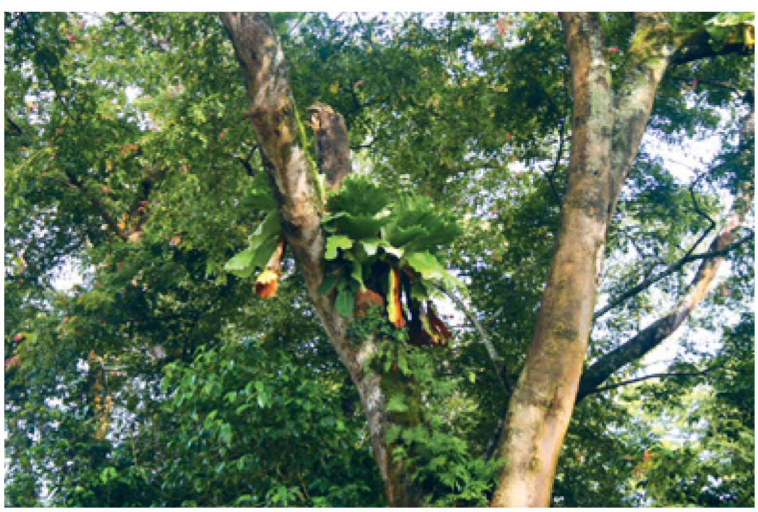


FIG. 28. C-D-E. Views of (7) *Transitional rain forest* (TRF).

F G

H J

FIG. 28. F-G-H-J. Views of (7) *Transitional rain forest* (TRF).

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FIG. 28

C: Base of trunk of large canopy tree, *Alstonia boonei* (Apocynaceae), in Transitional rain forest. Bebeka coffee plantation. Altitude approximately 1200 metres. KF floristic region. January 2009.

D: Clearing in Transitional rain forest near its lower limit, with huts and farmland in the foreground. In the background partly disturbed forest. Near Gog. Altitude approximately 600 metres. IL floristic region. October 1986.

E: Epiphytic fern, *Platycerium elephantotis* (Polypodiaceae) in Transitional rain forest. Tepi coffee plantation. Altitude approximately 1300 metres. IL floristic region. January 2009.

F-G: Tree of lower strata in Transitional rain forest. Leaves (E) and flowers (F) of *Baphia abyssinica* (Fabaceae subfam. Papilionoideae). Bebeka coffee plantation. Altitude approximately 900 metres. KF floristic region. January 2009.

H: Base of trunk of canopy tree, *Pouteria (Aningeria) altissima* (Sapotaceae) in Transitional rain forest, the lower storey of which has been partly replaced with shrubs of *Coffea arabica* (Rubiaceae). Bebeka coffee plantation. Altitude approximately 1100 metres. KF floristic region. January 2009.

J: Canopy tree, *Trilepisium madagascariense* (Moraceae), in Transitional rain forest, the lower storey of which has been partly replaced with shrubs of *Coffea arabica*. Bebeka coffee plantation. Altitude approximately 1100 metres. KF floristic region. January 2009.

Western lowlands of the IL floristic region (Friis, 1992). Also the forest grass *Streptogyna crinita* (Poaceae) is unknown elsewhere in Ethiopia.

However, field observations by the authors in 2009 have convinced us that there is probably a continuous transition from the forests observed at altitudes at 1000 to 1500 metres to the forests at 450 to 600 metres, and for this reason they have been combined in one vegetation type here. However, because most of these forests are only accessible on foot, only little is known about the floristic composition of the forests at altitudes between 600 and 780 metres. It may be possible that the forests at altitudes below a certain altitude, for example 700 metres, should be considered a distinct subtype of (7) *Transitional rain forest* (TRF), if additional species restricted to the low-lying areas are recorded.

The observed and modelled distributions of four characteristic species in this vegetation type has been illustrated in Fig. 27A-D (p. 107). It can be seen that *Alstonia boonei* (Fig. 27A) is strictly limited to a narrow transition zone between (6) *Moist evergreen Afromontane forest* (MAF) and the lowlands. *Morus mesozygia* (Fig. 27B) extends along rivers into the highlands, especially along the Gabba river, and extends also into the WG floristic region. *Pouteria altissima* (Fig. 27C) has a slightly wider distribution than *Alstonia boonei* and extends into WG, but is not found in riverine forests. *Trilepisium madagascariense* (Fig. 27D) is more widely distributed than the three other species and have been found in riverine forests quite far from the core area of the mapping unit "*Transitional rain forest* (TRF)." It is characteristic of the moist and hot lower south-western slopes of the Western highlands.

DISTRIBUTION: Scattered examples of these forests are known from the western escarpment of the Ethiopian highlands in the WG, IL and KF floristic regions, where the rainfall and hence humidity from the rain-bearing south-westerly winds is highest. The forests occur at altitudes between 450 and 1500 metres. The rainfall is close to 2000 millimetres/year or higher (up to 2700 millimetres/year), with some rain all the year round. The transitional rain forests are most similar in physiognomy and composition to the humid broad-leaved Afromontane rainforests of south-western Ethiopia (characterised as Moist Afromontane forests).

It is possible to give reasonably precise upper and lower altitudinal limits for this vegetation type, with the lower limit at approximately the 500 metres contour (defined as 500 metres in Appendix 4, p. 238-250) and the upper limit at the 1500 metres contour. But it has been more difficult to define the northern and southern boundaries of (7) *Transitional rain forest* (TRF). In the south, the forest type is delimited by (4) *Combretum-Terminalia woodland and wooded grassland* (CTW), which is expanding into the forest area due to frequent annual fires and with scattered, surviving forest trees left in the woodlands in protected areas (see discussion of this in similar habitats in south-eastern Sudan by Jackson (1956) and Friis and Vollesen (2005, especially the descriptions of lowland deciduous woodland and lowland forest on pp. 698-704); this boundary has been drawn with a reasonable degree of certainty, as defined in Appendix 4 (p. 238-250; the correction zone 4) and as shown on Fig. 13 (p. 37).

MAPPING: The northern boundary is even more poorly defined because patches of forest referable to mapping unit "Transitional rain forest (TRF)" have survived in woodland in the southern part of the WG floristic region, and many of the smaller woody species (non-emergent or non-upper canopy species) characteristic of the *Transitional rain forest* (TRF) survive and form part of riverine forest along the Gabba river and other northern tributaries of the Baro river. A northern border has been defined as a best fit in Appendix 4 (the correction zone 4) and as shown on Fig. 13, agreeing as well as possible with the field observations of the authors.

(8) *Ericaceous belt* (EB)

An Ericaceous belt is developed on all high mountains of eastern Africa (Hedberg, 1951). Although a well developed Ericaceous belt is characteristic for most of the higher mountains in Ethiopia, the upper and lower limits of this vegetation type are quite difficult to define. The vegetation is here defined somewhat arbitrarily by its occurrence between the 3000 and the 3200 metres contours. The term "*Ericaceous belt*" has been used here, rather than "*Ericaceous woodland*," "*Ericaceous bushland*" or "*Ericaceous scrub*," because vegetation in which Ericaceous species form an important component may occur at lower or higher altitudes than the rather narrow zone between 3000 and 3200 meters altitude ascribed to the "Ericaceous belt." In the different mountains, the lowest and the upper altitudinal limits shift slightly above or below the limits indicated here.

The physiognomy of the *Erica*-dominated vegetation may also be highly variable and is dependent on how much the vegetation has been disturbed. Burning is particularly important in this respect. Figs 29A and 29C show unburnt *Erica* forest or woodland, while Fig. 29B shows low, shrubby growth of *Erica* after frequent burning.

At the lower limit the *Ericaceous belt* (EB) borders with the upper zone of the montane forest belt. In most parts of northern and central Ethiopia the montane forest belt is occupied by (5) *Dry evergreen Afromontane forest and grassland complex* (DAF). In south-western and southern Ethiopia the montane forest belt con-

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FIG. 29

A: Ericaceous belt with mature or old trees of *Erica arborea* forming woodland. The ground is completely covered by ferns, grasses and mosses. Upper part of the Harenna escarpment above Rira, Bale mountains. Altitude approximately 3600 metres, BA floristic region. September, 2005.

B: Ericaceous belt with burnt vegetation. Probably the burning takes place regularly, and numerous shoots appear from the burnt stumps of *Erica*. In the foreground and between the green *Erica* there are greyish green subshrubs of *Alchemilla haumannii* (Rosaceae). Bale mountains, above Rira village. Altitude approximately 3800 metres, GD floristic region. December, 2007.

C: Ericaceous belt with mature or old trees of *Erica arborea* forming woodland. This locality has more grazing than the similar habitat in the Bale mountains shown in (A). The view over the escarpment has been photographed from a point west of Sankaber, Semien mountains. Altitude approximately 3300 metres, GD floristic region. October, 2009.

D: Rocky slope in the Ericaceous belt completely covered with the red- and yellow-flowered *Kniphofia foliosa*. Southern slope of Inatye mountain, Semien mountains. Altitude approximately 3600 metres. GD floristic region. October, 2009.

A

B

FIG. 29. A-B. Views of (8) *Ericaceous belt* (EB).

FIG. 29. C-D. Views of (8) *Ericaceous belt* (EB).

E

F

FIG. 29. E-F. Views of (8) *Ericaceous belt* (EB).

FIG. 29

E: Undergrowth with ferns (*Polystichum* cf. *wilsonii* (Dryopteridaceae)) in *Erica arborea* woodland above Rira, Bale mountains. Altitude approximately 3600 metres. BA floristic region. September, 2005.

F: Steep and moist rocky slope with *Primula verticillata*. Southern slope of Inatye mountain, Semien mountains. Altitude approximately 3600 metres, GD floristic region. October 2009.

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sists of (6) *Moist evergreen Afromontane forest* (MAF); most notable above the Harenna forest in the Bale mountains. At the upper limit the *Ericaceous belt* (EB) borders with the (9) *Afroalpine belt* (AA), which extends at altitudes between 3200 and 4620 metres (the highest peaks in Ethiopia).

The authors have made a number of observations with regard to the lower and upper limits of vegetation with Ericaceous species. In the Semien mountains the lowermost individuals of *Erica arborea* were observed at 2700 metres altitude, but they were only observed as scattered individuals in what was otherwise typical (5) *Dry evergreen Afromontane forest and grassland complex* (DAF) vegetation. Around 3000 metres altitude large, tree-like individuals of *Erica arborea* were commonly observed and dominated groves of tall shrubs or small trees together with *Hypericum revolutum* and *Rosa abyssinica*; mostly, this vegetation continued up to 3250 metres altitude. Rather similar limits were seen the river valleys leading to the Western highlands south of the High Semien. At Chenneck in the Semien mountains a mixture of giant lobelias (*Lobelia rhynchopetalum*) and *Erica arborea* occurred at 3650 metres altitude, but in places with mist and abundant oreographic rain *Erica* was observed to occur up to nearly 3800 metres altitude, while in slightly drier parts of the Semien mountains, 3600 metres altitude seemed to be the uppermost limit of Ericaceous bushland.

DIVERSITY AND FLORISTIC OVERLAP WITH OTHER VEGETATION TYPES: A total of 56 species, subspecies and varieties of woody plants have been recorded to occur in (8) *Ericaceous belt* (EB); none of these has been recorded from this vegetation type alone; 56 have been recorded from both this vegetation type and the adjacent vegetation type (5) *Dry evergreen Afromontane forest and grassland complex* (DAF); 21 have been recorded from both this vegetation type and the adjacent vegetation type (9) *Afroalpine belt* (AA); seven have been recorded from both this vegetation type and the non-adjacent vegetation type (6) *Moist evergreen Afromontane forest* (MAF), which is separated from this vegetation type by (5) *Dry evergreen Afromontane forest and grassland complex* (DAF); three have been recorded from both this vegetation type and the non-adjacent vegetation type (4) *Combretum-Terminalia woodland and wooded grassland* (CTW), which is separated from this vegetation type by (5) *Dry evergreen Afromontane forest and grassland complex* (DAF). Data from Appendix 3 (p. 177-237), Table 2 (p. 43) and Fig. 13 (p. 37).

Floristically, the (8) *Ericaceous belt* (EB) has a low diversity, with no unique woody species, subspecies and varieties and many shared with the adjacent vegetation types. The vegetation type is mainly characterized by its physiognomy.

CHARACTERISTIC SPECIES: The Ericaceous belt is physiognomically characterized by the dominance of shrubs and shrubby trees such as *Erica arborea, Erica (Phillipia) trimera* (both Ericaceae), *Hypericum revolutum* (Guttiferae), *Myrsine melanophloeos* (Myrsinaceae) and perennial subshrubs or herbs, for example *Alchemilla haumannii* (Rosaceae), *Geranium arabicum* (Geraniaceae), *Anthemis tigreensis*, *Erigeron afroalpinum, Haplocarpha rueppellii, Helichrysum citrispinum, H. splendidum, H. gofense, H. formosissimum, Senecio schultzii* (all Asteraceae), *Romulea fischeri* (Iridaceae), *Satureja biflora, Thymus schimperi* (Lamiaceae), *Trifolium acaule,* and *T. burchellianum* (Fabaceae subfam. Papilionoideae). Ferns, particularly belonging to the genus *Polystichum* (Dryopteridaceae; Fig 29E), are common. On dry rocky slopes in the Semien mountains *Aloe steudneri* is common, while *Kniphofia foliosa* (Asphodelaceae; Fig. 29D) dominates in moister places, also in the Bale mountains. A special flora is found on steep, moist and shaded places, for example *Primula verticillata* (Primulaceae; Fig.

29F); some of the species from this habitat are also found in the *Afroalpine belt* (AA) above.

No Afromontane species of *Acacia* seems to have been reported from Ericaceous vegetation, although the endemic Afromontane species *Acacia pilispina* and *A. negrii* are supposed to have their upper altitudinal limits as high as at approximately 3100 metres.

As discussed below under *Afroalpine belt* (AA), there are mountains that are marginally higher than the 3200 metres contour. According to the authors' observations even small areas higher than 3000 metres can have vestigial vegetation of the *Ericaceous belt*. Some areas 25-30 kilometres north of Gondar the terrain, intensively cultivated, reaches just above 3000 metres altitude. *Erica arborea* and *Kniphofia foliosa* occur in a few uncultivated places in these areas, where the potential vegetation would be Ericaceous bushland.

DISTRIBUTION: This vegetation type is very scattered from a few small areas in the highlands in the TU floristic region near the border with Eritrea through more extensive areas on the big massifs in the central part of the highlands (for example in the Semien mountains in the GD floristic region, the Choke mountains in the GJ floristic region and large massifs in the WU and northern SU floristic regions) to the smaller and more isolated areas in southern Ethiopia west of the Rift Valley (in the Gurage mountains in the SU floristic region and in the Guge highlands in the GG floristic region). East of the Rift Valley a small area exists on Gara Muleta mountain in the HA floristic region and in larger areas in the AR, SD and BA floristic regions. See Table 3 (p. 125).

MAPPING: The major vegetation type has been marked as mapping unit "*Ericaceous belt* (EB)." The vegetation type has for mapping purpose been defined as occurring at altitudes between 3000 and the 3200 metres. Although there may be some variation in the upper and lower limit of this vegetation type, it is usually found on steep slopes which mean that the vertical extension of the vegetation does not vary much with slight variation in altitudinal range.

(9) *Afroalpine belt* (AA)

An Afroalpine belt is developed on all high mountains of eastern Africa (Hedberg, 1951, in which this is called the Alpine belt; Hedberg, 1964a, in which the term is changed to Afroalpine belt), although some characteristic elements of the *Afroalpine belt* in tropical East Africa are lacking in Ethiopia (Hedberg, 1961): all species of the genus *Dendrosenecio* (Asteraceae) and most shrubby species of *Alchemilla* (Rosaceae). The *Afroalpine belt* is characterised by five distinctive life-forms (Hedberg, 1964a, 1964b): giant rosette plants, tussock grasses (and sedges), acaulescent rosette plants, cushion plants, and sclerophyllous shrubs (and dwarf-shrubs). The lower zones of the *Afroalpine belt* in Ethiopia are characterized by small trees, shrubs and shrubby herbs. The upper zones of this vegetation type are characterized by giant herbs, small herbs and grasses. This vegetation type occurs in areas above an altitude of approximately 3200 metres, occupying the highest mountains in the country.

Figs 30A, 30C and 30E show Afroalpine vegetation with young and flowering rosettes of *Lobelia rhynchopetalum* (Lobeliaceae) with an undergrowth of grasses, sedges or (in Fig. 30C) cushion-shaped subshrubs of the *Helichrysum citrispinum* (Asteraceae). The same species of *Helichrysum* is seen dominating large areas in Fig. 30B. Fig. 30D shows an Afroalpine lake surrounded by low vegetation of grasses and sedges. Fig.

FIG. 30

A: In the foreground rosettes of *Lobelia rhynchopetalum* (Lobeliaceae) before flowering. The low surrounding vegetation consists of Afroalpine grasses and sedges. In the background *Erica arborea* (Ericaceae) forming a belt at lower altitude on the slopes of the valley. Altitude in the foreground approximately 4100 metres. Near the pass leading round Bwahit mountain, Semien mountains, GD floristic region. October 2009.

B: *Helichrysum citrispinum* heath on the slopes of Tulu Dimtu, Sanetti plateau, Bale mountains. Altitude approximately 4200 metres. BA floristic region. September, 2005.

A

B

FIG. 30 A-B. Views of (9) *Afroalpine belt* (AA).

C

D

FIG. 30 C-D. Views of (9) *Afroalpine belt* (AA).


E


F


G

FIG. 30 E-F-G. Views of (9) *Afroalpine belt* (AA).

H

J

FIG. 30 H-J. Views of (9) *Afroalpine belt* (AA).

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FIG. 30

C: Mosaic of grass sward and *Helichrysum citrispinum* heath with flowering and sterile specimens of *Lobelia rhynchopetalum*. Near Batu mountain, Sanetti plateau, Bale mountains. Altitude approximately 4200 metres. BA floristic region. September, 2005.

D: Afroalpine lakes surrounded by tussock grassland. Sanetti plateau, Bale mountains. Altitude approximately 4200 metres. BA floristic region. September 2005.

E: Flowering and sterile specimens of *Lobelia rhynchopetalum* with ground cover of *Carex monostachya*, (Cyperaceae) brown, in the background. Near Saha, west of Imet Gogo.

Altitude approximately 3700 metres. GD floristic region. December, 1996 – January, 1997. Photograph by Christian Puff.

F: Rosettes of *Haplocarpha rueppellii* (Asteraceae) and other small herbs in waterlogged soil. Slope of Bwahit, Semien mountains. Altitude approximately 4200 metres. GD floristic region. October 2009.

G: Grass tussocks, presumably *Festuca* spp., on rocky slopes. GD floristic region. North of Bwahit. Semien mountains. Altitude approximately 4200 metres. GD floristic region. October 2009.

H: Annual herb, *Swertia lugardae* (Gentianaceae), in moss cushion. Sanetti plateau, Bale mountains. Altitude approximately 4200 metres. BA floristic region. September 2005.

J: Flowering rosettes of *Carduus macracanthus* (Asteraceae). The low vegetation in the foreground is a sward of *Alchemilla*. In the background cushions of *Helichrysum citrispinum*. Sanetti plateau, Bale mountains. Altitude approximately 4200 metres. BA floristic region. September 2005.

30F shows rosets of *Haplocarpha rueppellii* (Asteraceae) and other low herbs. Fig. 30G shows rocky slopes with tussocks of grasses and sedges. Fig. 30H shows vegetation of mosses with *Swertia lugardae* (Gentianaceae). Fig. 30J shows flowering rosettes of *Carduus macracanthus* (Asteraceae).

DIVERSITY AND FLORISTIC OVERLAP WITH OTHER VEGETATION TYPES: A total of 22 species, subspecies and varieties of woody plants have been recorded to occur in (9) *Afroalpine belt* (AA); of these one (4.55% of the total) has only been recorded from this vegetation type; 21 have been recorded from both this vegetation type and the adjacent vegetation type (8) *Ericaceous belt* (EB); 20 have been recorded from both this vegetation type and the non-adjacent (5) *Dry evergreen Afromontane forest and grassland complex* (DAF), which is separated from this vegetation type by the narrow (8) *Ericaceous belt* (EB). Data from Appendix 3 (p. 177-237), Table 2 (p. 43) and Fig. 13 (p. 37).

Floristically, the (9) *Afroalpine belt* (AA) has a low diversity and a low number of unique woody species, subspecies and varieties, of which the highest numbers are shared with (5) *Dry evergreen Afromontane forest and grassland complex* (DAF) and (8) *Ericaceous belt* (EB). The characteristic species of the Afroalpine vegetation types are not always well represented on all mountains that reach above an altitude of 3200 metres. An impoverished Afroalpine flora may represent this vegetation on the rather many small peaks that just reach above 3,200 metres altitude. Such peaks in Ethiopia that reach just above an altitude of 3200 metres include, in the TU floristic region, Amba-Simba mountain [Asimba mountain, north-east of Adigrat, 3204 metres), and Mugulat mountain [Alekeye mountain, south-west of Adigrat] (3245 metres), Tulu Welel mountain [Tulu Walel] (3273 metres) in the WG floristic region, Wechecha mountain [Wuchacha] (3320 metres) in the SU floristic region, Delo mountain (ca. 3600 metres), the highest point in the Amaro mountains in the SD floristic region, and Gara Muleta mountain (3380 metres) in the HA floristic region. Near Addis Abeba in the SU floristic regions the Entoto mountains barely reaches an altitude of approximately 3200 metres in a few places, and the vegetation and flora of the highest point should probably be referred to the previous vegetation type, the *Ericaceous belt* (EB). Surprisingly, a typical Afroalpine species like *Lobelia rhynchopetalum* (Lobeliaceae) is recorded from Gara Muleta, as can be seen from the distribution map in Fig. 19D.

CHARACTERISTIC SPECIES: The *Afroalpine belt* (AA) is best characterized by a combination of giant Lobelias, cushion-forming species of *Helichrysum* (Asteraceae), shrubby species of *Alchemilla* (Rosaceae), and prominence of temperate grass genera (*Festuca*, *Poa*, *Deschampsia*, etc.). Although the *Afroalpine belt* in East Africa has a number of species of giant Lobelias and Senecios, *Lobelia rhynchopetalum* (Lobeliaceae) is, in the *Afroalpine belt* in Ethiopia, alone among the giant rosette herbs with stems. The presence of *Lobelia rhynchopetalum* can be taken as an indicator of the *Afroalpine belt* (AA), but it appears from Fig. 19D that *Lobelia rhynchopetalum* has not been recorded from all areas of Ethiopia with altitudes above circa 3200 metres.

There are few woody plants in the *Afroalpine belt* (AA). The evergreen shrubs or small trees include *Erica arborea* (Ericaceae) and *Hypericum revolutum* (Guttiferae). They mostly occur as shrubs, but when protected against fire and cutting they can grow into trees. There are stands of *Erica* and *Hypericum* trees at altitude between 3200 and 3400 metres on the Harenna escarpment of the Bale mountains and near the top of the Choke mountains, and small trees thus occasionally transgress the formal lower boundary of the *Afroalpine belt* accepted here.

There are few woody species that do not occur elsewhere, especially in the *Ericaceous belt* (EB). *Maytenus cortii* (Celastraceae), however, seems only to have been recorded from above the 3500 metres contour, which is above the limit of the vegetation here defined.

Typical perennial herbs include a number of species of *Helichrysum* and *Artemisia schimperi* (endemic) (Asteraceae).

The grasses mainly belong to the subfamily Pooideae that is dominant in the northern temperate regions of the world, and include endemic species of *Festuca (F. gilbertiana, F. macrophylla), Poa (P. hedbergii, P. chokensis, P. pumilio, P. simensis)* and *Agrostis (A. gracilifolia* subsp. *parviflora*).

We agree with the plant communities of the Afroalpine zone proposed by Pichi Sermolli (1957), that is: (1) Vegetation on rocky scree, with low, herbaceous plants among the stones. (2) Vegetation on rocky slopes, with many rosette-plants and sometimes also *Lobelia rhynchopetalum*. (3) *Carex* swamps dominated by *Carex monostachya*. To these can be added (4) Afroalpine grassland, often with *Lobelia rhynchopetalum.* (5) Small fresh-water lakes (mainly on the Sanetti plateau in the Bale mountains.

DISTRIBUTION: As stated above, this vegetation type occurs in areas above an altitude of approximately 3200 metres. It occurs on the highest mountains in the country (all measurements must be taken with some reservation, as the indications often vary from source to source): Amba-Alage mountain (3440 metres) in the TU floristic region, the Choke mountains (4070 m) in the GJ floristic region, the Semien mountains in the GD floristic region (the tallest peak in the Semien mountains is Ras Dejen (4620 m), other notable peaks in the Semien include Bwahit mountain (4430 metres) and Abba Yared mountain (4460 metres)), other high mountains in GD include Guna mountain (4231 metres), high mountains in the WU floristic region are for example Abune Yosef mountain (4260 metres) and Amba Farit mountain (3975 metres), in the SU floristic region high mountains are for example Abuye Meda mountain (4305 metres) and the Gurage mountains (3720 metres), in the GG floristic region the Guge highlands (4200 metres), in the AR floristic region Chilalo mountain (4139 metres), Kaka mountain (4190 metres) and Badda mountain (4133 metres), in the BA floristic region the extensive Bale mountains (in which the highest peaks are Tulu Dimtu mountain (4377 metres) and Batu mountain (4307 metres), but the entire Sanetti plateau, an area of more then 20 x 18 kilometres, is above 4000 metres altitude. The first botanical records of the Sanetti plateau were made by Mooney (1963). As mentioned above, there are many small peaks in Ethiopia that reach just above an altitude of 3200 metres. These include, in the TU floristic region, Mt. Amba Simba (Mt. Asimba, north-east of Adigrat, 3204 metres), and Mugulat mountain (Alekeye mountain, south-west of Adigrat, 3245 metres), Tulu Welel mountain [Tulu Walel mountain] (3273 metres) in the WG floristic region, Wuchacha mountain (3320 metres) and Entoto mountains (c. 3200 metres) in the SU floristic region, Delo mountain (ca. 3600 metres), the highest point in the Amaro mountains in the SD floristic region, and Gara Muleta mountain (3380 metres) in the HA floristic region. See Table 3.

MAPPING: The major vegetation types are marked as mapping unit "*Afroalpine belt* (AA)." As mentioned above, areas marked as "*Afroalpine belt* (AA)" are found above the 3200 metres contour.

Table 3. Mountain peaks with maximum heights above 3200 metres in Ethiopia

The sources of this table are the National Atlas of Ethiopia (Anonymous, 1988), a map in 1:2,000,000 published in 1997 by the Ethiopian Mapping Authority (Anonymous, 1997), and, for the Semien mountains, a map in 1:100,000 published in 2003 by the Centre for Development and Environment, Institute of geography, University of Berne (Hurni & Messerli, 2003). Where not available from these sources coordinates have been recorded on the locality by the authors or from Google Earth (http://earth.gle.com).

Because of the highly dissected nature of the Semien mountains, with many individualised peaks distributed on several extensive massifs, these mountains will tend to be overrepresented in lists oh high mountain peaks in relation to the Bale mountains, where almost the entire Sanetti plateau form a flat table-land with altitudes over 4000 metres; similarly, there are fewer mountain peaks in the Galama mountains in the AR floristic region, and Kaka and Badda\ are isolated old volcanoes rising from the Arsi highland. The high peaks outside the Semien, Bale and Arsi mountains listed here mostly represent the highest point of the massif they occur in. The indication of height for the peaks may vary from source to source; the figures cites here represent the best values according to the judgement of the authors.

The list has been sorted according to height of the mountains. Peaks below an altitude of approximately 3200 metres are too numerous to be listed here.

Name of peak	Location	Floristic region	Coordinates	Maximum height (metres)
Ras Dejen	Highest peak in the Semien mountains and highest mountain peak in Ethiopia. Part of a large massif east of the deep Mesheha river valley. A number of nearby peaks are part of the same massif, including Analu (4473 metres), Kidus [Kidis] Yared (4453 metres), Tefew Leser (4449 metres) and Abbat Dejen (4400 metres [approximately]) and Shiwana (4113 metres).	GD	13° 14' N; 38° 22' E	4533
Bwahit	Prominent high peak in the Semien mountains. Part of a massif west of the deep Mesheha river valley. A number of nearby peaks are part of the same massif, including Mesarerya (4353 metres) and Digowa (3973 metres).	GD	13° 13' N; 38° 13' E	4430
Silki	Prominent high peak in the Semien mountains. Part of a massif north of the Mesheha river valley. A number of nearby peaks are part of the same massif, including Abba Yared (4409 metres), Beroch Wuha (4272 metres) and Walya Kend (4249 metres).	GD	13° 21' N; 38° 16' E	4420
Tulu Dimtu	Highest peak in the Bale mountains, rising from the Sanetti plateau.	BA	6° 50' N; 39° 49' E	4377

Batu	Second highest peak in the Bale mountains, rising from the Sanetti plateau.	BA	6° 55' N; 39° 44' E	4307
Abuye Meda	Highest peak in massif between Debra Sina and Dese.	SU	10° 31' N; 39° 46' E	4305
Abune Yosef	Highest peak in massif north-east of Lalibela	WU	12° 09'N; 39° 11' E	4284
Guna	Highest peak in the Guna massif east of Lake Tana	GD	11° 43' N; 38° 14' E	4231
Kaka	Old volcano south of the Galama mountains.	AR	7° 22' N; 39° 09' E	4190
Guge	Highest peak in the in the Guge highlands.	GG	6° 12' N; 37° 30- E	4176
Chilalo	Highest peak in the Galama mountains.	AR	7° 55' N; 39° 16' E	4139 (height sometimes stated as 4005)
Badda	Old volcano south of the Galama mountains.	AR	7° 55' N; 39° 23' E	4133
Choke	Highest peak in the Choke mountains north of Debre Markos	GJ	10° 45' N; 37° 35' E	4070 (height sometimes stated as 4154)
Inatye	Highest peak in the western part of the Semien mountains. A number of nearby peaks are part of the same massif, including Shayno Serfer (3962 metres; Serfer means village) and Imet Gogo (3926 metres).	GD	13° 14' N; 38° 08' E	4070
Amba Farit	Highest peak in massif between Weldiya and Debre Tabor.	WU	10° 56' N; 38° 58' E	3975
Gurage	Highest peak in the Gurage mountains west of Butajira.	SU	8° 24' N; 38° 24' E	3721 [height sometimes stated as 3697]
Delo	Highest peak in the Amaro mountains east of Lake Chamo.	SD	5° 49' N; 37° 50' E	3600 [approximately]
Amba-Alage	Highest peak in massif between Maichew and Enda Medhane Alem.	TU	12° 59' N; 39° 33' E	3939
Gara Muleta	Peak of old volcano west of Harar; the only mountain above 3200 metres in the HA floristic region.	HA	9° 05' N; 41° 43' E	3405
Wechecha (Wuchacha)	Old volcano west of Addis Abeba.	SU	8° 59' N; 38° 35' E	3320
Tulu Welel / Tulu Walel	Isolated mountain, possibly an old volcano, north-east of Dembidolo.	WG	8° 53' N; 34° 50' E	3302
Entoto	Highest peak in the Entoto mountains just north of Addis Abeba	SU	9° 04' N; 38° 48' E	3292

Mugulat	Highest peak in the Alequa massif west and south-west of Adigrat. (Asfawossen Asrat *et al.*, 2008).	TU	14° 14' N; 39° 27' E	3291
Amba-Simba [Asimba]	Highest peak in massif north-east of Adigrat.	TU	14° 27' N; 39° 37' E	3204

(10) *Riverine vegetation* (RV)

Rivers are fresh-water surface streams. The main rivers and their tributaries form the drainage systems of the country. Ethiopia has several major systems of rivers and tributaries: Abay [Blue Nile] (starting in the northern part of the Western highlands), Awash (starting in the central part of the Western highlands), Baro (starting in the Western highlands), Omo (starting in the southern-central part of the Western highlands), Tekeze (starting in the northern part of the Western highlands), Wabi Shebele (starting in the Eastern highlands). These rivers and their tributaries have riverine forests in areas below approximately 1800 metres altitude. This vegetation type consists of riverine forests with taller trees and riparian woodlands along faster moving water. Most riverine and riparian habitats are probably too narrow and strip-like to map at the scale of 1:2,000,000 used for the vegetation map in this work.

Figs 31A-B show canopy views of riverine forests above approximately 1500 metres. Figs 31C-E show examples of riverine forests below 1500 metres along rivers running through areas with fairly high rainfall to the Western escarpment and the Nile valley. Figs 31F-G show riverine forest below 1000 metres along rivers running through areas with low rainfall to the South-eastern lowlands (Fig. 31F) or the Afar lowlands (Fig. 31G)

DIVERSITY AND FLORISTIC OVERLAP WITH OTHER VEGETATION TYPES: A total of 242 species, subspecies and varieties of woody plants have been recorded to occur in (10) *Riverine vegetation* (RV); of these 64 (26.45% of the total) have only been recorded from this vegetation type; 102 have been recorded from both this vegetation type and the adjacent vegetation type (5) *Dry evergreen Afromontane forest and grassland complex* (DAF); 56 have been recorded from both this vegetation type and the adjacent vegetation type (6) *Moist evergreen Afromontane forest* (MAF); 32 have been recorded from both this vegetation type and the adjacent vegetation type (2) *Acacia-Commiphora woodland and bushland* (ACB); 30 have been recorded from both this vegetation type and the adjacent vegetation type (7) *Transitional rain forest* (TRF); 13 have been recorded from both this vegetation type and the adjacent vegetation type (4) *Combretum-Terminalia woodland and wooded grassland* (CTW); 10 have been recorded from both this vegetation type and the adjacent vegetation type (1) *Desert and semi-desert scrubland* (DSS); three have been recorded from both this vegetation type and the adjacent (though only marginally so) vegetation type (8) *Ericaceous belt* (EB). Data from Appendix 3 (p. 177-237), Table 2 (p. 43) and Fig. 13 (p. 37).

Floristically, (10) *Riverine vegetation* (RV) is moderately diverse, but with a relatively low number of unique woody species, subspecies and varieties. The highest numbers of woody species, subspecies and varieties are shared with (5) *Dry evergreen Afromontane forest and grassland complex* (DAF), followed by (6) *Moist evergreen Afromontane forest* (MAF) and a number of other vegetation types, mainly represented by forest and woodland species.

CHARACTERISTIC SPECIES: Riverine species may also be associated with high ground water table for other reasons than the presence of a river. In a place approximately 30 kilometres north-west of Gonder on the road to Humera at 1600 metres altitude a small depression contained riverine tree species (*Trema orientalis, Oncoba spinosa, Diospyros mespiliformis*, *Uvaria sp.*) without any river present and with a surrounding vegetation with typical species of (4) *Combretum-Terminalia woodland and wooded grassland* (CTW); this phenomenon would seem to be due to a locally high ground water table.

There is a considerable number of species of woody plants that are only recorded from riverine forest in Ethiopia.[4] Typical trees in riverine forest include *Acacia polyacantha* subsp. *campylacantha* (Fabaceae subfam. Mimosoideae), *Celtis africana* (Ulmaceae), *Ficus sycomorus* (Moraceae), *Mimusops kummel* (common in the forest in Fig. 31A), *Mimusops laurifolia* (both Sapotaceae; the latter only associated with rives and temporary streams running to the Afar lowlands), and *Breonadia salicina* (Rubiaceae).

The riverine forest vegetation is highly variable in structure and density, and the floristic composition is dependent on altitude and geographical location. Additional trees found in these forests are: *Lepisanthes senegalensis* (Sapindaceae), *Salix subserrata* (Salicaceae), *Trichilia emetica* (Meliaceae), *Diospyros mespiliformis* (Ebenaceae), *Syzygium guineense* subsp. *guineense* (Myrtaceae), *Tamarindus indica* (Fabaceae subfam. Caesalpinioideae), *Tamarix nilotica* (Tamaricaceae; Fig. 31G), *Hyphaene thebaica* (Fig. 31F) and *Phoenix reclinata* (both Arecaceae). *Zanthoxylum gilletii* (Rutaceae; Fig. 31D) is a riverine forest tree that was recently discovered from Ethiopia (Friis & Vollesen, 2010), it occurred at an altitude of approximately 1350 metres in the forest along a small, unnamed stream between Bambesi [Bambasi] and Begi in western WG surrounded by *Combretum-Terminalia woodland and wooded grassland* (CTW). *Zanthoxylum gilletii* has a distribution outside Ethiopia that is similar to those of many species of (7) *Transitional rain forest* (TRF), and it is possible that *Zanthoxylum gilletii* might in Ethiopia occur in both riverine forest and transitional rain forest.

The riverine forests have often a shrub layer, and lianas and vascular epiphytes occur. The moist types of riverine forests, mainly along the rivers running to the west, have a ground-cover includes grasses, ferns, and a few herbaceous dicotyledons. The rivers running to the east have a very sparse or no ground cover, except for annual species germinating during the rains.

DISTRIBUTION: *Riverine vegetation* (RV) as defined here can be found in almost all parts of the country with permanent or temporary rivers and other streams below an altitude of 1800 metres. (Table 4, p. 133) However, *Riverine vegetation* (RV) is relatively rare in the driest parts of the AF, HA and SD floristic regions,

4. Among the woody species predominantly or only known from Riverine forest are the following: *Abrus canescens; A. pulchellus* subsp. *tenuiflorus; Abutilon mauritianum; Acacia robusta* subsp. *usambarensis; Acalypha fruticosa* var. *eglandulosa; A. fruticosa* var. *fruticosa; Acridocarpus ugandensis; Antidesma venosum; Artabotrys monteiroae; Breonadia salicina; Bridelia atroviridis; Cocculus pendulus; Combretum capituliflorum; Diospyros scabra; Dregea abysinica; Erythrococca bongensis; Euphorbia goetzei; Feretia apodanthera* subsp. *apodanthera; Ficus capreaefolia; F. vallis-choudae; Garcinia livingstonei; Gomphocarpus semilunatus; Gymnema sylvestre; Hibiscus diversifolius; H. rostellatus; Hypericum gnidiifolium; Kanahia carlsbergiana; K. laniflora; Kigelia africana; Maerua triphylla* var. *calophylla; M. triphylla* var. *johannis; M. triphylla* var. *pubescens; M. triphylla* var. *triphylla; Melastomastrum capitatum; Monanthotaxis ferruginea; M. parvifolia* subsp. *kenyensis; Nuxia oppositifolia; Phyllanthus reticulatus; Pluchea dioscoridis; P. somaliensis; Plumbago truncata; Polysphaeria aethiopica; P. parvifolia; Psychotria capensis* subsp. *riparia var. puberula; Salix pedicellata; S. subserrata; Secamone punctulata; Sesbania dummeri; S. goetzei; Syzygium guineense* subsp. *guineense; Tacazzea apiculata; T. venosa; Thespesia danis; Tiliachora funifera; Tricalysia niamniamensis* var. *niamniamensis; Trichilia emetica; T. retusa; Tylophora oblonga; T. sylvatica; Uvaria angolensis; U. leptocladon* subsp. *septentrionalis.*

FIG. 31

A: Riverine forest along the Abay [Blue Nile] river above the Tis Isat falls. The most prominent trees in the canopy are *Diospyros mespiliformis* (Ebenaceae), *Mimusops kummel* (Sapotaceae) and *Syzygium guineense* subsp. *guineense* (Myrtaceae). Vegetation surrounding the riverine forest is a weakly differentiated mixture of (4) *Combretum-Terminalia woodland and wooded grassland* (CTW) and (subtype 5c) *Afromontane woodland, wooded grassland and grassland* (DAF/WG). Altitude approximately 1750 metres. GJ floristic region. October 2007.

B: Riverine forest along the Abay [Blue Nile] river around the Tis Isat falls. Falling over the basaltic rocks, the river produces a spray-zone with a more lush and species-rich forest than elsewhere along the stream. Surrounding vegetation is as for (A). Altitude approximately 1700 metres. GJ floristic region. October 2007.

A

B

FIG. 31. A-B.Views of (10) *Riverine vegetation* (RV).

C

D

E

FIG. 31. A-B.Views of (10) *Riverine vegetation* (RV).

F

G

FIG. 31. A-B.Views of (10) *Riverine vegetation* (RV).

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FIG. 31

C: Riverine forest along the Beles river just before its confluence with the Abay [Blue Nile] river south-east of Guba (Mankush). Vegetation surrounding the riverine forest is (4) *Combretum-Terminalia woodland and wooded grassland* (CTW). Altitude approximately 750 metres. GJ floristic region. November 2006.

D: *Zanthoxylum gilletii* (Rutaceae), a medium-sized to large tree in riverine forest along a small, unnamed stream between Bambesi [Bambasi] and Begi. Vegetation surrounding the riverine forest is (4) *Combretum-Terminalia woodland and wooded grassland* (CTW). Altitude approximately 1350 metres. WG floristic region. November 2006.

E: Riverine forest along Baro river. Vegetation surrounding the riverine forest is (4) *Combretum-Terminalia woodland and wooded grassland* (CTW); the leaves of the woodland trees are turning yellow and falling due to the advancing dry season. Altitude approximately 700 metres. IL floristic region. November 1995.

F: Riverine vegetation along the Genale river near Dolo Odo. The palm *Hyphaene thebaica* (or possibly *H. compressa*) emerges above the canopy. Vegetation surrounding the riverine forest is (1) *Desert and semi-desert scrubland* (DSS). Altitude approximately 250 metres. SD/BA floristic regions. February 2000.

G: Riverine vegetation along Mile river between Mile (in the Afar lowlands) and Bati (in the Western highlands). The most prominent trees in the forest are *Tamarix nilotica* (Tamaricaceae) and species of *Boscia* (Capparidaceae). Vegetation surrounding the riverine forest is (2a) *Acacia-Commiphora woodland and bushland proper* (ACB). Altitude approximately 650 metres. AF floristic region. October 2006.

especially where the salinity is high. *Riverine vegetation* (RV) is these places sometimes replaced with (Subtype 12b) *Salt pans, saline/brackish and intermittent wetlands and salt-lake shore vegetation* (SLV/SSS) of vegetation type (12) *Salt-water lakes, salt-lake shores, marsh and pan vegetation* (SLV).

MAPPING: This vegetation type has not been marked as such, but on the map it is represented by the main rivers as mapping unit "*Non-perennial and perennial river*" (above 1800 metres altitude), based on the AEON river database (de Wit & Stankiewicz, 2006). True riverine vegetation is basically found below approximately the 1800 metres contour, where the rivers pass from the Afromontane vegetation types, mostly dominated in the natural condition by continuous forest or mosaic of forest and grassland ((5) *Dry evergreen Afromontane forest and grassland complex* (DAF) and (6) *Moist evergreen Afromontane forest* (MAF), into (2) Acacia-Commiphora *woodland and bushland* (ACB) or (4) *Combretum-Terminalia woodland and wooded grassland* (CTW).

Table 4. Major rivers and river basins in Ethiopia

Consistent and detailed information about Ethiopian rivers is scarce. The data in this table has mainly been derived from the *National Atlas of Ethiopia* (Anonymous, 1988) and from the map *Ethiopia – Scale 1:2,000,000* produced by the Ethiopian Mapping Authority (Anonymous, 1997). The indication of run-off is based cited data in Sebsebe Demissew *et al.* (1996). The rivers and their catchment areas are listed clockwise from the north.

Name of major rivers, river systems and catchment areas (or name of catchment area with no major river)	Drains to:	Annual run-off in cubic metres	Floristic regions covered by part of catchment area	Catchment area (square kilometres)	Length of major rivers (in kilometres)			Major tributaries originating inside Ethiopia
					Total	Inside Ethiopia	Outside Ethiopia	
Mereb river.	The Mediterranean through the Atbara and the Nile; the river forms part of the Eritrean-Ethiopian boundary and leaves Ethiopia through Eritrea as Gash	Run-off not known	TU	23,455	600	440	160	Numerous small, seasonal tributaries
Rivers of the catchment area of the lakes of the Afar lowlands	Lakes in the northern Afar lowlands	860,000	AF, TU, WU	Approximately 74,000	Not applicable	Not applicable	0	Numerous small, seasonal rivers and tributaries
Awash river.	Lakes in the southern Afar lowlands	4,600,000	WU, SU, AR, AF	113,709	1200	1200	0	Akaki, Kesem, Borkena, Mile, etc.

Wabi Shebele river system.	The Indian Ocean through the Juba river in southern Somalia in years with high rainfall; to swamps in southern Somalia in years with low rainfall	3,160,000	SD, AR, BA, HA	205,407	2000	1340	660	Galeti, Ramis, Erer, Gobeli, Daketa, Jerer, Fafen, etc.
Genale river system. Weyb and Dawa rivers joins Genale near the Ethiopian-Somali border; from the conflu-ence the river is known as Juba	The Indian Ocean through the Juba river in southern Somalia	5,880,000	SD, BA	168,141	1050	480	570	Weyb, Mena, Welmel, Dawa, etc.
Rivers of the catchment area of the lakes of the central and southern Rift Valley	Lakes in the main (eastern) part of the Rift Valley	5,640,000	SU, AR, SD, GG	Approximate-ly 52,700	Not applica-ble	Not applica-ble	0	Bilate, Segan, etc.
Gibe-Omo river system.	Lake Turkana in the western part of the Rift Valley	17,960,000	WG, KF, SD, GG	77,205	760	760	0	Gojeb, Dincha, etc.
Baro-Akobo-Gilo river system. Akobo and Gilo originate inside Ethiopia and join Baro at the border between	The Mediterra-nean through the Nile	11,890,000	KF, IL, WG	75,718	507	227	280	Akobo, Gilo, Gabba, etc.

Ethiopia and Sudan; from the conflu-ence the river is known as Sobat								
Abay [Blue Nile]-Shinfa-Dinder river system. Shinfa and Dinder rivers originate west of Lake Tana, leave Ethiopia as separate streams that join with the Blue Nile in Sudan	The Mediterra-nean through the Blue Nile and the Nile	52,200,000	GD, WU, GJ, SU, WG, IL, KF	198,508	1360	800	560	Gilgel Abay, Reb, Gumara, Beshlo, Beto, Jema, Muger, Guder, Fincha, Didesa, Anger, Dabus, Beles, etc.
Tekeze-An-gereb-Atbara river system. Angereb and Atbara rivers originate north and west of Lake Tana and leave Ethiopia as separate streams that join with the Tekeze in Sudan; the river is known as Atbara after the conflu-ence	The Mediterra-nean through Atbara and the Nile	7,630,000	TU, WU, GD	87,773	1168	608	560 (part outside Ethiopia known as Atbara)	Tirari, Chiba, etc.

(11) *Freshwater lakes, lake shores, marsh and floodplain vegetation* (FLV)

For freshwater, the generally accepted upper limit of dissolved salts in the water is approximately 1000 parts per million (1 gram salt per litre equals 1000 parts per million). For saline water (salt-water) the concentration is generally considered to vary between 1000 and 35,000 parts per million. However, authors in the Ethiopian environment like Wood and Talling (1988), who carried out field studies of the plankton flora in a wide range of Ethiopian lakes and compiled chemical and salinity information on these lakes, followed the classification proposed by Williams (1964), with an upper limit for what is classified as fresh water somewhat higher than 1000 parts per million. According to for example Wood and Talling (1988) the major salt lakes in Ethiopia are identified as those containing dissolved salts in excess of 3000 parts per million. This view, based on studies of, for example, the flora of plankton algae, was also followed by Elisabeth Kebede *et al.* (1994).

The concepts of Wood and Talling (1988) and Elisabeth Kebede *et al.* (1994) have been followed here, and thus the lakes that are below the level of the concentration (3000 parts per million) are here considered as freshwater lakes, although those that are above 1000 parts per million could be considered slightly saline. This means that Lake Langeno, with a salinity of approximately 1800 parts per million, and Lake Turkana (Rudolf), with a salinity of slightly less than 2900 parts per million, are here classified as a fresh water lake, having a plankton flora containing both green algae and cyanobacteria.

DIVERSITY AND FLORISTIC OVERLAP WITH OTHER VEGETATION TYPES: A total of eight species, subspecies and varieties of woody plants have been recorded to occur in (11) *Fresh-water lakes, lake shores, marsh and floodplain vegetation* (FLV); of these none has been recorded from this vegetation type alone. Eight have been recorded from both this vegetation type and the adjacent vegetation type (10) *Riverine vegetation* (RV) and one is shared with the adjacent vegetation type (5) *Dry evergreen Afromontane forest and grassland complex* (DAF). Data from Appendix 3 (p. 177-237), Table 2 (p. 43) and Fig. 13 (p. 37).

Floristically, (11) *Fresh-water lakes, lake shores, marsh and floodplain vegetation* (FLV) has a very low diversity with regard to woody species, subspecies and varieties, and none of these are unique to the vegetation type, which is characterised by physiognomy and herbaceous taxa. These, however, have not been studied here.

CHARACTERISTIC SPECIES: See below under the subtypes.

MAPPING: See below under the subtypes.

This vegetation type is found in fresh-water lakes with open water, on lake shores, in marshes and floodplains. Two subtypes are recognized in this major vegetation type.

(Subtype 11a) *Freshwater lakes – Open water vegetation* (FLV/OW)

As mentioned above, this includes lakes which have a concentration of salts below approximately 3000 parts per million. This vegetation type is found in

FIG. 32

A: Remote view of the low-lying land north-east of the shore of Lake Tana. The lake is surrounded by a weakly differentiated mixture of (4) *Combretum-Terminalia woodland and wooded grassland* (CTW) and (subtype 5c) *Afromontane woodland, wooded grassland and grassland* (DAF/WG). The view had been photographed from below the ruined Guzara castle near the village of Infraz. Two islands are seen in the lake. Altitude approximately 1800 metres. GD floristic region. October 2009.

B: Western shore of Lake Abaya, with a view of the Guge highlands near Chencha in the background to the right and Yegzer Dildiy ("The bridge of God"), the mountains that separate Lake Abaya from Lake Chamo, to the left. The shore is covered by low vegetation of grasses and sedges, and further from the shore by (subtype 2a) *Acacia-Commiphora woodland and bushland proper* (ACB). Altitude approximately 1500 metres. GG floristic region. October 2005.

A

B

FIG. 32. A-B.Views of (Subtype IIa) *Freshwater lakes – Open water vegetation* (FLV/OW).

C

D

FIG. 32. C-D.Views of (Subtype 11a) *Freshwater lakes – Open water vegetation* (FLV/OW).

FIG. 32

C: Lake Wonchi, a crater lake surrounded by (subtype 5a) *Undifferentiated Afromontane forest* (DAF/U), (subtype 5c) *Afromontane woodland, wooded grassland and grassland* (DAF/WG) and, above the lake, vegetation of (8) *Ericaceous belt* (EB). Altitude approximately 2900 metres. SU floristic region. September 2003.

D: Lake Bishan-Waka, a crater lake surrounded by (7) *Transitional rain forest* (TRF) west of Tepi. Altitude approximately 1400 metres. IL floristic region. September 2005.

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the open water in lakes with an extensive water-surface.

Figs 32A-D show examples of Ethiopian freshwater lakes, both large lakes, as Lake Tana (Fig. 32A) and Lake Abaya (Fig. 32B), and small lakes, as Lake Wonchi (Fig. 32C) and Lake Bishan-Waka (Fig. 32D).

CHARACTERISTIC SPECIES: The characteristic species include floating aquatics such as native *Lemna aequinoctalis, L. gibba, L. minor, Wolfia arrhiza* (Lemnaceae), *Pistia stratiotes* (Araceae), the invasive *Eichhornia crassipes, E. natans* (both Pontederiaceae). In addition there are a number of phytoplankton species. Examples include: *Anabaena* spp., *Aphanothece microspora*, *Chroococus disperses*, *Closterium spp.*, *Meliorosa granulata*, *Microcystis aeruginosa*, etc. (Wood & Talling, 1988; Elisabeth Kebede *et al.*, 1994).

DISTRIBUTION: The major freshwater lakes in Ethiopia include Lake Tana (in the GJ and GD floristic regions), Lake Ashange [Ashenge] (in the TU floristic region), Lakes Hayk and Ardibo (in the WU floristic region), Lake Langeno and Lake Ziway (both in the SU floristic region), Lake Awasa (in the SD floristic region), Lakes Abaya, Chamo and Turkana (spanning the border between the SD and GG floristic regions). See Table 5 (p. 140). There are also smaller sized crater lakes such as Bishoftu Crater Lakes (Bishoftu, Hora, Arenguade, Pawlo and Kilotes) [Lake Chilotes; Lake Hora-Kilole] in the vicinity of Bishoftu (Debre Zeit) town, Lake Ziquala, Lake Hareshetan (west of Butajira town) (all in the SU floristic region) and Lake Zengena (in the GJ floristic region).

The Koka reservoir, damming the Awash river (in the SU floristic region), and the Fincha and Chomen reservoirs, damming the Fincha river (and surrounded by the Chomen swamp, in the WG floristic region), are the two oldest; they are shown on the map. The remaining reservoirs, such as Melka Wakena reservoir, damming the Melka-Wakena river (in the BA floristic region), and the Gilgel Gibe reservoir I, damming the Gilgel Gibe river (in the KF floristic region), are not shown on the map. These reservoirs have been established relatively recently and have not yet reached a steady state in their environmental balance.

MAPPING: This vegetation subtype is marked as mapping unit "*Freshwater lakes - Open water vegetation* (FLV/OW)." It has been defined mainly on information from the GLWD (Global Wetlands Database; see Lehner & Döll, 2004), but modified with regard to salinity as defined in Appendix 4 (p. 238-250) and shown on Fig. 40-41 (p. 249-250).

Table 5. Freshwater lakes and reservoirs in Ethiopia

Information about Ethiopian lakes is scarce and scattered. In order to distinguish between freshwater and salt water lakes in the map it has been necessary to establish a list of Ethiopian lakes and their salinity, as a complete list has not previously been published. The precise indications of salinity in this list and in Table 6 (p. 155) are indicated according to Wood and Talling (1988). Additional information (marked with *) has been derived from the general review of Ethiopian lakes by Tenalem Ayenew (2009).

Small crater lakes have generally been omitted both from the lists in Table 5 and 6 and from the maps; the information about these lakes is scanty or unreliable, and since most of them are less than one kilometre in diameter, they cannot be mapped in the present atlas. This applies for example to the small Rift Valley crater lakes between Lake Abaya and Lake Awasa (Lake Budemeda and Lake Mecheferia), the small crater lakes near Debre Zeyt / Bishoftu (Lake Bishoftu, Lake Bishoftu-Guda (Babogaya, Pawlo), Lake Kuriftu and Lake Hora-Arsedi (Bete Mengist [Mengest]), Lake Hora-Hado), the small crater lakes in the Blue Nile (Abay) basin (Lake Zengena, Lake Tirba, Lake Gudera, Lake Yetilba, Lake Tach Bahir and Lake Lay Bahir), Lake Ziquala in the caldera on top of the old volcano Mt. Ziquala, Lake Hareshetan west of Butajira and the little crater Lake Bishan-Waka west of Tepi. All these have a surface less than approximately one kilometre square.

The more than hundred small Afroalpine lakes on the Sanetti plateau in the Bale mountains have been excluded; even the largest of the lakes on the Bale mountains (Garba Gurach and Hora-Orgona) cover an area of only 0.1-0.2 kilometre square.

Two unnamed lake are shown in the atlas along the western edge of the Rift Valley south of Butajira and west of Ziway; nothing more than their existence and position is known about them. Many temporary ponds or small lakes may be found in the Gambela lowland of the IL floristic region. Their names, if they have any, have not been recorded in the literature; only the largest are shown in the atlas.

Tenalem Ayenew (2009) refers to a number of additional lakes, presumably relatively small and probably with highly fluctuating size, dependent on the flow of water in the Awash river (Lake Yardi [Lake Diaribet], Lake Dalay, Lake Liado, Lake Gargori and Lake Bil). Hardly anything is known about these lakes except their names and approximate position. Especially those lakes along the upper reach of the Awash river are probably to be classified as freshwater lakes, like Lake Gamari, others, especially the ones along the lower reach of Awash river, may have salinity fluctuating around 3 g/l or be definitely saline. Where it has been possible to indicate these lakes (often surrounded by swamps) on the map plates, they have been classified in agreement with the information available in the Global Lakes and Wetlands Database (GLWD); see Lehner and Döll (2004); no more information is provided about them in Table 5 and 6.

Name of Lake	Floristic region	Coordinates	Altitude (metres above sea level)	Area (square kilometres)	Salinity (parts per million)
Gamari	AF	11° 32' 14' N; 41° 40' 07" E	340*	70*	663
Abaya	GG / SD	6° 20' N; 37° 50' E	1260-1285 [fluctuating, generally slightly rising]*	1140-1160 [fluctuating]*	771
Chamo	GG / SD	5° 50' N; 37° 33' E	Approximately 1235 [fluctuating, generally slightly rising]*	317*	1099

Turkana / Rudolf	GG / Kenya	4° 30' N; 36° 5' E	360*	6750* (under 300 of this area is in Ethiopia)	2894
Tana	GJ/GD	12° 00' N; 37° 20' E	1780-1800*	3000-3500 [fluctuating, slightly declining since late 1990s]*	0.143
Alemaya	HA	9 24' N; 42 00' E	2020*	48 (before 1960); currently dried out completely*	Value before 1960 unknown
Adele	HA	Just NNW of Lake Alemaya	Approximately 2000*	c. 50 (before 1960); now nearly dried out*	Value before 1960 unknown
Fikle	HA	Just NNW of Lake Alemaya	Approximately 2000*	c. 20 (estimate from before 1960); now nearly dried out*	Value before 1960 unknown
Awasa	SD	7° 03' N; 38° 26' E	1680 [water level slightly rising]*	80 [moderately increasing]*	1008
Langeno	SU	7° 36' N; 38° 43' E	1585*	230*	1880
Ziway	SU	8° 00' N; 38° 50' E	1635*	440 [moderately declining]*	349
Koka reservoir [Gelila]	SU	8° 23' N; 39° 05' E	1590	180 [fluctuating]	Unknown
Wonchi	SU	8 47' N; 39 46' E	2095*	4*	0,106*
Ashange [Ashenge]	TU / WU	12° 35' N; 39° 30' E	2440*	20 [fluctuating, slightly declining since late 1990s]*	1200
Fincha reservoir	WG	9° 54' N; 37° 27' E	Approximately 2220 [water level slightly rising]	240 [in 2001; fluctuating, still rising]	Unknown
Chomen (area with open water, surrounded by swamp) reservoir	WG	9° 25' N; 37° 15' E	Approximately as in Fincha, which is connected by broad channel	Not known exactly [fluctuating, still rising]	Unknown
Hayk	WU	11° 21' N; 39° 43' E	1925*	c. 23 [sharply declining 1940-1980; moderately increasing area after 1980]*	0.771
Ardibo	WU	11° 14' N; 39° 45' E	2150*	16*	432*

(Subtype 11b) *Freshwater marshes and swamps, floodplains and lake shore vegetation* (FLV/MFS)

Marshes and swamps are wetlands with temporary or permanent body of water. Commonly *marshes* are restricted to those wetlands that are dominated by grasses, rushes, reeds, *Typha* spp., sedges and other herbaceous plants, while *swamps* often also contain low woody vegetation (shrubs and trees) in addition to the wetland vegetation: http://nwrcweb@usgs.gov (modified 2008). But in Africa the term *swamp* may also frequently be associated with floating bogs or even free-floating islands of papyrus (*Cyperus papyrus*) and other sedges. Hence, for the vegetation in Ethiopia, the terms marshes and swamps are used synonymously and the word swamps used in the following.

Figs 33A-E show a variety of swamps in the Western highlands; Fig. 33F shows an example of a freshwater intermittent wetland with specialised vegetation.

There are many areas with swamp vegetation in the central and western parts of Ethiopia, while there are fewer to the east. The Fogera (Fig. 33A) and Dembia swamps (both around Lake Tana in the GD floristic region), the Chomen swamps (Fig. 33C) and the Dabus swamps (both in the WG floristic region; Fig. 33D shows an overview of swamps at the upper reaches of the Dabus river) are among the larger swamps that have been possible to mark on the map plates. The extents of the Chomen and Dabus swamps are marked in the GLWD (Global Wetlands Database; see Lehner & Döll, 2004), and this has been reproduced in the map plates. The extents of the Fogera and Dembia swamps have, in the opinion of the authors, been underestimated in the GLWD. Due to the special interests the authors have taken in these areas during field trips it has been possible to estimate the extents of the swamps, and the have been marked as swamps or flood regions on the map plates. In recent years, the Fogera and Dembia swamps have been drained, and there is now cultivations in extensive parts of the potential swamps.

The Cheffa swamps in WU floristic region southwest of Kombolcha have formed a special problem. They have unfortunately not been marked in the Global Wetlands Database (GLWD); see Lehner and Döll (2004), and it has not been possible to map them on the map plates either. We have not found it possible to propose an outline for these swamps and marches ourselves, as not enough information about their extent is available. There is no large river running through Cheffa swamps, rather a network of small streams. The whole area is about 4-6 kilometres wide and at least 10 kilometres long, and forms the bottom of a valley parallel with the Eastern escarpment.

Special mention can also be made of the large swamps along the Awash river in the AF floristic region (for example near the town of Gewane and close to Lake Gamari). The main problem with these swamps has been lack of information about their salinity. But according to the field observations by the authors the flora of these swamps seems to indicate that they are mainly fresh water swamps, which agrees with the indication in the GLWD. The swamps along the Awash river have therefore been indicated as such on the map plates.

But there are hundreds of small marshes and swamps dotted throughout the country, mainly in the

FIG. 33

A: Swamp with white egrets near Ala Kebele in the Fogera plains east of Lake Tana. Small banks of earth have been established in the swamp in order to help controlling floods. In the background the main road between Bahir Dar and Adis Zemen has been raised above the swamp. The surrounding vegetation is a weakly differentiated mixture of (4) *Combretum-Terminalia woodland and wooded grassland* (CTW) and (subtype 5c) *Afromontane woodland, wooded grassland and grassland* (DAF/WG). Altitude approximately 1800 metres. GD floristic region. October 2007.

B: Swamp surrounded by dry evergreen Afromontane forest and cultivations. The surrounding vegetation is a mixture between (subtype 5a) *Undifferentiated Afromontane forest* (DAF/U) and (subtype 5c) *Afromontane woodland, wooded grassland and grassland* (DAF/WG). Between Gish Abay and Tilili. Altitude approximately 1800 metres. GJ floristic region. October 2007.

A

B

FIG. 33. A-B. View of (Subtype IIb) *Freshwater marshes and swamps, floodplains and lake shore vegetation* (FLV/MFS).

A

B

FIG. 33. C-D. View of (Subtype 11b) *Freshwater marshes and swamps, floodplains and lake shore vegetation* (FLV/MFS).

A

B

FIG. 33. D-E. View of (Subtype IIb) *Freshwater marshes and swamps, floodplains and lake shore vegetation* (FLV/MFS).

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FIG. 33

C: Swamp associated with one of the tributary streams entering the Chomen swamp. The surrounding vegetation is a mixture between (subtype 5a) *Undifferentiated Afromontane forest* (DAF/U) and (subtype 5c) *Afromontane woodland, wooded grassland and grassland* (DAF/WG). Altitude approximately 2100 metres. SU/WG floristic region. January 2009.

D: Distant view of the large swamp east of the road between Gidami and Begi. The surrounding vegetation is a mixture of (4) *Combretum-Terminalia woodland and wooded grassland* (CTW) and (subtype 5c) *Afromontane woodland, wooded grassland and grassland* (DAF/WG). Altitude approximately 1400 metres. WG floristic region. November 2006.

E: Swamp between Bambesi [Bambasi] and Begi. The surrounding vegetation is a mixture of (4) *Combretum-Terminalia woodland and wooded grassland* (CTW) and (subtype 5c) *Afromontane woodland, wooded grassland and grassland* (DAF/WG). Altitude approximately 1500 metres. WG floristic region. November 2006.

F: Temporary wetland with grass sward and leaf-rosettes of *Lannea edulis* (Anacardiaceae), a plant with creeping woody stems. The surrounding vegetation is a mixture of (4) *Combretum-Terminalia woodland and wooded grassland* (CTW) and (subtype 5c) *Afromontane woodland, wooded grassland and grassland* (DAF/WG). Altitude approximately 1500 metres. Between Bambesi [Bambasi] and Begi. WG floristic region. November, 2006.

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floristic regions with high rainfall, such as the IL and KF floristic regions, and in Benshangul-Gumuz. It has not been possible to include information about these swamps on the map plates.

Along the margins of one of the largest swamps in Ethiopia, the Dabus swamp, there are a few patches of swamp forest. These forests are not inundated throughout the year, but sometimes for up to six months of the year, according to local informants. They are dominated by species of *Ficus* (Moraceae), *Antidesma venosum* (Euphorbiaceae), *Syzygium guineense* subsp. *guineense* (Myrtaceae), and *Phoenix reclinata* (Arecaceae). Along the south-western shores of Lake Abaya, near the town of Arba Minch, there is a ground-water forest fed by numerous springs (the name of the town Arba Minch is Amharic for "forty springs"); the dominant tree in this forest is *Aeschynomene elaphroxylum* (Fabaceae subfam. Papilionoideae); this tree may reach a height of up to nine metres.

Floodplains are flat or nearly-flat landscapes adjacent to rivers that experience occasional or periodic flooding. For example: Large expanses near the village of Tefki (at about 50 kilometres west of Addis Abeba on the road to Jima), and near Koka (between the small towns of Mojo and Meki) are examples of flood plains created by the flooding of the Awash river, when it rises over its banks. The vegetation may be closely related to that of riverine vegetation or to that of swamps and marches, lake-shores or freshwater intermittent wetlands. Other important examples of floodplains are found around Lake Tana, where considerably larger areas than the Fogera and Dembia marshes/swamps may be flooded in the rainy seasons, or in large areas of the lower part of the Omo valley, just above the delta at Lake Turkana.

Lake shores are areas around the shores of the freshwater lakes indicated above. The vegetation is often rather similar to that of swamps and floristically closely related.

Freshwater intermittent wetlands are also seen in many parts of Ethiopia, mainly in the GJ, KF and IL floristic regions. Fig. 33F shows an example of a freshwater intermittent wetland wit a grass sward and leaf-rosettes of *Lannea edulis* (Anacardiaceae), a plant with creeping woody stems that are adapted to the temporary flooding.

CHARACTERISTIC SPECIES: The characteristic species in Freshwater marsh/swamp, floodplain and lake shore vegetation along the shores of fresh water lakes include the sedges such as *Cyperus digitatus*, *C. denudatus*, *C. dichroostachys*, *C. elegantulus*, *C. latifolius*, *Ascolepis capensis* (Cyperaceae), but also a number of other herbs, including *Juncus dregeanus* (Juncaceae), *Floscopa glomerata* (Commelinaceae), *Eriocaulon* spp., *Syngonanthus wahlbergii* (both Eriocaulaceae), *Xyris cap-*

ensis (Xyridaceae), *Persicaria decipiens* and other *Persicaria* spp. (Polygonaceae), *Ludwigia abyssinica* (Onagraceae), *Chenopodium album* (Chenopodiaceae), *Ranunculus multifidus* (Ranunculaceae), *Sphaeranthus* sp. (Asteraceae), *Plectranthus punctatus* (Lamiaceae), *Leersia hexandra*, and *Panicum hygrocharis* (both in Poaceae), and *Nymphaea lotus* (Nymphaeaceae). There are relatively few woody species that are clearly associated with lake shores, etc.

Among the woody species characteristic of these habitats are *Phoenix reclinata* (Arecaceae) and species of the genera *Aeschynomene* and *Sesbania* (Fabaceae subfam. Papilionoideae), particularly: *Aeschynomene cristata* var. *pubescens*, *Aeschynomene elaphroxylum*, *Aeschynomene pfundii* and *Aeschynomene schimperi*. The prostate woody species *Lannea edulis* (Anacardiaceae) has been found a few places in temporarily inundated grasslands in western WG floristic region (Fig. 33F).

DISTRIBUTION: Freshwater lakes are mainly found in the Western highlands (in GD, GJ, WU and SU floristic regions), and in the central and southern part of the Rift Valley in the GG, SD, SU and AF floristic regions. Only few and small freshwater lakes are found east of the Rift Valley. Freshwater swamps and lake shore vegetation occur often in association with the above mentioned lakes, but swamps are also scattered in the Western lowlands and in areas of the highlands mentioned above.

MAPPING: This vegetation subtype is marked as mapping unit "*Freshwater marshes and swamps, floodplains and lake shore vegetation* (FLV/MFS)." Its extent has been defined mainly on information from the Global Wetlands Database (GLWD); see Lehner and Döll (2004), but modified with regard to salinity as defined in Appendix 4 (p. 238-250) and shown on Fig. 39-41 (p. 248-250). Also the extent of the swamps around Lake Tana has been modified in relation to the GLWD.

(12) *Salt lakes, salt-lake shores, marsh and pan vegetation* (SLV)

This vegetation type is characterized by the occurrence of salt tolerant species in or along salt water lakes, pans and intermittent saline wetlands, where the water is saline with concentration normally taken to be between 1000 and 35,000 parts per million as indicated earlier (under (11) *Fresh-water lakes, lake shores, marsh and floodplain vegetation* (FLV)). As also indicated earlier, authors such as Wood and Talling (1988) and Elizabeth Kebede *et al.* (1994), who had field experience with the plankton flora and compiled chemical and salinity information on Ethiopian lakes, identified the salt lakes of Ethiopia as those containing dissolved salts in excess of 3000 parts per million, a concept followed here. There are different grades of salt in the water. Water with salt concentration between 1000 and 3000 parts per million is considered as slightly saline; between 3000 and 10,000 parts per million is considered moderately saline and between 10,000 and 35,000 parts per million is considered highly saline. (http://ga.water.usgs.gov/edu/saline.html, modified 13 May 2009). The highest salt concentration recorded in an Ethiopian salt lake is 276,500 parts per million recorded by Wood and Talling (1988) from Lake Asale in the Danakil depression, but other lakes have also highly saline water, for example Lake Abe with 160,000 ppm and Lake Afrera with 158,000 parts per million. Thus these Ethiopian salt lakes range with the most saline lakes of the World, for example the remains of the Aral Sea on the border between Kazakhstan and Uzbekistan, now with a salinity of more than 100,000 parts per million, the Dead Sea between Israel and Jordan, with an average salinity of approximately 315,000 parts per million, but in dry periods ranging up to 400,000 parts per million, and the Great Salt Lake in Utah, USA, with a fluctuating salinity that ranges up to approximately 270,000 parts per million. However, it has been demonstrated that the salinity is also rising sharply in the saline lakes of the Rift Valley in association with the shrinking size of the lakes, for example there has been a three-fold increase over 65 years in

Lake Abijata. Not all Ethiopian lakes are becoming more saline. There has been a ten-fold dilution of total ionic concentration for over 30 years in Lake Metahara [Beseka], which is connected with the Awash river system. That lake has increased in size over the past 20 years, possibly due to a combination of subterranean seepage from the basin and spillage from the Awash river (Elizabeth Kebede *et al.*, 1994).

Figs 34A-C show the shores of Lake Abijata and the vegetation around the lake; Lake Abijata is one of the saline lakes in the Rift Valley. Fig. 34D shows a satellite image of Lake Abe, the terminal saline lake on the Awash river system; salt pans are seen around the shores of the lake.

DIVERSITY AND FLORISTIC OVERLAP WITH OTHER VEGETATION TYPES: Only one species of woody plants has been recorded to occur in (12) *Salt-water lakes, salt-lake shores, marsh and pan vegetation* (SLV). The woody species is *Suaeda monoica* (Chenopodiaceae) that forms extensive stands on salt pans on the shores of salt lakes. No species, subspecies and variety of woody plants has only been recorded from this vegetation type; the only woody species has been recorded from both this vegetation type and the two adjacent vegetation types (1) *Desert and semi-desert scrubland* (DSS) and (2) *Acacia-Commiphora woodland and bushland* (ACB).

Floristically, (12) *Salt-water lakes, salt-lake shores, marsh and pan vegetation* (SLV) has very low diversity with regard to woody species, subspecies and varieties, none of which are unique for the vegetation type. The number of herbaceous species is also low, but has not been studied here.

CHARACTERISTIC SPECIES: See below under the subtypes.

DISTRIBUTION: See below under the subtypes.

MAPPING: See below under the subtypes.

As in the case of the non-saline counterpart, (11) *Fresh-water lakes, lake shores, marsh and floodplain vegetation* (FLV), this vegetation type is divided into two subtypes.

(Subtype 12a) *Salt lakes – open water vegetation* (SLV/OW)

These are also known as saline lakes. They are formed where there is no natural outlet, and where the water evaporates rapidly leaving a higher amount of salt than normal.

CHARACTERISTIC SPECIES: The vegetation along these lakes depends on the measure of salinity. At high salinity species of the family Chenopodiaceae tends to dominate.

There are also a number of characteristic species of phytoplankton in this vegetation type, mainly consisting of cyanobacteria (Cyanophyta). Examples include: *Anabaenopsis* spp., *Anomoeoneis sphaerocarpa*, *Oscillatoria* spp., *Spirulina platensisis*, etc. (Wood & Talling, 1988). The upper limits of photosynthetic activity in the extremely saline lakes of Ethiopia have been studied by Talling *et al.* (1973).

DISTRIBUTION: The salts in the salty lakes in the central rift valley including Lakes Abijata, Shala and Chitu (all in the SU floristic region) mainly consist of sodium bicarbonate (soda lakes), while the salts in the salt lakes in the in the more arid parts of the country, where both temperatures and evaporation are high, mainly consist of sodium chloride (the common salt of the ocean). There are three groups of salt lakes in the AF floristic region. The first consists of Lake Abe, Afambo and

FIG. 43

A: Shore of Lake Abijata with salt deposits. Surrounding vegetation as under (A). Altitude approximately 1700 metres. SU floristic region. January, 1983. Photograph by Christian Puff.

B: Bay of Lake Abijata with salt deposits in the foreground and *Acacia* woodland in the background. Most of the birds in the lake are flamingos. Surrounding vegetation as under (A). Altitude approximately 1700 metres. SU floristic region. January, 1983. Photograph by Christian Puff.


A


B

FIG. 34. A-B. Views and satellite image of (12) *Salt-water lakes, Lake Shores, salt marches and pan vegetation* (SLV).

C

D

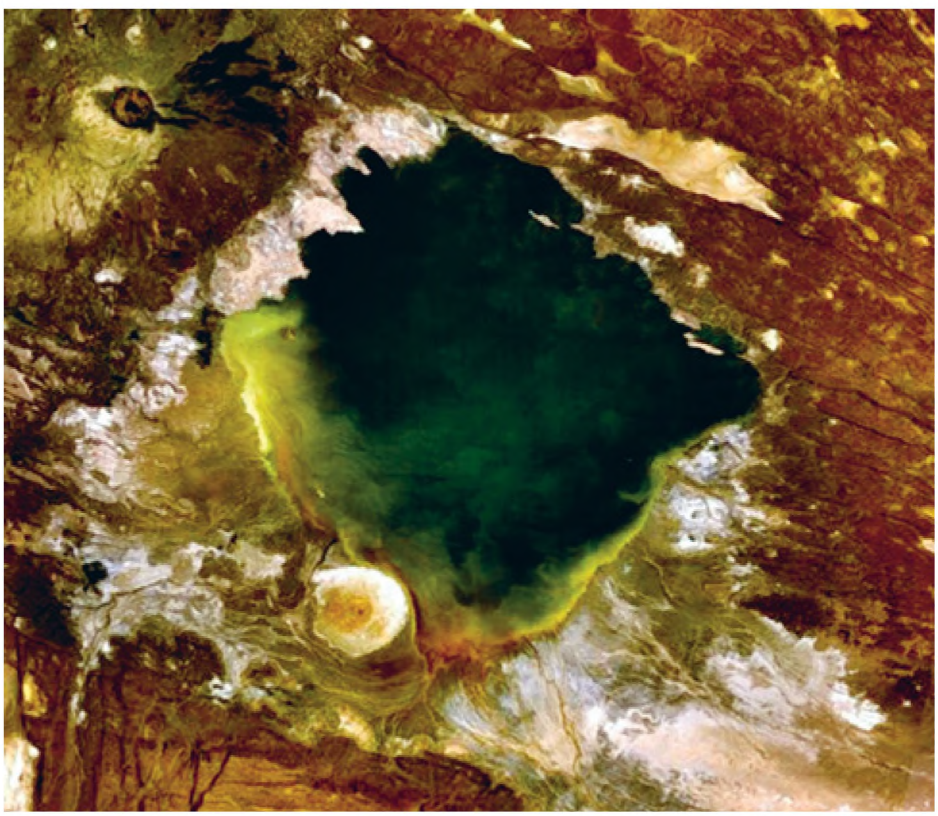

FIG. 34. C-D. Views and satellite image of (12) *Salt-water lakes, Lake Shores, salt marches and pan vegetation* (SLV).

FIG. 34

C: Distant view of Lake Abijata, surrounded by open *Acacia* woodland or wooded grassland of (subtype 2b) *Acacia wooded grassland of the Rift Valley* (ACB/RV). Altitude approximately 1700 metres. SU floristic region. January, 1983. Photograph by Christian Puff.

D: Satellite image showing Lake Abe, terminal on the Awash river. The surrounding vegetation is (1) *Desert and semi-desert scrubland* (DSS). Although partly in Djibouti, Lake Abe is the largest salt lake in Ethiopia and is surrounded by salt pans and volcanic cones. Altitude approximately 240 metres. AF floristic region. Colours are artificial, but white indicates salt- or volcanic deposits. The image is in the public domain layers of the NASA Landsat imagery.

Bario that are all fed by Awash river. The second group of salt lakes includes the desert lakes Lake Afrera and Lake Karum [Lake Asale]; they have extremely high salinity, and are located in the Danakil depression in the northern part of the AF floristic region. The third group includes an ephemeral lake, Lake Laitaf [Lake Laitali], in the northern part of the AF floristic region, north of the ultimate part of the Awash river. Lake Chew Bahir, is another ephemeral lake that is located on the border between the floristic regions SD and GG and bordering Kenya; it is far separated from the lakes in the AF floristic region, but is similar in having a high concentration of sodium chloride. There are hardly any vascular plants known to occur in these lakes.

Neither the list in Table 6 (p. 155), nor the map plates specify a number of small crater lakes with comparatively high salinity, such as a number of crater lakes near Debre Zeit [Bishoftu] (Lake Kilotes (not mentioned in Tenalem Ayenew, 2009) and Lake Hora-Kilole [Lake Arenguade, Lake Aranguade)]; these lakes are reported by Wood and Talling (1988) as having a salt concentration above 5000 parts per million and have an algal flora of cyanobacteria. Also Lake Tilo, one of the small Rift Valley crater lakes between Lake Abaya and Lake Awasa, is saline according to the criteria used in this work, but is too small for inclusion here.

MAPPING: This vegetation subtype is marked as mapping unit "*Salt lakes – open water vegetation* (SLV/OW)." It has been defined mainly on information from the Global Wetlands Database (GLWD); see Lehner & Döll (2004), but modified with regard to salinity as defined in Appendix 4 (p. 238-250) and shown on Fig. 40-41 (p. 249-250).

(Subtype 12b) *Salt pans, saline/brackish and intermittent wetlands and salt-lake shore vegetation* (SLV/SSS)

Salt Pans are a flat expanse of land covered with salt and other minerals. They are usually found in deserts, and the highest concentration of salt pans in Ethiopia is found in the hot and dry northern part of the AF floristic region and in the low-lying south-eastern part of the HA floristic region.

Saline/brackish and intermittent wetlands. The intermittent saline/brackish wetlands are characterized by seasonally fluctuating water levels.

Brackish water is water that has higher salinity than fresh-water; in Ethiopia approximately between 1000 and 3000 parts per million.

Saline/brackish and intermittent wetlands occur in the drier parts of Ethiopia with higher temperatures and higher evaporation rates, resulting in the concentration of salts in the water. Examples of such wetlands

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FIG. 35

A: Aerial view of volcano surrounded by salt pans without vegetation in the Danakil [Dalol] depression. The surrounding vegetation is (1) *Desert and semi-desert scrubland* (DSS). Altitude approximately 600 metres. AF floristic region. Year of recording not known. Photograph by Ethiopian Ministry of Sport and Tourism; in public domain.

B: Salt pan surrounded by scrub of *Suaeda monoica* (Chenopodiaceae). The surrounding vegetation is (1) *Desert and semi-desert scrubland* (DSS). Between Dichioto and the border with Djibouti, near the turn off from the road between Dichioto and Eli Dar, towards the Djibouti border. Altitude approximately 200 metres. AF floristic region. October 2006.

A

B

FIG. 35. A-B. Views of (Subtype 12b) *Salt pans, saline/brackish and intermittent wetlands and salt-lake shore vegetation* (SLV/SSS).

C

D

FIG. 35. C-D. Views of (Subtype 12b) *Salt pans, saline/brackish and intermittent wetlands and salt-lake shore vegetation* (SLV/SSS).

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FIG. 35

C: Temporarily flooded area with salt pan, surrounded by shrubby vegetation of Chenopodiaceae. In the background massive Quaternary lava flows with semi-desert scrub or almost devoid of vegetation. The surrounding vegetation is (1) *Desert and semi-desert scrubland* (DSS). South-west of Eli Dar towards Dichioto. Altitude of salt pan approximately 200 metres. AF floristic region. October 2006.

D: Salt pans surrounded by scrub of *Suaeda monoica* (Chenopodiaceae). In the background lava flows without vegetation. The surrounding vegetation is (1) *Desert and semi-desert scrubland* (DSS). Between Dichioto and the border with Djibouti, shortly before the border crossing point. Altitude approximately 200 metres. AF floristic region. October 2006.

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are found in parts of the AF floristic region and around Lake Chew Bahir in the GG floristic region.

Saline marshes are found as in areas south of Lake Abe in the AF floristic region.

Figs 25A-C show views of salt pans in the Afar lowlands. Fig. 35D shows a close view of a salt pan with small shrubs of *Suaeda monoica* (Chenopodiaceae).

CHARACTERISTIC SPECIES: The vegetation type is characterized by *Suaeda monoica*, and herbaceous species of *Atriplex* spp. and *Salicornia* spp. (all Chenopodiaceae).

DISTRIBUTION: This subtype is restricted to the Danakil depression in the AF floristic region, the lakes in the central and southern part of the Rift Valley in SU, SD and GG floristic regions, and along the Wabi Shebele river in the southern part of the HA floristic region.

MAPPING: This vegetation subtype is marked as mapping unit "Salt pans, saline/brackish and intermittent wetlands and salt-lake shore vegetation (SLV/SSS)." It has been defined mainly on information from the Global Wetlands Database (GLWD); see Lehner & Döll, 2004), but modified with regard to salinity as defined in Appendix 4 (p. 238-250) and shown on Fig. 39-41 (p. 249-250).

Table 6. Saline lakes in Ethiopia

The classification of these lakes as saline or salt lakes is in accordance with the definition of Williams (1964). This means that lakes with a salinity above 3000 parts per million are considered saline; see further in the text under (11) *Fresh-water lakes, lake shores, marsh and flood-plain vegetation (FLV)* and (12) *Salt-water lakes, salt-lake shores, marsh and pan vegetation (SLV)*. The precise indications of salinity are according to Wood and Talling (1988) or Elizabeth Kebede *et al.* (1994). As For Table 2, additional information (marked with *) has been derived from the general review of Ethiopian lakes by Tenalem Ayenew (2009). The salinity indicated for Lake Metahara [Beseka] is not cited by Wood and Talling (1988) or Elizabeth Kebede *et al.* (1994), but only known from Tenalem Ayenew (2009); it places this lake in a marginal position between the saline and freshwater lakes. However, due to the highly fluctuating water level and extent of the lake it seems likely that the salinity could also be fluctuating and occasionally sinking below 3000 parts per million. It has not been possible to trace figures for the salinity of Lake Afambo, Lake Bario [Lake Baria] and Lake Laitaf [Lake Laitali], which are dependent on water flow in the Awash river, but most likely saline. Tenalem Ayenew (2009) has not traced information about their salinity and states that little is known about them.

See also note in the legend to Table 5 (p. 140) about the lakes along the Awash river in the AF floristic region (Lake Yardi [Lake Diaribet], Lake Dalay, Lake Liado, Lake Gargori and Lake Bil). The lakes recognized as saline and mapped as such in this work have been marked on Fig. 13, 14 and 15 in Appendix 4. (p. 238-250).

Name of Lake	Floristic region	Coordinates	Altitude (metres above or below sea level)	Area (square kilometres)	Salinity (parts per million) or general information
Karum / Asale (lake without outlet)	AF	14° 01' N; 40° 25'E	Approximately 120 metres below sea level*	55*	276,500
Unnamed near Karum / Asale (lake without outlet)	AF	13° 56' N; 40° 29' E	Approximately 120 metres below sea level*	Approximately 25*	Unknown; probably similar to that of Lake Karum/L. Asale
Unnamed near Karum / Asale (lake without outlet)	AF	13° 55' N; 40° 34' E	Approximately 120 metres below sea level*	Unknown	Unknown; probably similar to that of Lake Karum/L. Asale
Afrera (lake without outlet)	AF	13° 17' N; 40° 54' 40" E	Approximately 80 metres below sea level*	70*	158,000
Abe (terminal on the Awash drainage system)	AF	11° 10'N; 41° 47' E	243*	320-350 [only approximately half of this is in Ethiopia, the other part is in Djibouti]*	160,000

Afambo (sub-terminal on the Awash drainage system)	AF	11° 25'N; 41° 41' E	Approximately 250	Approximately 17 [fluctuating and dependent on the flow of the Awash river]*	(Permanent, probably mostly saline lake; salinity not known, most likely fluctuating)
Bario (subterminal on the Awash drainage system)	AF	11° 22' 30'' N; 41° 36' E	Approximately 250	Unknown [size highly fluctuating and dependent on the flow of the Awash river]*	(Permanent, probably mostly saline lake; salinity not known, most likely fluctuating)
Laitaf / Laitali (connected with the Awash drainage system)	AF	11° 44' N; 41° 43' E	Approximately 250	? [size highly fluctuating and dependent on the flow of the Awash river]*	(Intermittent, probably mostly saline lake; salinity not known, most likely fluctuating)
Metahara / Beseka (currently without outlet)	AF / SU	8 53' N; 39 52' E	945 (1964) – 950 (1997) [see next column]*	2.5 (in 1963) – 41 (in 2005) [lake rapidly expanding, but area and water level now artificially stabilised]*	3,652*
Chew Bahir (southern Rift Valley intermittent lake without outlet)	GG	4° 40' N; 36° 56' E	570	Zero – 300 [highly fluctuating]* Around 1950 the lake covered more than 1000 square kilometres, but it has shrunk to a swamp with very little or frequently no open water over the rest of the 20th century	(Intermittent lake; salinity high, but highly fluctuating; extensive salt pans)
Abijata (central Rift Valley lake without outlet)	SU	7° 30' N; 38° 37' E	1580*	180 [area of open water dramatically declining]*	16,200
Chitu (central Rift Valley lake without outlet)	SU	7° 24' N; 38° 25' E	1552*	Approximately 1*	38,300
Shala (central Rift Valley lake without outlet)	SU	7° 29' N; 38° 32' E	1550*	Approximately 380*	21,500

APPENDIX I

The vegetation types of Ethiopia according to Pichi Sermolli (1957)

The following provides a detailed comparison between the vegetation types of Ethiopia according to Pichi Sermolli (1957), compared with the present system. A precise comparison is part of the goals of the VECEA project.

(1) *Deserto* [Desert]

PICHI SERMOLLI'S CRITERIA: Vegetation type with large areas completely without, or with extremely scarce vegetation.

DISTRIBUTION: According to Pichi Sermolli's map true *Deserto* occurs in Ethiopia only in the eastern and southern part of the AF floristic region, west of the Danakil Alps.

We have included most of these areas in our vegetation type *Desert and subdesert scrubland*, but small areas with higher ground has been placed in *Acacia-Commiphora woodland and bushland*.

(2) *Steppa graminosa, perenniboscosa e suffruticosa* [Grass, perennial herb and subshrub steppe]

PICHI SERMOLLI'S CRITERIA: A heterogeneous vegetation type, the *Steppa graminosa, perenniboscosa e suffruticosa* ranges from areas that could be termed subdesert steppe (*steppa subdesertica*) to types with a denser grass cover or with scattered subshrubs, but not with shrubs. Apart from this type, which is characterised by entirely herbaceous vegetation, Pichi Sermolli decided to distinguish types of steppe with increasing presence of plants with woody stems (Pichi Sermolli's type no. 3).

DISTRIBUTION: According to Pichi Sermolli's map the *Steppa graminosa, perenniboscosa e suffruticosa* occurs in Ethiopia only in (1) areas in the extreme eastern part of the Ogaden, probably equivalent to the Haud in Somalia, (2) in an area east-northeast of Wabi Shebele near the Somali border, and (3) a small area east of lower Omo river near its outlet in Lake Turkana.

Based on later information, we have decided that the lowest lying and driest of these areas should be classified as *Desert and subdesert scrubland*, others, for example areas along Wabi Shebele near the Somali border as *Salt pans, saline/brackish and intermittent wetlands and salt-lake shore vegetation*, and yet other areas, for example along the Omo river, as *Freshwater march / swamp, floodplain and lake shore vegetation*. Yet others, especially small areas with higher ground in the Ogaden, are by us placed under *Acacia-Commiphora woodland and bushland*.

(3) *Steppa arbustata* [Shrub steppe]

PICHI SERMOLLI'S CRITERIA: A type of steppe with open vegetation in which there are widely scattered larger shrubs (up to three or four metres high, often branched from the base or with a short trunk, whole plant often hemispherical or obconical), and occasionally also scattered trees. Often there is a slight tendency to clumping of the woody species. The herbaceous stratum is similar to that of (2) *Steppa graminosa, perenniboscosa e suffruticosa*.

DISTRIBUTION: According to Pichi Sermolli's map the *Steppa arbustata* occurs in Ethiopia only in (1) a few areas in the AF floristic region (between the foothills of the Eastern escarpment and the true *Deserto* (Pichi Sermolli's vegetation type no. 1), and a small area between (2) *Steppa graminosa, perenniboscosa e suffruticosa* and the mountain range in the HA floristic region), and (2) in the Ogaden on the western fringe of (2) *Steppa graminosa, perenniboscosa e suffruticosa*.

We have included these areas in our vegetation type "Desert and subdesert scrubland" and "*Acacia-Commiphora* woodland and bushland". See also our comments to the following vegetation type.

(4) *Fruticeto subdesertico* [Subdesert scrub]

PICHI SERMOLLI'S CRITERIA: This vegetation contains three strata, a tree stratum hardly reaching more than three metres, a layer of shrubs, and a layer of herbs and subshrubs with succulents and bulbous or tuberous plants, all so open that it is easy to walk through. After rains there is an additional, often abundant component of annual herbs, including annual grasses, while perennial grasses are nearly totally absent. This vegetation is often in English literature referred to as "subdesert scrub." The scarcity of trees distinguishes this vegetation from the *Boscaglia xerofila rada*. It is pointed out that species of the genera *Commiphora*, *Acacia*, *Maerua*, *Cadaba*, *Euphorbia*, *Jatropha*, *Sansevieria*, *Aloe*, etc., are common in this vegetation type.

DISTRIBUTION: According to Pichi Sermolli's map the *Fruticeto subdesertico* occurs in Ethiopia only in the AF floristic region, where it surrounds areas with true *Deserto* (Pichi Sermolli's no. 1) and in a small area along the border with Somalia between Juba and Wabi Shebele rivers.

It is our impression that the emphasis given by Pichi Sermolli to physiognomy may be somewhat misleading. The physiognomy is highly dependent upon the concentration of grazing animals, and a floristic analysis would in our opinion give a more reasonable result. However, at the present stage it is not yet possible to make a floristic-phytogeographical analysis of these areas. We have included them in our vegetation types *Desert and subdesert scrubland*, and *Acacia-Commiphora woodland and bushland*.

(5) *Fruticeto subdesertico succulento alberato* [Subdesert trees succulent scrub]

PICHI SERMOLLI'S CRITERIA: This vegetation type is characterised by much-spaced shrubs, with even more scattered trees. The shrubs are about 1-2 metres high, usually solitary or in small clumps. The subshrubs are also usually more or less isolated from each other or occur around the base of the shrubs, and many species are succulent. The trees are 6-7 metres high, and scattered, but not rare, and most are deciduous.

DISTRIBUTION: According to Pichi Sermolli's map the *Fruticeto subdesertico succulento alberato* occurs in Ethiopia only along the periphery of the AF floristic region, both along the Eastern escarpment, along the northern escarpment of the Eastern highlands, and on the slopes of the Danakil Alps.

The same comments on physiognomy and the need for floristic studies as were made for the previous vegetation type apply here. We have included these areas in our *Acacia-Commiphora woodland and bushland*.

(6) *Boscaglia xerofila rada* [Broken xerophilous open woodland]

PICHI SERMOLLI'S CRITERIA: Pichi Sermolli's two types, *Boscaglia xerofila rada* and *Boscaglia xerofila*, are stated to be rather similar to each other. The distinction, where it is possible, can be found only in how dense the tree stratum is, and on certain differences in floristic composition, but not in the general physiognomy of the vegetation. *Boscaglia xerofila rada* is an open type of vegetation, in which it is easy to walk, consisting of many woody plants; the large shrubs are 3-5 metres high and branched from the base, their crowns generally do not touch each other. Scattered trees may be present, but mostly isolated. Between the shrubs there is a stratum of subshrubs and mostly perennial grasses. The density of the herbaceous stratum depends to a high degree on grazing pressure.

DISTRIBUTION: According to Pichi Sermolli's map the *Boscaglia xerofila rada* occurs in Ethiopia in (1) a large part of the Ogaden east of a line from Juba river to near Jijiga, and (2) in the upper, narrow part of Awash valley south-west of the town of Gewane; there is also an indication of tiny zones of this vegetation type around the higher parts of the Danakil Alps.

Again, the same comments on physiognomy and the need for floristic studies as were made for the previous vegetation type apply here. We have included these areas in our broadly defined vegetation type *Acacia-Commiphora woodland and bushland.*

(7) *Boscaglia xerofila* [Xerophilous open woodland]

PICHI SERMOLLI'S CRITERIA: As already mentioned, Pichi Sermolli maintains that the *Boscaglia xerofila rada* and the *Boscaglia xerofila* are rather similar to each other. The distinction, where it is possible, can only be found in how dense the tree stratum is, and on a certain difference in floristic composition, but not in the general physiognomy of the vegetation. In this vegetation the trees form a less open stratum than in the previous vegetation type, but the tree stratum is still far from continuous. There is also a well developed shrub layer and an herbaceous layer. The dominant species belong to the genera *Acacia, Terminalia, Sterculia, Capparis, Dobera, Boswellia,* and *Commiphora.*

DISTRIBUTION: According to Pichi Sermolli's map the *Boscaglia xerofila* occurs in Ethiopia in (1) between the Omo river where it enters Lake Turkana and the southern edge of the highlands, forming a broad zone between the mountains and *Boscaglia xerofila rada*, in (2) a narrow zone along the southern edge of the Awash valley between *Boscaglia xerofila rada* and the highlands, and (3) a broad zone covering most of the Western lowlands in the IL floristic region.

For a number of reasons it is definitely wrong to include the areas along the Awash river and the Western lowlands in the IL floristic region under the same mapping unit. The main reason for considering these two areas different is that the area along the Awash river has rather low biomass and is infrequently burnt, whereas the area in the Western lowlands in the IL floristic region have considerably higher biomass and are usually burnt at least once a year. These differences in fire-regimes lead to structural and floristic differences. Moreover, it is now known that the flora of the upper lowland part of the Awash river is a not particularly rich type of the Somalia-Masai flora, while the areas in the Western lowlands in the IL floristic region have a Sudanian flora (both according to the phytogeographical categories of White 1983). For the areas along the Awash river, the same comments on physiognomy and the need for floristic studies as were made for the previous vegetation type do apply here. We have included these areas in our broadly defined vegetation type *Acacia-Commiphora woodland and bushland*, and we have included large parts of the Western lowlands in the IL floristic region under a separate vegetation type, *Wooded grassland of the western Gambela region*. The rest of the Western lowlands in the IL floristic region will, according to our classification, come under our *Combretum-Terminalia woodland and wooded grassland.*"

(8) *Boscaglia a bambù (Oxytenanthera)* [Bamboo thicket (*Oxytenanthera*)]

PICHI SERMOLLI'S CRITERIA: This is a vegetation type in which the lowland bamboo *(Oxytenanthera abyssinica)* forms dense stands, and it is the totally dominant species. Occasionally it is mixed with a few trees of *Boswellia papyrifera*, *Anogeissus leiocarpa* and various species of *Terminalia*, *Combretum* and *Gardenia*.

DISTRIBUTION: According to Pichi Sermolli's map the *Boscaglia a bambù (Oxytenanthera)* occurs in Ethiopia in a row of elongated patches along the western escarpment of the highlands, stretching from near the Eritrean border to GG.

It would probably have been better for Pichi Sermolli to see this vegetation as part of his *Bosco caducifolio*, a vegetation type which forms the core of our *Combretum-Terminalia woodland and wooded grassland*.

[Pichi Sermolli's vegetation type no. 9 does not occur in Ethiopia.]

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

PICHI SERMOLLI'S CRITERIA: The *Boscaglia e fruticeto sempreverdi montani* consists of dense vegetation of evergreen shrubs, small trees and lianas, with few and scattered tall trees. The shrubs form the main and most dense stratum and are 2-3 metres high, their leaves are mostly sclerophyllous. Deciduous shrubs are found scattered among the evergreen ones. The lianas often have succulent stems. Subshrubs and perennial herbs and grasses form a stratum that barely covers the ground. In several associations of this vegetation type large and tree-formed succulent species of *Euphorbia* are common, and sometimes also large species of *Dracaena*. Species of *Acokanthera, Euclea, Rhamnus, Maytenus, Rhus, Calpurnia, Dodonaea, Grewia, Tarchonanthus* and *Sideroxylon* (for example *S. oxyacanthum and S. mascatense*) are dominant. In this vegetation type there are large candelabra-shaped and succulent species of *Euphorbia*, for example *Euphorbia abyssinica*, etc., and sometimes a transgression of species from the dry montane forest, for example *Olea europaea* subsp. *cuspidata* and *Barbeya oleoides*, species of *Ficus* and even *Juniperus procera*. In dryer aspects there may be species of *Acacia, Grewia* and *Maytenus*. In the lower stratum there are frequently succulents, for example species of *Aloe*, *Kleinia*, *Sansevieria*, etc. Species of Acanthaceae and semi-succulent Lamiaceae may occur in this vegetation type.

DISTRIBUTION: According to Pichi Sermolli's map the *Boscaglia e fruticeto sempreverdi montani* occurs in Ethiopia in a fringe around, and in the lower part of, the highlands; this zone is wide in south-western Ethiopia and around the upper reach of Tekeze valley. The zone is narrow along the Eastern escarpment (also in the Rift Valley). The zone is also wide on the western and southern side of the eastern highlands (bordering on the *Boscaglia xerofila* (no. 7) and the *Savanna (vari tipi)* (no. 11)), and is narrow again on the northern side of the Eastern highlands towards the Awash Valley. There is also a tiny patch of this vegetation on the highest peak of the Danakil Alps. Pichi Sermolli distinguished two subtypes, "fruticeto" and "boscaglia," the latter having a denser stratum of shrubs, but the difference is not specified further.

The recognition of this vegetation as a separate mapable type has survived until recently, for example in Sebsebe Demissew *et al.* (1996) and CSE (1997), as represented in Sebsebe Demissew *et al.* (2004). As discussed later, we find it impossible to map this vegetation with the methods used here, and we have therefore included it under the open subtypes of the "*Dry evergreen Afromontane forest and grassland complex*."

(11) *Savanna (vari tipi)* [Savanna (various types)]

PICHI SERMOLLI'S CRITERIA: Pichi Sermolli uses this composite mapping unit, the *Savanna (vari tipi)*, for all sorts of wooded grasslands, using the term in a purely physiognomic way: vegetation with scattered trees and a grass stratum. Pichi Sermolli admits that this mapping unit may include many aspects, depending on the density of the trees (various types of *savanna alberata*, tree savanna) and the presence of a shrub layer (*Savanna arbustata*, savanna with shrubs), and the shrubs in this layer may also be denser or more scattered. Pichi Sermolli gives no further documentation of the *Savanna (vari tipi)*.

DISTRIBUTION: According to Pichi Sermolli's map the *Savanna (vari tipi)* occurs in Ethiopia in two major regions and in a number of small areas scattered elsewhere. The two major areas are (1) a broad zone through the Southern lowlands of GG to near Dolo Odo on the Somali border, and (2) a belt along the border with Sudan from near Humera to the northern edge of the Western lowlands in the IL floristic region; the isolated patches occur further upland in the KF and IL floristic regions and fringes on the Montane moist evergreen forest (no. 17). This is a "dustbin" mapping unit into which all sorts of vegetation types have been placed.

As mentioned above, the western variant of this vegetation type is a Sudanian wooded grassland, and we have included that under *Combretum-Terminalia woodlands and wooded grasslands*, whereas the southern variant has been included under our *Acacia-Commiphora woodland and bushland*.

(12) *Savanna montana* [Montane savanna]

PICHI SERMOLLI'S CRITERIA: Pichi Sermolli characterises the *Savanna montana* basically as high altitude grassland with many grazing animals [*pascolo d'altipiano*]. The grass stratum is low, 30-80 cm high, and the vegetation appears almost like a meadow. Mixed with the grasses are many bulbous and tuberous herbs, or herbs with long rhizomes, particularly Cyperaceae. A tree and a shrub stratum may be present, but the trees and shrubs are not dominant and have "modest" dimensions, so they just interrupt the monotony of the grassland. Larger herbaceous plants may also break this monotony. The vegetation is largely flat or gently undulating. The lower limit of the *Savanna montana* is found at altitudes between 1800 and 2000 metres, the upper limit is between 2600 and 2800 metres altitude, but similar vegetation may be found at higher altitudes, up to approximately 3000 metres altitude, where it transgress into high montane vegetation. Pichi Sermolli considers this vegetation as deeply influenced by man and his grazing animals, and it may long ago have replaced a previous cover of forest or more open woody vegetation [*bosco*]. This is demonstrated by the presence of tree species belonging to forest or more open *bosco* in the middle of the *Savanna montana*. From this vegetation type Pichi Sermolli has recorded species of highland *Acacia*, species of *Maytenus*, *Olea europaea* subsp. *cuspidata [*as *O. africana]*, *Rosa abyssinica*, species of *Echinops* and *Protea*, etc.

DISTRIBUTION: According to Pichi Sermolli's map the *Savanna montana* occurs in Ethiopia in two major regions, (1) along the eastern part of the highlands west of the Rift Valley, towards the south in a narrow line from the Guge highlands to approximately north of Addis Abeba, where the area covered by this vegetation widens out and reaches to the border with Eritrea, and (2) over most of the Eastern highlands.

We have included this variable and largely manmade vegetation as an open subtype of the *Dry evergreen Afromontane forest and grassland complex*.

(13) *Bosco caducifolio* [Deciduous woodland]

PICHI SERMOLLI'S CRITERIA: Pichi Sermolli characterizes the *Bosco caducifolio* as a vegetation type dominated by deciduous, broadleaved trees, mostly 5-12 metres high and forming a clear tree stratum. Below there may be more heterogeneous strata of small trees or shrubs, often 2-3 metres high and mainly deciduous. The ground-cover consists of subshrubs or perennial grasses of heights varying from less than one metre to several metres. The altitudinal range is not indicated, but there is a report of this vegetation in the Tekeze valley at approximately 1000 metres altitude. Among the genera of trees are: *Boswellia, Combretum, Anogeissus, Lonchocarpus, Stereospermum, Gardenia, Balanites, Erythrina, Dombeya*, etc. Pichi Sermolli emphasizes various characteristic features of this vegetation: that all strata in it are deciduous, that the trees flower either when the leaves have fallen or when the new leaves are coming out, and that the soil is dominated by stones and rocks.

Having emphasized these characteristics of the vegetation, it is surprising that Pichi Sermolli does not mention another distinguishing feature which is closely related to the other characteristics: that the vegetation is subject to burning normally at least once a year. When rain comes, the burnt vegetation is highly susceptible to soil erosion, and this is an important reason for the many exposed stones and rocks in this vegetation type.

DISTRIBUTION: According to Pichi Sermolli's map the *Bosco caducifolio* occurs in Ethiopia in a broad fringe along or on the western escarpment of the north-western highlands, but it is does not penetrate the deep river valleys, with the exception of the Tekeze valley. Along the southern part of the western Escarpment it is shown as only reaching the Omo river, but not further to the east.

We have included this vegetation type under *Combretum-Terminalia woodlands and wooded grasslands*, and we include the vegetation in the deep river valleys in the Western highlands in this vegetation type.

[Pichi Sermolli's vegetation type no. 14 does not occur in Ethiopia.]

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

PICHI SERMOLLI'S CRITERIA: Pichi Sermolli defines the *Foresta secca sempreverde montana* as a forest with a clearly defined upper stratum that is neither uniform nor completely closed or very compact. Below there is a more compact stratum of trees of different height; below this rather continuous stratum there is a more open stratum of small trees and shrubs. On the forest floor there is an open layer of subshrubs, herbs and shade-tolerant grasses. This forest may develop in areas with fairly constant humidity (1100-1300 millimetres rain/year) and with a clearly marked dry season. This forest is only found on fairly deep soil.

DISTRIBUTION: According to Pichi Sermolli's map *Foresta secca sempreverde montana* occurs in Ethiopia in many patches, mainly inside his *Boscaglia e fruticeto sempreverdi montani* (his map unit no. 10) and his *Savanna montana* (his map unit no. 12), from west of Yabelo to the border with Eritrea; the south-westernmost patch is in the SU floristic region, all forests east of the Rift Valley are shown as being of this type; the patches seem largely to correspond to forest that existed before or when the map was prepared.

There are five subtypes according to Pichi Sermolli, but these are not mapping units:

1. Forest with *Mimusops kummel* around Lake Tana.
2. Forest with *Podocarpus falcatus [*as *Podocarpus gracilior]*, widespread in southern part of the highlands: *Podocarpus* is often mixed with *Juniperus*, but makes up at least 60% of the tree stratum. Other genera of forest trees are *Prunus, Ekebergia* and *Olea* (other species than *O. europaea* subsp. *cuspidata*),
3. Forest with *Juniperus procera*, with top of canopy at a height of 30-50 metres, mainly in the eastern and southern part of the highlands, in these dryer areas pure *Juniperus* forest replaces the mixed *Podocarpus-Juniperus* forests. In an intermediate stratum with trees 10-20 metres high there are *Apodytes, Olea europaea* subsp. *cuspidata [*as *O. africana], Pittosporum, Prunus, Hagenia*, etc. In the shrub stratum there are species of *Grewia, Maytenus, Hypericum, Euclea, Rhus, Pistacia, Sideroxylon, Dodonaea*, etc. In Borena [Berana] in the SD floristic region there are exceptionally dry types of *Juniperus* forest with *Pistacia, Acokanthera, Olea europaea* subsp. *cuspidata [*as *O. africana], Barbeya oleoides, Catha*, species of *Euclea, Heteromorpha, Dodonaea*, etc.
4. Forest with mixture of *Juniperus* and *Podocarpus* in the SU, HA and SD floristic regions, said to occur below the pure *Juniperus* forest. This is not particularly different from subtype 2 and 3.
5. Forest of *Acacia abyssinica*, found for example in the region around Lake Tana and north of the town of Gonder at altitudes between 1800 and 2300 metres: The tree stratum, manly consisting of *Acacia abyssinica*, is 10-12 metres high, and forms a closed layer, but light can easily penetrate and there is therefore much undergrowth.

These vegetations are, by us, mainly included as subtypes of "*Dry evergreen Afromontane forest and grassland complex*."

[Pichi Sermolli's vegetation type no. 16 does not occur in Ethiopia.]

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

PICHI SERMOLLI'S CRITERIA: Pichi Sermolli also defines *Foresta umida sempreverde montana* as a forest with several strata. The canopy is closed or somewhat open, and the highest trees are 30-50 metres high. If the upper stratum is somewhat open, there is often a closed stratum with trees 18-25 metres high. Light does not penetrate the upper strata well and the vegetation in the lower strata is therefore scarce, only an open layer of small trees and shrubs that reach a height of 7-8 metres. The ground-cover is fairly rich in species of subshrubs and herbs depending on the density of the strata above. Epiphytes and lianas are abundant. This forest type occurs in the south-western part of Ethiopia at altitudes between 1200 and 2300 metres.

DISTRIBUTION: According to Pichi Sermolli's map the *Foresta umida sempreverde montana* occurs in Ethiopia in a number of patches in the KF, IL and WG floristic regions; these patches seem to correspond to forest that existed before or when the map was prepared. By us this vegetation is mainly included as subtypes of "Moist Evergreen Afromontane forest."

(18) *Foresta a bambù (Arundinaria)* [Bamboo forest (*Arundinaria*)]

PICHI SERMOLLI'S CRITERIA: Pichi Sermolli defines the *Foresta a bambù (*Arundinaria*)* as a forest completely dominated by the mountain bamboo, *Arundinaria alpina* with stems 16-18 metres high. The stem-density is high (c. 10,000-20,000 stems/ha), but a diffuse light can penetrate to the ground. There is therefore a ground-cover of shade-tolerant herbs, including ferns, and a few subshrubs. Lianas and epiphytes, particularly ferns, are also present. Scattered shrubs and a few trees are also found.

DISTRIBUTION: According to Pichi Sermolli's map the *Foresta a bambù* (Arundinaria) occurs in Ethiopia in a number of patches in the WG, IL, KF, AR and BA floristic regions, usually in association with either his *Foresta secca sempreverde montana* (his mapping unit no. 15), or his *Foresta umida sempreverde montana* (his mapping unit no. 17).

By us this vegetation type is mainly included as subtypes of "*Dry evergreen Afromontane forest and grassland complex*" or "*Moist evergreen Afromontane forest.*"

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

PICHI SERMOLLI'S CRITERIA: Pichi Sermolli stated that the *Fruticeto e steppa altimontani* is a mosaic of vegetation types on the highest mountains in Ethiopia, including the Semien massif (Ras Dejen, by Pichi Sermolli called Ras Degièn, quoted altitude 4620 metres), the Lasta mountains (Abune Yosef, by Pichi Sermolli called Abuna Josef, quoted altitude 4194 metres), the Guna massif (including according to Pichi Sermolli Mt. Guna, quoted altitude 4251 metres, and what could be called the Amba Farit massif [called Mt. Collo by Pichi Sermolli], quoted altitude 4300 metres), the Choke massif [called Ciocchè by Pichi Sermolli] (highest peak called Ras Birhan according to Pichi Sermolli, quoted altitude 4154 metres), Mt. Guge [called Gughè by Pichi Sermolli], quoted altitude 4200 metres), and the chain of mountains with Chilalo [called *Monte* Cillalo by Pichi Sermolli] and *Monte* Galama (with *Monte* Badda, quoted altitude 4133 metres; *Monte* Chilalo, quoted altitude 4127 metres; and *Monte* Encuolo, quoted altitude 4340 metres). Pichi Sermolli further mentions this vegetation type from a number of lower mountains in SU floristic region Wechecha, the peaks of which Pichi Sermolli refers to as Monte Uociacià [Wechecha] and Monte Menagaccià, the peak on which Menagesha forest is located. In the HA floristic region Pichi Sermolli lists Monte Kondudo and Gara Mulata [Gara Muleta] as having Ericaceous bushland. Kondudo is a flat-topped mountain, an *amba*, near the town of Harar; its altitude is approximately 2960 metres, and according to the information available to the authors it has a form of (Subtype 5c) *Afromontane woodland, wooded grassland and grassland* (DAF/WG) on its flat summit. Therefore, unlike Gara Muleta, Kondudo is not marked with the signature for (8) *Ericaceous belt* (EB) in this atlas.

Pichi Sermolli makes special mentioning of the vegetation on *Monte* Jesus Tabor [now Eyesus Tabor], quoted to reach an altitude of approximately 3000 metres and located east of the town of Debra Tabor in the GD floristic region. The vegetation is described as bushland floristically most closely related to (Subtype 5c) *Afromontane woodland, wooded grassland and grassland* (DAF/WG), but with some *Erica arborea*. Jesus Tabor mountain is not specifically marked with the signature for (8) *Ericaceous belt* (EB) in this atlas.

It should be noted here that the Bale mountains and the Sanetti plateau (the most extensive area at heights above approximately 4000 metres in Ethiopia, and indeed in the whole of tropical Africa), are not mentioned by Pichi Sermolli; these high montane areas, with an area of more then 20 x 18 kilometres at altitudes above 4000 metres, were only made generally known on maps later, after the first botanical records were made by Mooney (1963) on two journeys by pack animals across the mountains in 1958 and 1959-60. The altimontane scrub and the altimontane steppe are rather different, but form a mosaic and cannot be mapped independently, mainly because of their limited extension.

Altimontane scrub is found from the Semien in the north to Mt. Gughè [Guge] and Mt. Delo in the south. The vegetation is dominated by large shrubs 2-3.5 metres high; sometimes the shrubs may form a short trunk and a globular crown, and can thus be termed trees, which may reach a height of 5-6 metres. However, most of the species in this vegetation can exist in both growth forms and may, near the upper limit, even appear as shrubs 60-80 cm high. Between the shrubs there are smaller shrubs, herbs or short grass. The altimontane steppe is found at slightly higher altitudes than the altimontane scrub; it is found on the slightly fewer mountains that reach above altitudes at 2800 to 3000 metres, and it forms transition to the following vegetation type, the Afroalpine formations [*Formazioni afroalpine*]. On the Semien mountains the dominant species is *Erica arborea*, which has its upper limit between 3300 and 3700 metres altitude, above which the vegetation passes though an intermediate zone for 200-400 metres, dominated by dwarf forms of the same shrubs as below, into altimontane steppe. In the lower zone the altimontane scrub in the Semien mountains occur *Hypericum revolutum* and *Rosa abyssinica*, at slightly higher altitudes *Erica arborea* becomes dominant, mixed with *Hypericum revolutum*, etc. In the transition zone to the steppe *Lobelia rhynchopetalum* is common. In the SU floristic region *Helichrysum horridum* may be common in this vegetation. Pichi Sermolli mentions no characteristic genera or species from the altimontane steppe.

DISTRIBUTION: According to Pichi Sermolli's map the "Altimontane scrub and steppe [Fruticeto e steppa altimontani]" occurs in Ethiopia in patchy areas around the Afroalpine formations (no. 20), but apparently also on Mt. Delo in the Amaro and Bale mountains

This is almost the same vegetation as our "*Ericaceous belt.*"

(20) *Formazioni afroalpine* [Afroalpine formations]

PICHI SERMOLLI'S CRITERIA: Pichi Sermolli records the *Formazioni afroalpine* from the *Massiccio del* Semien, the *Massiccio del* Lasta, *Monte* Guna, *Monte* Collo [which is Amba Farit mountain], the *Massiccio del* Ciocchè [Choke mountains], the *Monti* Cillalo [Chilalo mountains] and *Monti* Galamo [Galama] and the *Monti* Gughe [Guge mountains] mentioned under (19) *Fruticeto e steppa altimontani*. He points out that parts of the afroalpine flora may also be found on the mountains higher than at altitudes between 3500 and 4000 metres, but these have not been recorded. Afroalpine vegetation is characterised by the giant lobelia, *Lobelia rhynchopetalum*, either growing in afroalpine grassland or together with a number of small shrubs of the genus *Helichrysum*. Other physiognomic types in the afroalpine formations are rocky scree vegetation almost completely dominated by subshrubs or herbs, vegetation on steep rocky slopes, and *Carex* swamps dominated by Cyperaceae and grasses.Pichi Sermolli points out that an important subtype of the Afroalpine formations is the altimontane steppe with *Lobelia rhynchopetalum* (lower limit at altitudes between 3800 and 4000 metres): Between the tall specimens of *Lobelia* is a low vegetation of species of the grass genera *Agrostis, Koeleria, Pentaschistes, Agrostis, Poa, Festuca, Bromus*, etc. Several species of *Carex* also occur. Small shrubs or herbs of the genus *Alchemilla* is common in places, together with species of *Thymus, Cerastium, Trifolium, Satureja, Wahlenbergia, Lobelia, Sagina, Senecio, Luzula*, etc. Above altitudes between 4300 and 4350 metres the altimontane steppe with *Lobelia* changes gradually into one the following formations (not mapped by Pichi Sermolli):

(1) Rocky scree which, according to Pichi Sermolli, is found near the top of *Monte* Ras Degièn [Ras Dejen]. Among the stones are the following low plants, all subshrubs or herbs: species of *Helichrysum, Oreophytum, Arabis, Ranunculus, Satureja, Cineraria, Carduus, Festuca, Anthemis, Cotula, Poa, Conyza, Sagina, Trifolium, Senecio, Swertia, Anthemis*, etc.

(2) Vegetation on steep rocky slopes, with many rosette-plants like *Afrovivella, Carduus, Arabis*, etc.

(3) *Carex* swamps that are dominated by *Carex monostachya*. Other genera in these swamps are *Saxifraga, Limosella, Ranunculus, Veronica, Deschampsia*, etc.

DISTRIBUTION: According to Pichi Sermolli's map "Afroalpine formations [Formazioni afroalpine]" occurs in Ethiopia on the highest peaks of the Semien mountains, the peaks of *Monte* Abune Yosef [Abuna Josef, *Monte* Guna, *Monte* Amba Farit, and the *Massiccio del* Ciocchè [Choke mountains], with Ras Birhan as the highest peak, quoted to reach an altitude of 4154 metres, on various mountain peaks in the SU, AR and HA floristic region near Harar (presumably Mt. Gara Muleta, which is only 3380 m, but the only possible mountain in that part of Ethiopia that could qualify as anything near Afroalpine), and in the Gughe highlands in GG, but not the Bale mountains, which were not shown on maps of Ethiopia until after ca. 1960.

This is almost the same range of vegetation types as found in our "*Afroalpine belt* (AA)."

(23) *Formazioni riparie* [Riparian formations]

PICHI SERMOLLI'S CRITERIA: According to Pichi Sermolli the *Formazioni riparie* are the highly varied vegetation types that occur along rivers and temporary or permanent streams. Only riparian vegetation along the major rivers and wadis has been marked on his map.

DISTRIBUTION: According to Pichi Sermolli's map the *Formazioni riparie* occur in Ethiopia along almost all the larger rivers, from Tekeze in the north to Wabi Shebele and Omo rivers in the south.

Species mentioned from Ethiopia: [Only trees, shrubs or lianas are cited]: From along the Awash river species of *Maytenus, Acacia, Tamarix, Balanites, Combretum, Capparis, Cadaba, Salvadora, Triaspis*, etc. In Berana in the SD floristic region: *Tamarindus, Tamarix, Dobera, Mimusops, Carissa*, etc. Along the Wabi Shebele: *Commiphora, Croton, Pistacia, Maytenus, Phoenix, Acacia, Tamarindus, Kigelia, Moringa, Cordia*, etc. Along the streams in the highlands the following genera of trees and lianas have been recorded according to Pichi Sermolli: *Ficus, Tamarindus, Syzygium, Acacia, Salix, Tamarix, Trichilia, Kigelia, Cordia, Diospyros, Vernonia*, etc. Along the small rivers leading to Lake Tana the following genera of trees and shrubs have been observed: *Syzygium and Ficus*. Along the Abay [Blue Nile] river the following have been observed: *Syzygium, Phoenix, Apodytes, Pittosporum, Millettia, Mimusops, Ficus, Maytenus, Cassia, Euclea*, etc. From the shores of Lake Tana a number of plant associations have been recorded, including forests with *Mimusops, Millettia, Phoenix, Syzygium*, etc. The vegetation dominated by Cyperaceae from Lake Tana and the Rift Valley has not been cited here.

This vegetation is largely equivalent to our "riverine forest," but the genera listed by Pichi Sermolli are highly varied, and some of them are not at all characteristic of riparian vegetation or riverine forest in our experience. However, our map will undoubtedly, with a more detailed indication of rivers, cover all the vegetation indicated as "Riparian formation" on Pichi Sermolli's map.

(24) *Formazioni palustri* [Swamp formations]

PICHI SERMOLLI'S CRITERIA: The *Formazioni palustri* include permanent swamps or swamps that partly dry out during the dry season. The fresh-water swamp vegetation contains mainly Cyperaceae and grasses and other herbaceous plants. Pichi Sermolli also included swamps with salty water in this vegetation type, Most swamps are too small to be shown on maps; only the saline swamps along the shores of Lake Abe Abé in the AF floristic region on the border with Djibouti, the swamps along the salt lakes in the northern part of the Afar Depression and the saline swamp at Stefania [Lake Chew Bahir] are shown on the map. Pichi Sermolli cites a number of characteristic species from his swamp formations, of which only some of the trees and large herbs are cited here: *Aeschynomene elaphroxylum*, species of *Tamarix* and *Phoenix*, several species of *Sesbania, Phragmites, Typha, Cyperus*, etc., incl. *Cyperus papyrus*.

DISTRIBUTION: As indicated in the above text.

On our map we have distinguished between fresh-water swamps and salt-water swamps. Among the fresh-water swamps on the new vegetation map are large areas not indicated as swamps on Pichi Sermolli's map, for example swamps along the upper reach of the Awash river, swamps along the upper reach of the Dabus river in the western WG floristic region, swamps around and south of Lake Tana, as well as temporarily flooded river plains along the lower Omo river, etc. Among the salt swamps we have included are numerous larger or smaller salt pans and other saline habitats in the AF floristic region, along the Wabi Shebele and Lake Chew Bahir, etc.

APPENDIX 2
The vegetation types of Ethiopia according to White (1983)

The following provides a detailed comparison between the vegetation types of Ethiopia according to White (1983), compared with the system of Pichi Sermolli (1957) and the present system. Precise comparisons are part of the goals of the VECEA project.

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

This mapping unit represents a highly complex system of physiognomically defined subtypes: *Afromontane forest* (including *Afromontane rain forest*, *Undifferentiated Afromontane forest*, *Single-dominant Afromontane forest* [with *Juniperus procera forest* and *Hagenia abyssinica forest*], and *Dry transitional montane forest*), *Afromontane bamboo*, a part of *Afromontane evergreen bushland and thicket*, a part of *Afromontane and Afroalpine shrubland*, and a part of *Afromontane and Afroalpine grassland*.

WHITE'S CRITERIA: There are few general criteria for White's broadly defined mapping unit *Undifferentiated montane vegetation (A) Afromontane*, except that the Afromontane plant communities in most areas near the Equator occur at altitudes above approximately 2000 metres, but in moist (oceanic) climate considerably lower, in places as low as approximately 1200 metres altitude. The physiognomically defined subtypes range from forest to grassland, with some intermediate vegetation types dominated by evergreen shrubs.

A forest is, according to White, a continuous stand of trees with a canopy that varies in height from 10 to 50 metres or more. The crowns of individual trees interdigitate or overlap each other and are often interlaced with lianas. A shrub layer is usually present. The range from *Afromontane rainforest* to *Dry transitional montane forest* is based on decreasing precipitation through the types. The vegetation dominated by Afromontane bamboo (*Arundinaria alpina*) has been defined both as a forest and as a thicket, and White does not indicate a preference, but keeps it as a separate subtype.

Bushland and thicket is, according to White, land of which 40 per cent or more is covered by shrubs or bushes. A bush is, for this purpose, defined as a woody plant intermediate in habit between a tree and a shrub and usually between 3 and 7 metres high. Bushy trees are often present in bushland. Taller trees may also occur as emergents, but are widely scattered or clumped. The ground-cover is physiognomically subordinate in bushlands. White's physiognomically defined subtypes *Afromontane evergreen bushland and thicket* and *Afromontane and Afroalpine shrubland* span the border between the *Afromontane* (mapping unit 19a) and the *Afroalpine* (mapping unit 65).

Grassland is, according to White, land covered with grass and other herbs, with the former physiognomically dominant. Grassland may be devoid of woody plants, but pure grasslands are rare or occur in mosaic with other vegetation; communities with a woody cover of 10 – 40 per cent are classified as wooded grasslands. White's physiognomically defined subtype *Afromontane and Afroalpine grassland* spans the border between the *Afromontane* (mapping unit 19a) and the *Afroalpine* (mapping unit 65). In White (1983) there is no mentioning or treatment of Afromontane wooded grassland, a vegetation type that Pichi Sermolli (1957) had recognised and termed *Montane savanna [Savanna montana]* and characterised, for example, by a number of endemic species of highland *Acacia*.

DISTRIBUTION IN ETHIOPIA: Although not specifically stated, it seems from the map that White has included all areas in Ethiopia above an altitude of approximately 1800 metres in his vegetation type *Undifferentiated montane vegetation. (A) Afromontane*. This is confirmed by the way he has treated the vegetation in the Rift Valley, where the Rift Valley lakes, with water levels at altitudes somewhere between 1200 and 1600 metres, are close to the lower limit of White's Afromontane undifferentiated vegetation. The same observation can be made from the western border of the vegetation as indicated on White's map. However, on White's map, Lake Tana, which has a water level at altitudes of approximately 1850 metres, is entirely surrounded by vegetation (*Undifferentiated woodland (B) Ethiopian*) that is otherwise characteristic of lower altitudes in western Ethiopia.

According to the text, White's *Afromontane rain forest* occurs at altitudes between 1200 and 2500 metres, but the limits vary greatly, and the rainfall is between 1250 and 2500 millimetres/year. On White's map the presence of *Afromontane rain forest* is indicated by the letter "M" in the areas west of the town of Jima in the KF floristic region, in adjacent parts of the IL floristic region, and in the SD floristic region on the mountains east of Lake Chamo. – In physiognomy and floristic composition White's Afromontane rain forest is almost equivalent with our main type *Moist Afromontane forest*, with the subtype: *Primary or mature secondary moist evergreen Afromontane forest*, and another subtype: *Edges of moist evergreen Afromontane forest, bushland, woodland and wooded grassland*.

The low-altitude western forests in the floristic regions WG, IL and KF, which we call *Transitional rain forest*, were not known to White (1983); see further below under the discussion of White's (17) *Cultivation and secondary grassland replacing upland and montane forest in Africa*.

White's subtype *Undifferentiated Afromontane forest* is said to replace his *Afromontane rain forest* at higher altitudes, and in slightly drier habitats at the same altitudes. Species of the conifer genus *Podocarpus* are usually important components. Inside the area of Ethiopia indicated as White's Afromontane undifferentiated vegetation there is no particular area stated to represent the *Undifferentiated Afromontane forest*. Physiognomically and floristically the *Undifferentiated Afromontane forest* is almost equivalent with our main type *Dry evergreen Afromontane forest and grassland Complex*, and our subtype *Undifferentiated Afromontane forest*.

White's subtype *Single-dominant Afromontane forest* is either characterised by *Juniperus procera* or *Hagenia abyssinica* being dominant. The *Juniperus* forest occurs in drier sites than White's *Undifferentiated Afromontane forest*, while *Hagenia* forest occurs at higher altitudes towards the upper limit of closed forest. Only areas with *Juniperus procera* are indicated on White's map inside the border of Ethiopia, where they are marked with the letter "J"; *Juniperus procera* forest is indicated to occur along almost the entire length of the Eastern escarpment of the plateau above the AF floristic region, in some isolated central parts of the central plateau itself, and in a few places in the southern range of the plateau east of the Rift Valley. Physiognomically and floristically the *Single-dominant Afromontane forest* is almost equivalent with our *Dry single-dominant Afromontane forest of the Ethiopian highlands*.

White's subtype *Dry transitional montane forest* represents a special subtype on the border between the Afromontane areas and the *Acacia-Commiphora* woodland or bushland of the South-eastern lowlands. On White's map there is no area inside Ethiopia that has been assigned to this vegetation type, and the floristic composition for areas so designated by White in Kenya shows only limited similarity with forested areas in the transition between dry Afromontane forest and *Acacia-Commiphora* woodland or bushland in Ethiopia. Nevertheless, because of similarities in phytogeographical position and physiognomy, we are convinced that White's *Dry transitional montane forest* is almost equivalent with our *Transition between Afromontane vegetation and Acacia-Commiphora bushland on the Eastern escarpment*.

White's *Afromontane bamboo* occurs in East Africa between 1630 and 3200 metres, but is mostly found above 2380 metres; there is no indication of range in Ethiopia. The vegetation is completely dominated by the mountain bamboo *Arundinaria alpina*. On White's map there is no indication of where this vegetation occurs inside Ethiopia. Stands of *Arundinaria alpina* do not represent a permanent vegetation type, and they may die back completely after flowering, and the area will then be invaded by trees and shrubs of the surrounding vegetation. We have therefore decided to place White's *Afromontane bamboo* as a form of *Dry single-dominant Afromontane forest of the Ethiopian highlands*.

Within his *Undifferentiated montane vegetation (A) Afromontane*, White has also listed non-forest vegetation types, *Afromontane evergreen bushland and thicket*, *Afromontane and Afroalpine shrubland*, and *Afromontane and Afroalpine grassland*. As mentioned above, inside Ethiopia these are divided between mapping unit 19A, which we deal with here, and mapping unit 66, which is dealt with later. Concerning White's "Afromontane Parts" of these vegetation types there is only limited floristic information given by him, except that shrubs of the family Ericaceae form an important part of the two first types, and that grasses of the genera *Themeda, Exotheca, Andropogon, Brachiaria, Digitaria, Hyparrhenia, Pennisetum* and *Setaria* dominate the typical Afromontane part of the grasslands. On White's map there is no indication of where these vegetation types occur within the *Undifferentiated montane vegetation (A) Afromontane* of Ethiopia. We consider these vegetation types an important part of our subtype *Edges of moist evergreen Afromontane forest, bushland, woodland and wooded grassland*; see also below, where we discuss White's (38) *Evergreen and semi-evergreen bushland and thicket*.

In connection with the discussion of these high altitude communities and White's "Mixed Afroalpine communities" it is mentioned that those with specialist knowledge regard the flora and vegetation of the highest East African peaks as sufficiently distinct to justify the recognition of a separate phytogeographical Afroalpine region, and that one of those scientists, O. Hedberg, extended this unit to include the higher peaks of Ethiopia. But there is no further discussion of this in White's text, and such areas are mapped under his unit (65) *Altimontane vegetation*, which is here dealt with separately below.

The area covered by White's mapping unit no. 19a does not agree well with any of Pichi Sermolli's mapping units. Digitalised versions of the two maps show that White's mapping unit no. 19a covers a small part of Pichi Sermolli's mapping unit (7) *Boscaglia xerofila*, a large part of his (10) *Boscaglia e fruticeto sempreverdi montani*, parts of his (11) *Savanna (vari tipi)*, almost the entire of his (12) *Savanna montana*, a small part of his (13) *Bosco caducifolio*, nearly all of his (15) *Foresta secca sempreverde montana*, nearly all of his (17) *Foresta umida sempreverde montana* and also of his (18) *Foresta a bambù (Arundinaria)*, parts of his (19) *Fruticeto e steppa altimontani* and a small part of his (20) *Formazioni afroalpine*.

We have largely subdivided this vegetation type of White's into "Dry Afromontane evergreen forest and grassland complex" and "Moist Afromontane evergreen forest."

(29b) *Undifferentiated [Sudanian] woodland (B) Ethiopian*

WHITE'S CRITERIA: White defines woodland as open stands of trees, the crowns of which form a canopy from 8 to 20 metres or more in height and with a cover of at least 40 per cent of the surface. Crowns of adjacent trees are often in contact but are not densely interlocking. A ground-cover may consist of grass or other herbs or dwarf shrubs. The Sudanian woodlands consist of a mainly deciduous tree stratum with a rather open canopy, and dense herbaceous undergrowth or various floristically related types with a more open canopy. The particular Ethiopian type almost completely lacks the caesalpiniaceous trees, mainly species of the genus *Isoberlinia*, that are characteristic of the Sudanian woodlands to the west of the Nile Valley, and it contains a few endemic species of *Combretum* (for example *C. hartmannianum*).

DISTRIBUTION IN ETHIOPIA: According to White's map these woodlands occur along the Western escarpment and in the Western lowlands from the extreme north to the Omo river Valley in the south, and sometimes entering the western slope of the Rift Valley. White has classified the extensive wooded grasslands and grasslands in the western IL floristic region as (35) *Transition from undifferentiated woodland to Acacia deciduous bushland and wooded grassland (B) Ethiopian type* and (61) *Edaphic grassland of the Upper Nile basin*. These will be dealt with below, in a discussion concerning problems with some vegetation types along the border between Sudan and Ethiopia where we, contrary to White's views, do not accept that certain vegetation types characteristic of the Sudanian lowlands occur in Ethiopia. Digitalised versions of the maps by Pichi Sermolli and White show that White's mapping unit no. 29b largely agrees with a combination of Pichi Sermolli's (13) *Bosco caducifolio* and (8) *Boscaglia a bambù (Oxytenanthera)*, but also covers small parts of several of Pichi Sermolli's other mapping units, including (3) *Steppa arbustata* and (7) *Boscaglia xerofila*, parts of (10) *Boscaglia e fruticeto sempreverdi montani* and (11) *Savanna (vari tipi)*, as well as small parts of (15) *Foresta secca sempreverde montana*, (17) *Foresta umida sempreverde montana*, and (23) *Formazioni riparie*.

This vegetation type is almost equivalent with our *Combretum-Terminalia woodland and wooded grassland*, apart from the western parts of the IL floristic region.

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

WHITE'S CRITERIA: According to White this vegetation occurs mainly below an altitude of 900 metres; it is dominated by deciduous bushland which occasionally may contain scattered trees, patches of semi-evergreen or evergreen bushland or thicket on the lower slopes of mountains. Characteristically, the vegetation is a dense to locally impenetrable deciduous bushland with 3-5 metres high shrubs and scattered emergent trees up to 9 metres high. The dominant genera are *Acacia* and *Commiphora,* represented by species that are often spinous, impeding progress by walking, even in more open types except along tracks made by game, cattle or man. The ground-cover contains grasses, often annual species, but succulents and geophytes, sometimes with twining or climbing stems, are more prominent.

DISTRIBUTION IN ETHIOPIA: According to White's map this vegetation occurs in a narrow zone along the western and southern margins of the AF floristic region (where, according to White, it is almost completely replaced by *Semi-desert grassland and shrubland (B) Somalia-Masai*), in the Rift Valley, and westwards to the Omo river Valley. However, its main distribution area is the whole of the South-eastern lowlands to the borders with Somalia and Kenya.

Inside Ethiopia, White's mapping unit no. 42 covers a range of Pichi Sermolli's mapping units that represent lowland bushlands and woodlands, with the exception of the *Combretum-Terminalia* woodland that is part of (2) *Steppa graminosa, perenniboscosa e suffruticosa*, (3) *Steppa arbustata*, (4) *Fruticeto subdesertico*, (5) *Fruticeto subdesertico succulento alberato*, (6) *Boscaglia xerofila rada*, (7) *Boscaglia xerofila*, (10) *Boscaglia e fruticeto sempreverdi montani*, (11) *Savanna (vari tipi)*, (12) *Savanna montana*, (15) *Foresta secca sempreverde montana*, (23) *Formazioni riparie*, and (24) *Formazioni palustri*.

In our view this vegetation, which we refer to as a main type called *Acacia-Commiphora woodland and bushland*, should be split into two subtypes: the *Acacia-Commiphora woodland and bushland proper* and the *Acacia wooded grassland of the Rift Valley*.

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

WHITE'S CRITERIA: Deserts and semi-deserts are, according to White, areas with sparse or very sparse vegetation limited by lack of water as a result of low rainfall and high evaporation throughout the greater part of the year. In places where the rainfall is lower than between 100 and 200 millimetres/year vegetation consisting of deciduous bushland becomes more and more scarce, and the plant-cover gradually changes to semi-desert grassland on sand, and to semi-desert shrubland on stony ground. However, according to White, it is not possible to give an objective criterion for climatic separation of deciduous bushland and semi-desert and desert. A criterion of semi-desert is that the substrate, soil, sand, stones or rocks, are more conspicuous than the vegetation, so that the aspect in general view is dominated by the colour of the substrate, rather than by the plants. White gives no objective upper altitudinal limit of this vegetation either.

DISTRIBUTION IN ETHIOPIA: According to White's map this vegetation occurs in large parts of the AF floristic region and in a narrow marginal zone along the border with Kenya from Lake Turkana to Moyale.

The area covered by White's mapping unit no. 54 does not agree well with any of Pichi Sermolli's mapping units. Inside Ethiopia White's mapping unit covers part of Pichi Sermolli's (1) *Deserto*, part of (2) *Steppa graminosa, perenniboscosa e suffruticosa*, part of (3) *Steppa arbustata*, part of (5) *Fruticeto subdesertico succulento alberato*, part of (6) *Boscaglia xerofila rada*, part of (7) *Boscaglia xerofila*, small parts of (10) *Boscaglia e fruticeto sempreverdi montani,* and of (11) *Savanna (vari tipi)*, and tiny parts of (12) *Savanna montana*, and of (24) *Formazioni palustri*.

We basically agree with White's view that some of the vegetation inside Ethiopia should be classified as desert and semidesert, but the limit between open *Acacia-Commiphora* woodland and bushland and semidesert grassland and shrubland is not easy to draw. While we have largely accepted White's definition of this vegetation type, we think that he has exaggerated the areas covered by this vegetation within Ethiopia. According to us the vegetation type, which we call *Desert and Semi-desert Scrubland*, occurs in smaller parts of the AF floristic region, but in larger areas in southern Ethiopia than according to White.

(65) *Altimontane vegetation in tropical Africa*

WHITE'S CRITERIA: According to White's list of mapping units this major vegetation type includes *Afromontane evergreen bushland and thicket*, *Afromontane and Afroalpine shrubland*, and *Afromontane and Afroalpine grassland*, as well as *Mixed Afroalpine communities*. While the mapping unit is clearly marked on the map and obviously relates to a contour, the criteria that distinguish between the parts of the *Afromontane evergreen bushland and thicket*, *Afromontane and Afroalpine shrubland*, and *Afromontane and Afroalpine grassland* that have been mapped under (19a) *Undifferentiated montane vegetation (A) Afromontane*, and those that have been mapped under (65) *Altimontane vegetation in tropical Africa* is not clear. According to White, the Ericaceous vegetation in the *Ericaceous belt,* defined according to Hedberg (1951), is divided between the two mapping units *Afromontane evergreen bushland and thicket* and *Afromontane and Afroalpine shrubland*. The same applies to the grass-dominated vegetation type *Afromontane and Afroalpine grassland*. White paraphrases Hedberg's definition of Afroalpine vegetation, according to which nearly half of the plant species in *Afroalpine belt* (AA) belong to the following specialised growth forms (Hedberg, 1964a): giant rosette plants (in Ethiopia a rosette-bearing giant species of *Lobelia, L. rhynchopetalum,* up to 6 metres high or more), tussock grasses or sedges with filiform xeromorphic leaves; acaulescent rosette plants (for example the species *Haplosciadium abyssinicum*, *Oreophyton falcatum*, *Haplocarpha rueppellii*, *Dianthoseris schimperi* [= *Crepis dianthoseris*]), cushion plants (a number of species of *Helichrysum*), sclerophyllous shrubs, or dwarf shrubs.

DISTRIBUTION IN ETHIOPIA: According to White's map this covers relatively large areas of the high mountains in the floristic regions WU, GD, GJ, SU, KF, GG, AR, SD and BA.

White's map unit no. 65 covers, inside Ethiopia, a range of Pichi Sermolli's mapping units, some of which represent vegetation at lower altitudes, including a small part of (10) *Boscaglia e fruticeto sempreverdi montani*, and an equally small part of (11) *Savanna (vari tipi)*, small parts of (12) *Savanna montana*, (15) *Foresta secca sempreverde montana*, and (17) *Foresta umida sempreverde montana*, large parts of (18) *Foresta a bambù (Arundinaria)*, and nearly all of (19) *Fruticeto e steppa altimontani*, and of (20) *Formazioni afroalpine*.

We have split this vegetation type into two major high montane vegetation zones: "*Ericaceous belt* (EB)" and "*Afroalpine belt* (AA)," with a number of habitats that cover areas too small to be mapped. We have tried to apply new altitudinal criteria in order to avoid the ambiguity between White's mapping units 19A and 65.

(71) *Regs, hamadas, wadis*

WHITE'S CRITERIA: According to White's list of mapping units the vegetation type is associated with the transition zone between Sahara and Sahel, and should therefore not occur in Ethiopia. According to his memoir the vegetation type covers a range of vegetation types, for example *Tamarix* communities and *Aca-*

cia communities and *Hyphaene* ('Doum') communities along temporary streams (wadis), which do occur in Ethiopia, while the presence of the other two categories is less certain: hamadas are natural stone pavements from which all fine products of weathering have been swept away by the wind, and regs are gravel deserts from which all fine soil or sand has been swept away by the wind.

DISTRIBUTION IN ETHIOPIA: According to the part of White's vegetation map that covers Ethiopia, the category has only been used for an area below sea level in the northern part of the AF floristic region. This is the Dalol or Danakil depression that contains extensive areas with salt lakes and pans.

Within Ethiopia, White's mapping unit no. 71 covers a small part of Pichi Sermolli's (1) *Deserto*, a small part of (2) *Steppa graminosa, perenniboscosa e suffruticosa*, and a part of (3) *Steppa arbustata*.

We have tried to define a range of fresh-water and salt-water swamps, intermittent wetlands and lake shore vegetations to cover this.

White's mapping units with doubtful or marginal occurrence in Ethiopia

Seven of the vegetation types which White has recorded from inside the Ethiopian borders occur, according to his vegetation map, only marginally in Ethiopia or are for other reasons doubtful. White has based most information about the marginal vegetation types in Ethiopia on the carefully prepared vegetation map of Sudan by Harrison and Jackson (1958). Where vegetation types on Harrison and Jackson's map cover a sector of the Sudanian-Ethiopian border, White has assumed an extension of these Sudanese vegetation types into various parts of the Western lowlands.

(17) *Cultivation and secondary grassland replacing upland and montane forest in Africa*

WHITE'S CRITERIA: In the list of mapping units, White gives the following information: "The natural vegetation, which is mostly destroyed, probably originally contained a mixture of Afromontane and lowland species. There is virtually no published information."

DISTRIBUTION IN ETHIOPIA: This mapping unit on White's vegetation map covers an area from the town of Maji in the KF floristic region, in the south, to an area south-west of the town of Gore in the IL floristic region, in the north, and from the westernmost foothills of the Western highlands of the KF and IL floristic regions, in the west, to approximately the town of Mizan Teferi in KF, in the east. There is no topographic feature in Ethiopia matching White's mapping unit no. 17.

The area covered by White's mapping unit no. 17 does not agree well with any of Pichi Sermolli's mapping units. Digitalised versions of the two maps show that White's mapping unit covers part of Pichi Sermolli's (8) *Boscaglia a bambù (Oxytenanthera)*, part of (10) *Boscaglia e fruticeto sempreverdi montani*, part of (11) *Savanna (vari tipi)*, part of (13) *Bosco caducifolio*, and part of (17) *Foresta umida sempreverde montana*.

On recent field trips we have made specific observations across several transects of White's mapping unit (17). While it is true that the forests in this area may be slightly more disturbed by clearing or farming than in the areas immediately to the east, we can see no basic distinction between the area marked as (17) and the areas further east, marked as (19a) *Undifferentiated montane vegetation (A) Afromontane*, which in this case would be represented by the subtypes *Afromontane rain forest*, and we have therefore decided to redefine the area of White's mapping unit no. 17 according to the altitudinal criteria: The lower western parts of the area are placed in our unit *Transitional rain forest*, while the higher eastern parts are referred to the unit *Moist evergreen Afromontane forest*. This follows the mapping criteria described later.

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

WHITE'S CRITERIA: This vegetation occurs on sandy soil in the southern Sahel, where the annual rainfall is between 250 and 500 millimetres/year. The chief woody species is in some areas *Acacia tortilis*; in other areas, where the soil is black cracking clays and rocky hills, *Acacia senegal* is dominant.

DISTRIBUTION IN ETHIOPIA: The mapping unit on White's vegetation map covers only a few square kilometres north-east of Humera in the GD floristic region, where the borders between Sudan, Ethiopia and Eritrea meet.

Inside Ethiopia White's mapping unit no. 43 covers a minute part of Pichi Sermolli's (11) *Savanna (vari tipi)*, and a small part of (23) *Formazioni riparie*.

The tiny area in north-western Ethiopia covered by White's mapping unit no. 43 is marginal to the present extent of Ethiopia. According to the outline of the units indicated on White's map near the border between Sudan and Ethiopia, the indication of vegetation types in this part of Ethiopia is clearly based on extrapolations from the map by Harrison and Jackson (1958). White's mapping unit (43) only enters Ethiopia in the extreme north-eastern part near the border with Eritrea, and only for a few square kilometres. We have visited this area and find that, although the area is flat with either sandy or dark soils and a tree stratum dominated by *Acacia*, it does not seem reasonable to distinguish it from the adjacent extensive (29) *Undifferentiated woodland (B) Ethiopian type*, within which there are many areas on cracking, black-cotton soil dominated by nearly pure stands of various species of *Acacia*, including *A. senegal*.

We have included this apparently small area of open *Acacia* vegetation in our broad vegetation type *Combretum-Terminalia woodland and wooded grassland*.

(62) *Mosaic of edaphic grassland and Acacia wooded grassland*

WHITE'S CRITERIA: In the descriptive memoir, White has placed this mapping unit under his *Grassland and wooded grassland on Pleistocene clays* in the Sudanian regional centre of endemism. The Pleistocene clays of the Nile valley in Sudan are stretched from areas with a rainfall of ca. 400 millimetres/year to areas with close to 1000 millimetres/year, and they do therefore extend into Ethiopia. In the rainy season the dark clays cannot absorb all the rain and there may be extensive flooding; in the dry season the clay shrinks when drying out and may form deep cracks. In areas with frequent flooding edaphic grasslands tend to dominate, while wooded grassland with *Acacia seyal* tends to dominate in better drained places and on more permeable soils. See descriptions and discussions below under mapping unit (35), and (64) that also involve areas with clay soil in western Ethiopia.

DISTRIBUTION IN ETHIOPIA: According to White's vegetation map this marginal case is found adjacent to and just south of the previous area, mapping unit (43). Here, White has indicated another marginal, but somewhat larger area of (62) *Mosaic of edaphic grassland and Acacia wooded grassland*, stretching a few kilometres into Ethiopia along an approximately 30 kilometres long sector of the border. Our observations in this area show that the vegetation in this area consists of a mosaic of rocky outcrops almost devoid of vegetation, areas of *Acacia* wooded grassland on sand and *Acacia* bushland on black cotton soils.

Inside Ethiopia, White's mapping unit no. 62 covers a small part of Pichi Sermolli's (11) *Savanna (vari tipi)*.

Again, it does not seem reasonable in a map of the vegetation of Ethiopia to accept White's vegetation type (65) as an entity distinguished from vegetation type (29) *Undifferentiated woodland (B) Ethiopian type*, and we have included this apparently small area of open *Acacia* vegetation in our broad vegetation type *Combretum-Terminalia woodland and wooded Grassland*. As it appears from our description of that vegetation type, there are locally areas dominated by almost pure stands of *Acacia*.

(35) *Transition from undifferentiated woodland to Acacia deciduous bushland and wooded grassland (B) Ethiopian type* and (61) *Edaphic grassland of the Upper Nile basin*

WHITE'S CRITERIA: White (1983) noted about his mapping unit (35b): "This unit forms the transition from the edaphic grasslands of the Flood Region of the Nile [in the west] to the *Anogeissus-Combretum hartmannianum* woodland … flanking the Ethiopian highlands to the East. *Acacia seyal* and *Balanites aegyptiaca* occur throughout except for patches of thornless woodland dominated by *Combretum hartmannianum, Sterculia setigera, Stereospermum kunthianum* and *Adansonia digitata*." And about his mapping unit (61) he stated that it is a regularly flooded version of his *Grassland and wooded grassland on Pleistocene clays*: "As the flooding increases [with higher rainfall and closer to the main Nile basin] the trees disappear, to be replaced by open grass plains of *Setaria incrassata*, and the conditions of the Flood Region of the Nile are reached. Within the Flood Region, however, areas of slightly higher ground, which are only flooded to a shallow depth, carry typical *Acacia seyal* communities and associated grassland under rainfall of up to 1000 millimetres per year. The transition zone between swamp grassland and the better-drained areas with *Acacia seyal* is sometimes dominated by *Hyphaene thebaica* and *Borassus aethiopum*, singly or together."

DISTRIBUTION IN ETHIOPIA: According to White's vegetation map the extreme western part of the Gambela region (previously lowland part of the IL floristic region) is classified as (61) *Edaphic grassland of the Upper Nile basin*. This area is and has during all the years we have worked with Ethiopian flora and vegetation been inaccessible. However, extensive areas of seasonally flooded grassland occur along the Baro river further to the east, and at slightly higher ground there is *Acacia* wooded grassland also liable to seasonal flooding. Between (61) *Edaphic grassland of the Upper Nile basin* and (29) *Undifferentiated woodland (B) Ethiopian type*, which White has indicated for the areas closer to the Ethiopian escarpment, he has marked a 30-60 kilometres broad zone across the Gambela region from north to south as (35b) *Transition from undifferentiated woodland to Acacia deciduous bushland and wooded grassland (B) Ethiopian type*. Again, this marks an extension into Ethiopia of a vegetation type mapped by Harrison and Jackson (1958) on their vegetation map of Sudan for a nearly 850 kilometres long zone west of and parallel with the Ethiopian border, but mainly outside Ethiopia.

The area covered by White's mapping unit no. 35b does not agree well with any of Pichi Sermolli's mapping units. Inside Ethiopia (35b) *Transition from undifferentiated woodland to Acacia deciduous bushland and wooded grassland (B) Ethiopian type* covers a small part of Pichi Sermolli's (7) *Boscaglia xerofila*, large parts of (11) *Savanna (vari tipi)*, of (13) *Bosco caducifolio*, and a small part of (17) *Foresta umida sempreverde montana*. White's mapping unit (61) is covered by part of Pichi Sermolli's (6) *Boscaglia xerofila rada*.

In the authors' experience the areas in the Gambela region that White has marked as mapping unit no. 35b are not substantially different from the almost treeless and more frequently flooded areas. White pointed out how, in Sudan, the *Acacia* trees gradually get scarcer and scarcer as one moves away from the highlands towards the large swamps of the Flood Region of the Nile. We have also observed this pattern of transition repeated on a small scale in many places in western Ethiopia at quite some distance from the border with Sudan: deciduous *Combretum-Terminalia* woodland with *Anogeissus* and *Stereospermum* on or near rocky outcrops gradually changes to almost treeless grassland through stages with *Acacia seyal* wooded grassland.

Since these plant communities, *Combretum-Terminalia* woodland through *Acacia seyal* wooded grassland to almost treeless grassland, seem to belong closely together in a frequently repeated catena, we have therefore found it more helpful to distinguish between only two vegetation types, on one hand seasonally flooded grasslands with many trees or nearly or completely without trees, which is equivalent with White's combined (35b) *Transition from undifferentiated woodland to Acacia deciduous bushland and wooded grassland (B) Ethiopian type* and (61) *Edaphic grassland of the Upper Nile basin*, and on the other hand his (29) *Undifferentiated woodland (B) Ethiopian type*.

We have divided the non-forested vegetation in the Western lowlands in the IL floristic region into two vegetation types: The moist western *Wooded grassland of western Gambela region* near to the border with Sudan, and "*Combretum-Terminalia* woodland and wooded grassland" closer to the Escarpment of the Ethiopian highlands. And we have to accept that small patches of *Wooded grassland of western Gambela region* do occur in suitable sites inside our *Combretum-Terminalia woodland and wooded grassland*.

(38) *East African evergreen and semi-evergreen bushland and thicket*

WHITE'S CRITERIA: White's information about this unit is quite difficult to summarise. In the list of his mapping units, he has placed the vegetation type in four different phytogeographical regions, of which only two are relevant here: (IV) *The Somalia-Masai regional centre of endemism*, where he writes that this often forms an ecotone between montane forest, especially *Juniperus* forest, and deciduous *Acacia-Commiphora* bushland and thicket. White quoted Ib Friis (pers. com.) for a statement that not all that was mapped by White as unit (38) belonged to that category. According to Friis *et al.* (1982) this was definitely not the case in south-western Ethiopia, where the evergreen bushland is different from that associated with the Eastern escarpment and floristically associated with the forest margins of the moist Afromontane forests (we still agree with that, see further below). About the part of (38) in (IV) *The Somalia-Masai regional centre of endemism* White states the following: "Because of this uncertainty [the one pointed out in the comment by Ib Friis] and for cartographic reasons mapping unit 38 in Ethiopia has been included within the Afromontane Region on the map." About the part of (38) in (VIII) *The Afromontane Region* White states: "This unit often forms the transition between the Somalia-Masai and Afromontane Regions. For cartographic reasons it has been placed partly in the former and partly in the latter. ..."

DISTRIBUTION IN ETHIOPIA: According to White's vegetation map the mapping unit (38) *East African evergreen and semi-evergreen bushland and thicket* covers an extensive area surrounding (19a) *Undifferentiated montane vegetation (A) Afromontane*, which is restricted to the highlands, and this vegetation type is, according to the map, the dominant vegetation in all the large river valleys that have cut into the highlands.

The area covered by White's mapping unit no. 38 does not agree well with any of Pichi Sermolli's mapping units, although there is great overlap with parts of (10) *Boscaglia e fruticeto sempreverdi montani*. White's unit no. 38 also covers a small part of Pichi Sermolli's (5) *Fruticeto subdesertico succulento alberato*, (6) *Boscaglia xerofila rada*, and (7) *Boscaglia xerofila*, small parts of (8) *Boscaglia a bambù (Oxytenanthera)*, smaller parts of (11) *Savanna (vari tipi)*, (12) *Savanna montana*, (13) *Bosco caducifolio*, (15) *Foresta secca sempreverde montana*, (17) *Foresta umida sempreverde montana*, (18) *Foresta a bambù (Arundinaria)*, and small parts of (23) *Formazioni riparie*.

As it is clear from the above, White's vegetation type (38) *East African evergreen and semi-evergreen bushland and thicket* has long been somewhat controversial. Here we have applied the studies of the evergreen bushlands which were largely begun by Friis *et al.* (1982). In these studies it has been proposed that the large areas covered by evergreen scrub in the highlands represented the regrowth of forest. It was also concluded that the evergreen bushland seen in most places represented either a narrow vegetation-zone along forest margins or a seral stage in the regrowth of forest, or a combination of both. This may even apply to the dry evergreen bushlands in eastern Ethiopia with *Acokanthera, Buxus*, etc., which are associated with our *Transition between Afromontane vegetation and Acacia-Commiphora bushland on the Eastern escarpment*.

Therefore the extensive areas of White's (38) *East African evergreen and semi-evergreen bushland and thicket*" in the highlands are split on the following three of our vegetation types:

- In most of the central, eastern and north-eastern parts of the highlands: (5) *Dry evergreen Afromontane forest and grassland Complex* (DAF), especially the following subtypes: (Subtype 5c) *Afromontane woodland, wooded grassland and grassland* (DAF/WG) and (subtype 5d) *Transition between Afromontane vegetation and Acacia-Commiphora bushland on the Eastern escarpment* (DAF/TR).
- In the south-western part of the Western highlands: (6) *Moist evergreen Afromontane forest* (MAF), especially (Subtype 6B) *Edges of moist evergreen Afromontane forest, bushland, woodland and wooded grassland* (MAF/BW).

- In the deep river valleys of the north-western highlands: This vegetation has here been referred White's (38) *East African evergreen and semi-evergreen bushland* and thicket to (4) *Combretum-Terminalia woodland and wooded grassland* (CTW).

(64) *Mosaic of edaphic grassland and semi-aquatic vegetation (II) Sudanian Region*

WHITE'S CRITERIA: Only White's description of this mapping unit in (III) *Sudanian Region* is relevant here. Again the grassland component of the mosaic is basically the same as the ones referred to above as *Grassland and wooded grassland on Pleistocene clays*, but representing the most humid extreme of the range. The semi-aquatic vegetation is represented by south Sudanese swamp vegetation.

DISTRIBUTION IN ETHIOPIA: According to White's vegetation map there is marginal occurrence of *(64) Mosaic of edaphic grassland and semi-aquatic vegetation (II) Sudanian Region* in the extreme south-western Ethiopia, west of the Omo river and just crossing the border with Sudan.

Inside Ethiopia White's mapping unit no. 64 covers a small part of Pichi Sermolli's (7) *Boscaglia xerofila*, and a small part of (11) *Savanna (vari tipi)*.

The small area covered by White's mapping unit no. 64 is virtually inaccessible by vehicles from the Ethiopian side because of lack of roads and bridges, and the situation on the Sudanian side has been highly politically unstable. It has not been possible for any of us to confirm the presence of this mosaic of vegetation types in Ethiopia. Again, White seems to have inferred the presence in Ethiopia of his mapping unit (64) from indications on the vegetation map of Sudan (Harrison and Jackson, 1958).

Our experience of the areas east of the Omo river is that the vegetation here is a transition between or a mosaic of the eastern *Acacia-Commiphora* bushland on sandy or black soils, mainly in flat areas, and the western *Combretum-Terminalia woodland and wooded Grassland*, mainly in areas with rocky outcrops or, in the lowest and hottest places, our *Desert and semidesert scrubland*. The area west of the Omo river indicated by White as (64) *Mosaic of edaphic grassland and semi-aquatic vegetation (II) Sudanian Region* is small, and we have, in the absence of real evidence for the existence of a mosaic, chosen to indicate the whole area below 400 metres as *Desert and Semidesert Scrubland*, the 400 metres contour being our criteria used in the GIS modelling of that vegetation type.

APPENDIX 3

Woody plants in the *Flora of Ethiopia and Eritrea*, assigned to vegetation types

This appendix contains a table of taxa of woody plants in Ethiopia based on the *Flora of Ethiopia and Eritrea*, with indication of the vegetation type from which they have been recorded.

The names used in the *Flora of Ethiopia and Eritrea* are indicated in the left hand column, arranged in the same sequence of families, genera and species as in the Flora. However, additions or corrections published in later volumes of the flora have been applied, as well as a few corrections made on the authority of the specialist knowledge of the present authors. Life forms of the individual taxa is indicated in the second column following the descriptions in the *Flora of Ethiopia and Eritrea.* The altitudinal ranges and the flora provinces, from which the taxa have been recorded, are listed in the third column and follow the indications in the *Flora of Ethiopia and Eritrea,* unless the authors have information that outdates the information in the *Flora.*

The vegetation types from White (1983) listed in column number five are the vegetation types used in the text of the memorandum *The Vegetation of Africa*, not the less specific mapping units applied on the vegetation map. The two classifications do not always correspond (for example Afroalpine vegetation types overlap the border between mapping unit 19a and 65). The vegetation types from Pichi Sermolli (1957) have not been indicated because too many problems were encountered in the exact identification of the plant names cited in the vegetation descriptions in his memoir accompanying the vegetation map.

The distribution of the taxa in the vegetation types or subtypes of this work is indicated in the last column, using the same abbreviations as the ones indicated in the main text. For species that occur in several vegetation types all types have been listed, separated by semicolons. An example is *Gyrocarpus hababensis* that is indicated to occur in "(1) *Desert and semi-desert scrubland* (DSS); (2) *Acacia-Commiphora woodland and bushland* (ACB)," meaning that the species occurs in desert and semi-desert scrubland and in *Acacia-Commiphora* woodland and bushland. For taxa that span several subtypes, the main vegetation type has been indicated only once, and the range of subtypes has been indicated in a string with hyphens. An example is *Juniperus procera* that is indicated to occur in "DAF/U-SD-TR," meaning that the species occurs in the *Dry evergreen Afromontane forest and grassland complex* (DAF), and, within that, in the subtypes Undifferentiated Afromontane forest, the Dry single-dominant Afromontane forest of the Ethiopian highlands, and in the Transition between Afromontane vegetation and *Acacia-Commiphora* bushland on the Eastern escarpment.

This is the first time a large segment of the Ethiopian flora has been classified according to a standardised set of vegetation types, in which they are supposed to occur.

Taxa (families, species, subspecies and varieties)	Life form	Altitudinal range	Distribution on FEE flora regions	Vegetation types of F. White (1983)	Distribution in the vegetation types or subtypes of this work
CYATHEACEAE					
Cyathea manniana	Tree	1300-2200	WG KF IL SD	No information	MAF/P
CUPRESSACEAE					
Juniperus procera	Tree	1100-3500	TU GD WU GJ SU AR HA SD	Juniperus procera forest; Afromontane bamboo; East African evergreen and semi-evergreen bushland and thicket	DAF/U-SD-TR; EB
PODOCARPACEAE					
Podocarpus falcatus	Tree	1350-2900	GD GJ WG SU IL KF GG AR SD BA HA	Undifferentiated Afromontane forest	DAF/U; MAF/P
EPHEDRACEAE					
Ephedra foliata	Shrub or liana	c. 1400	SU	No information	DAF/TR
ANNONACEAE					
Uvaria angolensis	Tree or liana	1400-1700	WG IL KF SD	No information	RV
Uvaria schweinfurthii	Tree or liana	500-550	IL	No information	TRF
Uvaria leptocladon subsp. *septentrionalis*	Tree or shrub	375-1400	KF GG SD	No information	RV
Artabotrys monteiroae	Tree, shrub or liana	1150-1800	KF IL GG SD BA	No information	RV
Xylopia parviflora	Tree	550-650	IL	No information	TRF
Monanthotaxis ferruginea	Tree, shrub or liana	c. 1000	IL	No information	RV
Monanthotaxis parvifolia subsp. *kenyensis*	Tree or shrub	c. 1400	GG SD	No information	RV
Annona senegalensis	Tree or shrub	500-1500	GJ WG IL KF GG BA	No information	CTW
LAURACEAE					
Ocotea kenyensis	Tree	1500-2450	WG IL KF GG SD	Undifferentiated Afromontane forest	MAF/P

RANUNCULACEAE					
Clematis hirsuta var. *hirsuta*	Liana	850-3200	TU GD GJ WU SU AR IL KF SD BA HA	No information	DAF/U-SD; MAF/BW; EB
Clematis hirsuta var. *dolichopoda*	Liana	2400-?	TU GD AR HA	No information	DAF/U
Clematis simensis	Liana	1500-3350	TU GD GJ WU SU AR WG KF GG SD BA HA	No information	DAF/U-SD; MAF/BW; EB
HERNANDIACEAE					
Gyrocarpus americanus subsp. *africanus*	Tree	c. 1500	EW	No information	?
Gyrocarpus hababensis	Tree	330-1150	AF GG SD HA	No information	DSS; ACB
Gyrocarpus angustifolius	Tree	550-750	HA	No information	ACB
BERBERIDACEAE					
Berberis holstii	Shrub	2400-3200	TU WU SU	No information	DAF/TR; EB
MENISPERMACEAE					
Tiliachora funifera	Liana	400-650	IL	No information	RV
Tiliachora troupinii	Liana	1500-2100	SU IL KF SD	No information	DAF/U; MAF/P
Cocculus hirsutus	Liana	400-1500	IL SD GG	No information	DSS; RV
Cocculus pendulus	Liana	650-1000	GG HA	No information	RV
Chasmanthera dependens	Liana	150-1600	TU GD GJ SU GG SD BA	No information	DSS; ACB; CTW
Tinospora bakis	Liana	c. 1000	GG SD HA	No information	ACB
Tinospora caffra	Liana	850-1700	SU KF SD BA	No information	ACB; CTW
Cissampelos mucronata	Liana	400-1700	SU AR WG IL KF GG SD HA	No information	ACB; RV
Cissampelos pareira var. *wildei*	Liana	1750-2500	SU AR WG SD GG HA	No information	ACB; RV
Cissampelos pareira var. *hirsuta*	Liana	700-1900	KF GG SD BA HA	No information	ACB; CTW
Cissampelos owariensis	Liana	1700-2050	KF IL	No information	MAF/P
Stephania cyanantha	Liana	1500-2000	GJ WG KF	No information	MAF/P; RV
PIPERACEAE					
Piper guineense	Liana	1050-1600	WG IL KF	No information	MAF/P
TURNERACEAE					
Loewia glutinosa	Shrub	500-750	HA	No information	ACB

LOASACEAE					
Kissenia arabica	Shrub	550-720	AF	No information	DSS; ACB
CAPPARIDACEAE					
Cadaba divaricata	Shrub	300-400	SD HA	No information	DSS; ACB
Cadaba longifolia	Tree or shrubx	0-1200	AF SD HA	No information	DSS; ACB
Cadaba baccarinii	Shrub	500-1000	HA	No information	DSS; ACB
Cadaba gillettii	Shrub or liana	300-450	GG	No information	DSS; ACB
Cadaba heterotricha	Tree or shrub	200-1300	AF BA HA	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	DSS; ACB
Cadaba ruspolii	Shrub	1200-2000	SD HA	No information	ACB
Cadaba barbigera	Shrub	200-300	SD	No information	DSS; ACB
Cadaba mirabilis	Shrub	200-1200	SD BA HA	No information	DSS; ACB
Cadaba glandulosa	Shrub	0-1200	AF GD SU KF GG SD HA	No information	DSS; ACB
Cadaba rotundifolia	Shrub	500-1200	AF WU SU KF GG SD HA	No information	DSS; ACB
Capparis decidua	Shrub	0-1600	AF TU GD HA	No information	DSS; ACB
Capparis cartilaginea	Liana	0-1300	SU GG SD HA	No information	DSS; ACB
Capparis erythrocarpos	Liana	950-1700	WG IL KF	No information	MAF/P; TRF
Capparis tomentosa	Liana	500-2200	AF GD WU SU AR WG IL KF GG SD HA	No information	ACB; DAF/WG; RV
Capparis fascicularis var. *fascicularis*	Tree or liana	500-1900	WU SU KF GG SD HA	East African evergreen and semi-evergreen bushland and thicket	ACB; DAF/WG; RV
Capparis separia var. *rivae*	Shrub or liana	1200-1800	SD	No information	ACB; DAF/WG; RV
Capparis separia var. *boscioides*	Shrub or liana	1600-2200	GD GJ WU SU SD	No information	ACB; DAF/WG
Capparis separia var. *fischeri*	Shrub or liana	500-1000	IL	No information	?
Crateva adansonii subsp. *adansonii*	Tree or shrub	450-1250	TU GD AR IL GG SD	No information	TRF; RV
Ritchiea albersii	Tree	1200-2400	GD GJ SU WG IL KF SD	No information	DAF/U; MAF/P; ?TRF
Maerua subcordata		450-1250	KF GG SD	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	ACB
Maerua intricata	Shrub	300-400	HA	No information	DSS; ACB

Maerua denhardtiorum	Shrub	0-950	?SD	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	ACB
Maerua boranensis	Liana	750-1400	SD	No information	ACB
Maerua triphylla var. *calophylla*	Tree, shrub or lianax	500-1700	SU IL GG SD BA HA	No information	RV
Maerua triphylla var. *pubescens*	Tree, shrub or liana	c. 1300	SD BA	No information	RV
Maerua triphylla var. *triphylla*	Tree, shrub or liana	?	HA	No information	RV
Maerua triphylla var. *johannis*	Tree, shrub or liana	1000-2100	GJ SU AR GG SD BA HA	No information	RV
Maerua candida	Tree or shrub	100-300	SD BA	No information	DSS; ACB
Maerua angolensis subsp. *angolensis*	Tree, shrub or liana	500-1900	TU GD WU SU KF SD BA HA	No information	ACB; DAF/WG
Maerua angolensis subsp. *socotrana* var. *africana*	Tree, shrub or liana	500-700	HA	No information	ACB
Maerua crassifolia	Tree or shrub	400-1350	GG SD BA HA	Sahel wooded grassland	ACB
Maerua endlichii	Shrub	1150-1250	SD	No information	ACB
Maerua sessiliflora	Tree or shrub	600-1000	SD HA	No information	ACB
Maerua aethiopica	Shrub	650-850	IL KF	No information	CTW
Maerua macrantha	Shrub or liana	300-1000	BA HA	No information	DSS; ACB
Maerua oblongifolia	Shrub or liana	0-1800	GD SU IL KF GG SD BA HA	No information	DSS; ACB
Maerua glauca	Shrub or liana	c. 1400	BA	No information	ACB
Maerua gillettii	Shrub or liana	c. 1200	SD	No information	ACB
Boscia minimifolia	Tree or shrub	750-1500	SD HA	No information	ACB
Boscia angustifolia var. *angustifolia*	Tree or shrub	50-1900	AF TU GD SD GG	No information	DSS; ACB
Boscia mossambicensis	Tree or shrub	1000-1500	SD HA	No information	ACB
Boscia senegalensis	Tree or shrub	700-1300	SD BA	Sahel wooded grassland	ACB; RV
Boscia salicifolia	Tree or shrub	800-1900	TU WU SU AR KF SD GG	No information	ACB; DAF/WG
Boscia coriacea	Tree or shrub	500-2500	KF GG SD BA HA	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	ACB; DAF/WG; RV

BRASSICACEAE					
Farsetia somalensis	Tree or shrub	600-1200	SD HA	No information	ACB
MORINGACEAE					
Moringa peregrina	Tree or shrub	100-850	AF	No information	DSS; ACB
Moringa rivae subsp *rivae*	Tree	850-1000	SD HA	No information	ACB
Moringa rivae subsp. *longisiliqua*	Tree	1100-1350	SD BA HA	No information	ACB
Moringa borziana	Tree	c. 600	SD	No information	ACB
Moringa ruspoliana	Tree or shrub	250-400	SD BA HA	No information	DSS; ACB
Moringa longituba	Shrub	300-1300	SD HA	No information	DSS; ACB
VIOLACEAE					
Rinorea ilicifolia subsp. *ilicifolia*	Tree or shrub	600-1050	IL KF	No information	TRF
Rinorea friisii	Tree or shrub	900-1100	IL KF	No information	TRF
Hybanthus durus	Shrub	c. 1000	SD HA	No information	ACB
RESEDACEAE					
Ochradenus baccatus	Shrub	0-1000	AF EW	Somalia-Masai semi-desert grassland and shrubland	DSS; ACB
Ochradenus somalensis	Shrub	1150-1450	HA	No information	ACB
POLYGALACEAE					
Securidaca longipedunculata var. *longipedunculata*	Tree	500-1750	TU GD GJ WG SU IL	No information	CTW
MOLLUGINACEAE					
Limeum fruticosum	Shrub	c. 550	HA	No information	ACB
PORTULACACEAE					
Calyptrotheca somalensis	Shrub	640-720	GG SD	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	ACB
NYCTAGINACEAE					
Pisonia aculeata	Liana	1050-1300	IL KF	No information	TRF

PHYTOLACCACEAE					
Phytolacca dodecandra	Liana	1500-3000	TU GD WU WG WG SU IL KF AR GG SD BA HA	No information	DAF/U-WG
CHENOPODIACEAE					
Suaeda monoica	Shrub	0-1200	AF WU GG SD HA	No information	DSS; ACB; SLV/SSS
AMARANTHACEAE					
Sericostachys scandens	Liana	1500-2000	WG KF	No information	MAF/P
Pleropterantha revoilii	Shrub or liana	350-1150	HA	No information	DSS; ACB
Sericocomopsis hildebrandtii	Shrub	800-1670	GG SD	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	ACB
Sericocomopsis pallida	Shrub	250-1400	AF WU SU KF GG SD HA	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	DSS; ACB
Chionothrix latifolia	Tree or shrub	700-1750	SD BA HA	No information	ACB
ZYGOPHYLLACEAE					
Zygophyllum robecchii	Shrub	300-500	BA HA	No information	DSS; ACB
Zygophyllum. hildebrandtii	Shrub	-950	HA	Somalia-Masai semi-desert grassland and shrubland	DSS; ACB
Kelleronia splendens	Shrub	300-1350	SD BA HA	No information	DSS; ACB
Kelleronia gillettiae	Shrub	?-500	BA	No information	DSS; ACB
LYTHRACEAE					
Woodfordia uniflora	Tree or shrub	1250-2500	TU GD GJ WU SU AR KF SD BA HA	No information	DAF/WG; RV
Lawsonia inermis	Tree or shrub	0-1100	AF KF SD BA HA	No information	DSS; ACB
OLINIACEAE					
Olinia rochetiana	Tree or shrub	1250-3500	GD GJ WU SU AR WG KF SD BA	No information	DAF/U; EB

THYMELAEACEAE					
Gnidia glauca	Shrub	950-3200	GD WU GJ SU AR KF SD HA	No information	?ACB; ?CTW; DAF/U-WG; ?EB
Gnidia lamprantha	Tree or shrub	1200-2300	WG KF GG SD	No information	CTW; DAF/WG
Struthiola thomsonii	Shrub	1850-2150	SD	No information	DAF/?U-?SD-?TR
PROTEACEAE					
Faurea speciosa	Tree	1200-2100	GD GJ SU KF SD BA	No information	CTW; DAF/WG
Protea gaguedi	Tree or shrub	1400-3000	TU GD GJ SU AR WG IL KF GG SD BA HA	No information	DAF/WG
Protea madiensis	Tree or shrub	1200-1700	GD WG KF GG SD BA	No information	CTW
DILLENIACEAE					
Tetracera stuhlmanniana	Liana	1000-1150	IL KF	No information	TRF
FLACOURTIACEAE					
Oncoba spinosa	Tree or shrub	400-1800	TU SU AR WG IL KF SD BA HA	No information	CTW; DAF/WG; RV
Oncoba routledgei	Tree or shrub	1350-2000	AR WG IL KF SD BA	No information	DAF/U-WG; MAF/P; RV
Trimeria grandifolIa	Tree (possibly also liana)	c. 1700	SD	No information	DAF/TR
Scolopia theifolia	Tree	1700-2800	GD SU AR WG SD	No information	DAF/U-SD
Scolopia zeyheri	Tree	1700-1800	SD	No information	DAF/SD-TR
Flacourtia indica	Tree or shrub	1100-2350	GD GJ SU AR WG IL KF GG SD BA HA	No information	ACB; DAF/U-WG; RV
Dovyalis abyssinica	Tree or shrub	1700-3000	TU GD GJ WU SU AR GG SD BA HA	No information	DAF/U-SD; RV
Dovyalis verrucosa	Tree or shrub	1700-3200	GD WU GJ SU SD HA	No information	DAF/U-SD; EB
CANELLACEAE					
Warburgia ugandensis	Tree	1400-1600	BA	Dry transitional montane forest	DAF/TR
TAMARICACEAE					
Tamarix aphylla	Tree	15-900	WU SU SD HA	Tamarix communities	DSS; RV
Tamarix nilotica	Tree	300-1750	TU WU GJ SU HA	Tamarix communities	DSS; RV
Tamarix arborea	Tree or shrub	400-1650	SU HA	No information	DSS; RV

PASSIFLORACEAE					
Adenia venenata	Liana	500-1700	SU GG BA HA	No information	ACB
Adenia globosa subsp. *globosa*	Shrub or liana	c. 1000	SD	No information	ACB
Adenia aculeata subsp. *aculeate*	Liana	350-1600	SD BA HA	No information	ACB
Adenia inermis	Liana	1000-1300	SD BA	No information	ACB
Adenia schweinfurthii	Liana	1600-1700	SU	No information	DAF/U-WG
Adenia rumicifolia	Liana	1000-1650	WG IL KF BA	No information	?ACB; CTW
Adenia gummifera	Liana	600-1400	IL GG	No information	CTW
Basananthe berberoides	Shrub	c. 750	HA	No information	ACB
CUCURBITACEAE					
Momordica spinosa	Liana	100-900	SD HA	No information	DSS; ACB
Momordica rostrata	Liana	c. 1160	SD	No information	ACB
Momordica sessilifolia	Liana	400-1180	SD HA	No information	DSS; ACB
OCHNACEAE					
Ochna holstii	Tree	1700-2000	AR SD	Afromontane rain forest	DAF/?SD; MAF/P
Ochna schweinfurthiana	Shrub	1100-1700	SD	No information	CTW
Ochna inscuplta	Tree or shrub	1650-2000	SD	No information	DAF/SD
Ochna leucophloeos	Tree	400-1500	TU GD GJ WG IL	No information	CTW
Ochna inermis	Shrub	500-1900	GD SU WU GG SD BA HA	No information	ACB
Ochna bracteosa	Shrub	c. 950	KF	No information	TRF
Gomphia sp. = Mooney 9249	Shrub	1250-1350	IL KF	No information	TRF
MYRTACEAE					
Eugenia bukobensis	Tree	1000-2000	WG KF IL SD	No information	MAF/P; TRF; RV
Syzygium guineense subsp. *guineense*	Tree	1200-2500	TU WU GD GJ SU WG KF AR GG SD HA	No information	RV; FLV/MFS
Syzygium guineense subsp. *afromontanum*	Tree	1400-2600	GD SU WG KF IL AR GGSD BA	Afromontane rain forest	DAF/U; MAF/P
Syzygium guineense subsp. *macrocarpum*	Tree or shrub	1400-2500	SU WG KF SD BA	No information	CTW; DAF/WG
MELASTOMATACEAE					
Melastomastrum capitatum	Shrub	c. 1300	WG	No information	RV

COMBRETACEAE					
Combretum contractum	Shrub	c. 1050	SD	No information	ACB
Combretum collinum subsp. *collinum*	Tree	500-1950	TU GD GJ IL	Sudanian undifferentiated woodland	CTW
Combretum collinum subsp. *binderianum*	Tree	450-1950	GJ SU WG IL KF GG SD BA HA	No information	CTW
Combretum collinum subsp. *elonense*	Tree	1325-2200	WG SU	No information	CTW
Combretum collinum subsp. *hypopilinum*	Tree	c. 1800	WG	No information	CTW
Combretum adengonum	Tree	500-2000	TU GD GJ SU WG IL GG SD	No information	CTW; DAF/WG
Combretum hartmannianum	Tree	500-1200	TU GD GJ	Sudanian undifferentiated woodland; Transition from undifferentiated woodland to Acacia deciduous bushland and wooded grassland	CTW
Combretum rochetianum	Tree	1000-1900	TU GD GJ	No information	CTW
Combretum nigricans	Tree	c. 1900	GJ	No information	CTW
Combretum molle	Tree	500-2500	TU GD GJ WU SU WG AR IL KF GG SD BA HA	No information	CTW; DAF/WG
Combretum hereroense subsp. *parvifolium*	Tree or shrub	650-1500	GG SD BA	No information	ACB
Combretum capituliflorum	Liana	550-850	IL	No information	RV
Combretum paniculatum	Liana	1500-2600	SU WG IL KF SD	No information	MAF/BW; ?TRF
Combretum acueatum	Liana	325-1600	TU GD WU KF GG SD BA HA	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	?DSS; ACB
Terminalia orbicularis	Tree or shrub	400-1500	SD BA HA	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	ACB
Terminalia brevipes	Tree or shrub	250-450	AF GG SD BA HA	No information	DSS; ACB; RV
Terminalia spinosa	Tree	500-1000	KF GG HA	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	ACB
Terminalia prunioides	Tree	800-1000	SD BA HA	No information	ACB
Terminalia polycarpa	Tree	300-1400	SD BA HA	No information	DSS; ACB
Terminalia basilei	Tree	400-800	HA	No information	ACB
Terminalia macroptera	Tree	1300-1400	WG	Valley and flood-plain grassland	CTW

Terminalia brownii	Tree	300-2000	TU GD WU SU AR GG SD BA HA	Sudanian undifferentiated woodland	ACB (incl. ACB/RV); CTW
Terminalia laxiflora	Tree	450-1500	GD GJ IL	No information	CTW
Terminalia schimperiana	Tree	1000-2200	TU GD GJ SU WG IL KF GG SD BA	No information	CTW
Anogeissus leiocarpa	Tree	450-1900	TU GD GJ SU WG IL	Sudanian undifferentiated woodland	CTW
RHIZOPHORACEAE					
Cassipourea malosana	Tree	1250-3100	GD SU WG IL KF SD BA HA	Dry transitional montane forest	DAF/U; MAF/P; ?EB
GUTTIFERAE					
Hypericum revolutum	Tree or shrub	2250-3650	TU GD GJ WU SU AR IL KF GG SD BA HA	*Hagenia abyssinica* forest	DAF/U; EB; AA
Hypericum quartinianum	Tree or shrub	1500-3000	TU GD GJ WU SU AR WG KF GG SD BA HA	No information	DAF/U-WG
Hypericum synstylum	Shrub	2000-2200	HA	No information	?DAF/SD
Hypericum roeperianum	Tree or shrub	2000-3000	TU GD GJ WU SU	No information	DAF/?U-SD
Hypericum gnidiifolium	Tree or shrub	1900-2700	TU SU	No information	RV
Psorospermum febrifugum	Tree or shrub	1500-1800	WG IL	No information	CTW
Garcinia ovalifolia	Tree or shrub	900-1500	KF	No information	TRF; RV
Garcinia livingstonei	Tree or shrub	1200-1500	GG SD	No information	RV
Garcinia buchananii	Tree or shrub	1250-1800	KF IL GG	No information	MAF/P; RV
TILIACEAE					
Grewia arborea	Tree or shrub	550-1500	TU GG SD BA HA	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	ACB
Grewia bicolor	Tree or shrub	500-1800	TU GD GJ WU SU WG IL KF GG SD BA HA	No information	ACB; CTW
Grewia mollis	Tree or shrub	600-2200	TUGD GJ SU WG IL KF GG BA	No information	CTW
Grewia trichocarpa	Tree or shrub	650-2390	TU GD GJ WU SU AR WG IL KF GG SD BA HA	No information	ACB; RV
Grewia gillettii	Shrub	460-1400	SD BA HA	No information	ACB

Grewia tristis	Shrub	850-1700	TU WU SU AR SD BA HA	No information	ACB
Grewia velutina	Tree or shrub	550-2450	TU GJ WU SU AR IL KF GG SD BA HA	No information	ACB; DAF/WG
Grewia balensis (in Flora as "= Gilbert & Sebsebe 8598")	Shrub	1060-2050	SD BA	No information	ACB
Grewia flavescens	Shrub or liana	900-2300	TU GD GJ WU SU IL KF GG SD BA HA	No information	ACB; DAF/SD-TR
Grewia forbesii	Shrub	c. 650	GG	No information	ACB
Grewia schweinfurthii	Shrub	600-1600	WU SU AR HA	No information	ACB
Grewia ferruginea	Tree or shrub	1350-2700	TU GD GJ WU SU AR WG IL KF SD BA HA	No information	DAF/U-SD-WG
Grewia similis	Tree or shrub	1000-2300	SD BA HA	East African evergreen and semi-evergreen bushland and thicket	DAF/TR
Grewia lilacina	Shrub	450-1400	GG SD	No information	ACB
Grewia tembensis var. *tembensis*	Shrub	450-2250	TU GD GJ WU SU SD BA HA	East African evergreen and semi-evergreen bushland and thicket; Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	ACB; DAF/TR
Grewia tembensis var. *ellenbeckii*	Shrub	1300-1800	WU SU AR HA	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	ACB
Grewia kakothamnos	Shrub	450-1850	SD BA	No information	ACB
Grewia tenax	Shrub	0-1800	TU WU SU AR KF GG SD BA HA	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	ACB
Grewia erythraea	Shrub	450-1650	TU WU SU GG SD HA	No information	ACB
Grewia ogadensis	Shrub	250-450	SD BA HA	No information	DSS; ACB
Grewia villosa	Shrub	400-1800	TU WU SU IL KF GG SD BA HA	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	ACB
Grewia pennicillata	Shrub or liana	700-1350	WU SU SD BA HA	No information	ACB
Sparmannia ricinocapa	Shrub	2400-3500	TU GD GJ SU AR WG KF GG SD BA HA	No information	DAF/U-WG; EB
Sparmannia macrocarpa	Shrub	1800-3000	GD GJ WU SU AR WG KF GG HA	No information	DAF/U-WG
Triumfetta tomentosa	Shrub	1600-2400	GJ SU WG SD BA HA	No information	DAF/U-WG
Triumfetta pilosa	Shrub	1000-2750	TU GD GJ SU WG KF GG SD BA HA	No information	CTW

Triumfetta brachyseras	Shrub	1400-2650	WU GJ SU WG IL KF GG SD BA	No information	DAF/U-WG
Triumfetta actinocarpa	Shrub	400-800	HA	No information	ACB
Triumfetta heterocarpa	Shrub	400-1600	SU SD BA HA	No information	ACB
STERCULIACEAE					
Byttneria catalpifolia subsp. *africana*	Tree or liana	1050-1150	KF	No information	TRF
Dombeya longibracteolata	Tree or shrub	c. 1900	KF GG SD	No information	CTW
Dombeya torrida	Tree or shrub	1600-3100	TU GD GJ WU SU AR WG IL KF GG SD BA HA	Afromontane bamboo	DAF/U-WG; MAF/P-BW; ?EB
Dombeya buettneri	Shrub	1300-1800	IL KF	No information	CTW
Dombeya aethiopica	Tree	1700-2200	GJ SU KF GG SD	No information	DAF/U-WG
Dombeya kefaensis	Shrub	1700-2200	KF	No information	DAF/U-WG
Dombeya kirkii	Tree or shrub	1250-1600	GG SD BA	No information	ACB
Dombeya quinqueseta	Tree or shrub	850-2200	TU GD GJ SU WG IL KF GG	No information	CTW
Dombeya rotundifolia	Tree	1800-1900	SD	No information	?DAF/TR
Sterculia setigera	Tree	700-1900	TU GD GJ WU SU KF SD	Transition from undifferentiated woodland to Acacia deciduous bushland and wooded grassland	?ACB; CTW
Sterculia cinerea	Tree	0-650	IL	No information	?DSS; ?ACB; CTW
Sterculia africana	Tree	0-1775	WU SU IL GG BA HA	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	?DSS; ACB; CTW
Sterculia rhynchocarpa	Tree or shrub	300-1300	GG SD BA HA	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	ACB
Sterculia stenocarpa	Tree	500-1400	GG SD BA HA	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	ACB

BOMBACACEAE					
Adansonia digitata	Tree	700-1700	TU GD WG (SD BA)	Transition from undifferentiated woodland to Acacia deciduous bushland and wooded grassland; Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	CTW
Ceiba pentandra	Tree	500-1200	IL (PLANTED IN TU AR WG HA)	No information	TRF
MALVACEAE					
Hibiscus calophyllus	Tree	450-2100	TU GD GJ SU WG IL KF GG SD BA	No information	DAF/WG; RV
Hibiscus seineri	Shrub	c. 1100	SD	No information	ACB
Hibiscus ovalifolius	Shrub	400-2100	TU WU SU AR KF GG SD BA HA	No information	CTW; DAF/WG
Hibiscus dongolensis	Shrub	600-2000	AF TU GD WU SU KF GG SD BA HA	No information	?ACB; ?CTW; DAF/WG
Hibiscus macranthus	Shrub	1300-2850	TU GD GJ WU SU AR WG IL KF SD HA	No information	DAF/WG; RV
Hibiscus ludwigii	Shrub	1450-2800	SU AR KF SD BA	No information	DAF/WG
Hibiscus diversifolius	Shrub	1400-2000	TU GD GJ SU WG KF SD	No information	RV
Hibiscus berberidifolius	Shrub	1400-2650	TU GD GJ SU AR WG IL KF SD BA HA	No information	DAF/WG; RV
Hibiscus sparseaculeatus	Shrub	1200-1800	SD BA	No information	ACB
Hibiscus rostellatus	Shrub or liana	c. 800	SD	No information	RV
Hibiscus noldeae	Shrub or liana	950-1900	WG KF	No information	CTW; RV
Hibiscus vitifolius	Shrub	0-2400	TU GD WU SU WG IL KF GG SD BA HA	No information	DAF/WG
Hibiscus fuscus	Shrub	1600-2300	SD	No information	DAF/TR
Hibiscus flavifolius	Shrub	1150-2000	GG SD BA HA	No information	ACB
Hibiscus crassinervius	Shrub	500-2650	TU GD WU SU AR KF GG SD BA HA	No information	CTW; DAF/WG; ACB and possibly other types
Hibiscus pycnostemon	Shrub	1000-1800	TU WU SU GG SD BA HA	No information	ACB; DAF/WG
Symphyochlamys erlangeri	Shrub	c. 300	HA	No information	ACB

Gossypium anomalum subsp. *senarense*	Shrub	600-1000	EW	No information	?ACB
Gossypium somalense	Shrub	450-1250	SU SD HA	No information	ACB
Gossypium brichettii	Shrub	c. 300	BA	No information	ACB
Gossypium benadirense	Shrub	300-400	SD	No information	DSS; ACB
Thespesia danis	Tree or shrub	250-400	SD HA	No information	RV
Pavonia burchellii	Shrub	400-2500	TU GD GJ WU SU WG IL GG SD HA	No information	?ACB; ?CTW; DAF/WG; RV
Pavonia friisii (In flora "= Friis et al. 2801")	Shrub	1000-1450	SD	No information	ACB
Pavonia urens	Shrub	1500-3500	TU GD GJ WU SU AR WG IL KF GG SD BA HA	No information	DAF/WG; EB
Pavonia schimperiana	Shrub	1300-2500	TU GD GJ SU AR WG IL KF GG SD BA	No information	DAF/U-WG
Pavonia kilimandscharica	Shrub	2000-2800	SU AR WG KF SD BA HA	No information	DAF/U-WG
Abutilon longicuspe	Shrub	1275-2800	TU GD GJ SU AR WG IL SD BA HA	No information	DAF/WG; RV
Abutilon cecilii	Shrub	1500-2650	GD GJ SU KF GG SD BA HA	No information	?DAF/WG; MAF/BW
Abutilon angulatum	Shrub	900-1700	TU GD GJ SU SD HA	No information	ACB; CTW; RV
Abutilon mauritianum	Shrub	1200-2500	GD GJ WU SU AR KF GG SD HA	No information	RV
Abutilon anglosomaliae	Shrub	350-1200	SD HA	No information	ACB
Abutilon hirtum	Shrub	275-2250	AF TU SU GG SD BA HA	No information	ACB
Sida sp. = Bally 9622	Shrub	500-800	HA	No information	ACB
MALPIGHIACEAE					
Acridocarpus glaucescens var. *ferrugineus*	Shrub	c. 500	HA	No information	DSS
Acridocarpus ugandensis		400-500	IL	No information	RV
Caucanthus auriculatus	Liana	1200-2000	WU SU AR GG SD BA HA	No information	?ACB; ?CTW; DAF/SD
Caucanthus albidus	Shrub or liana	400-1200	SU SD HA	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	DSS; ACB
Caucanthus edulis	Shrub or liana	350-1200	HA	No information	DSS; ACB

Triaspis erlangeri	Liana	600-1650	GG SD BA HA	No information	ACB
Triaspis niedenzuiana	Liana	850-1350	SD BA	No information	ACB
Flabellaria paniculata	Liana	1150-1650	KF	No information	TRF
ERYTHROXYLACEAE					
Erythroxylon fischeri	Tree or shrub	500-600	IL	No information	TRF; RV
EUPHORBIACEAE					
Bridelia scleroneura	Tree or shrub	440-1800	GD WG IL KF GG BA	No information	CTW; RV
Bridelia taitensis	Tree or shrub	c. 1000	GG SD	No information	?
Bridelia cathartica	Tree or shrub	800-1300	SD BA	No information	ACB
Bridelia atroviridis	Tree or shrub	1000-1150	IL KF	No information	RV
Bridelia micrantha	Tree or shrub	1050-2200	GD GJ SU AR WG IL KF GG SD BA	No information	DAF/WG; RV
Antidesma venosum	Tree or shrub	c. 600	IL	No information	RV; FLV/MFS
Flueggea virosa subsp. *virosa*	Tree or shrub	400-2050	TU GD GJ WU SU WG IL KF GG SD BA HA	No information	ACB; CTW
Flueggea leucopyrus	Tree or shrub	1600-1800	SD BA HA	No information	ACB
Phyllanthus ovalifolius	Tree or shrub	900-2750	GD GJ WU WG SU AR IL KF GG SD BA HA	No information	DAF/WG; RV
Phyllanthus reticulatus	Tree or shrub	375-1700	AF GJ SU AR WG IL KF GG HA	No information	RV
Phyllanthus limmuensis	Shrub or liana	1050-2200	GD GJ WG IL KF	No information	MAF/P
Phyllanthus sepialis	Shrub	1100-1950	SU KF GG SD BA	No information	CTW; DAF/WG; RV
Phyllanthus hildebrandtii	Shrub	c. 1200	SD	No information	ACB
Phyllanthus borenensis	?		SD	No information	ACB
Margaritaria discoidea var. *fagifolia*	Tree or shrub	1050-1750	IL KF SD BA	Dry transitional montane forest	TRF; DAF/WG
Margaritaria discoidea var. *nitida*	Tree or shrub	1600-2200	SD BA	No information	DAF/U
Hymenocardia acida	Tree or shrub	c. 1500	WG	No information	CTW

Clutia abyssinica	Shrub	1450-2950	TU GD WU GJ SU AR KF SD BA HA	No information	DAF/U-WG
Clutia lanceolata subsp. *lanceolata*	Shrub	1270-3250	TU GD GJ WU SU WG KF GG SD BA HA	No information	DAF/U-SD-WG; EB
Argomuellera macrophylla	Tree or shrub	450-2000	WG IL KF	No information	TRF
Cephalocroton cordofanus	Shrub	300-1600	SD HA	No information	ACB
Cephalocroton incanus	Shrub	c. 1400	SU	No information	CTW
Alchornea laxiflora	Tree or shrub	900-1360	IL KF	No information	TRF
Macaranga capensis var. *kilimandscharica*	Tree	1500-2400	WG KF GG SD BA	No information	DAF/U; MAF/P
Erythrococca abyssinica	Shrub	1250-2000	WU SU AR GG SD HA	No information	DAF/U-WG
Erythrococca trichogyne	Tree or shrub	1400-2200	GJ SU WG IL KF BA	No information	MAF/P
Erythrococca bongensis	Tree or shrub	c. 1300	SD	No information	RV
Acalypha acrogyne	Tree or shrub	500-1200	IL KF	No information	TRF
Acalypha ornata	Shrub	550-1800	TU GD GJ SU WG IL KF GG SD	No information	CTW; RV
Acalypha fruticosa var. *fruticosa*	Tree or shrub	435-1800	WU SU GG SD HA	No information	RV
Acalypha fruticosa var. *eglandulosa*	Tree or shrub	1150-1700	GG SD BA HA	No information	RV
Mallotus oppositifolius var. *oppositifolius*	Tree	600-1800	WG IL KF	No information	TRF; RV
Suregada procera	Tree or shrub	1500-1950	SD BA	Dry transitional montane forest	DAF/U-TR
Jatropha dichtar	Shrub	300-750	SD BA HA	No information	ACB
Jatropha rivae subsp. *rivae*	Shrub	c. 400	HA	No information	ACB
Jatropha rivae subsp. *quercifolia*	Shrub	600-800	GG	No information	ACB
Jatropha ellenbeckii	Shrub	750-1050	GG SD HA	No information	ACB
Croton dichogamus	Tree or shrub	1350-2250	SU AR GG BA HA	No information	ACB (incl. ACB/RV)
Croton zambesicus	Tree	650-1650	GG	No information	ACB (incl. ACB/RV)

Croton meynhartii	Tree or shrub	c. 1125	BA	No information	ACB
Croton somalense	Shrub	400-1200	SD	No information	ACB
Croton schimperianus	Shrub	900-1450	TU WU SU SD BA	No information	ACB
Croton macrostachyus	Tree or shrub	500-2350	TU GD GJ WU SU AR WG IL KF SD BA HA	No information	CTW; DAF/U-WG; MAF/P-BW
Croton sylvaticus	Tree or shrub	1050-1200	IL KF	No information	TRF
Givotia gosai	Tree	c. 600	HA	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	ACB
Sapium ellipticum	Tree or shrub	1050-2100	TU GD GJ WG SU IL KG SD	No information	MAF/P; TRF; RV
Euphorbia venenifica	Tree or shrub	c. 1200	WG	No information	CTW
Euphorbia ampliphylla	Tree	1200-2700	TU GD GJ WU SU ILKF SD HA	No information	DAF/U; MAF/P-BW; TRF; ?RV
Euphorbia abyssinica	Tree	1300-2400	TU GD GJ SU SD HA	No information	DAF/SD-WG-TR
Euphorbia candelabrum	Tree	1200-1700	SU SD BA HA	East African evergreen and semi-evergreen bushland and thicket	ACB (incl. ACB/RV); CTW
Euphorbia adjurana	Tree	c. 1800	GG SD	No information	ACB
Euphorbia breviarticulata var. *breviarticulata*	Shrub	c. 1000	GG SD BA	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	ACB
Euphorbia breviarticulata var. *truncuformis*	Tree	250-1000	GG SD BA	No information	ACB
Euphorbia cactus	Shrub	5-1000	AF SU	No information	DSS; ACB
Euphorbia burgeri	Tree	1200-1550	HA	No information	ACB
Euphorbia robecchii	Tree	1000-1200	SD BA HA	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	ACB
Euphorbia tescorum	Shrub	850-1250	GG SD BA	No information	ACB
Euphorbia borenensis	Shrub	850-1550	GG SD	No information	ACB
Euphorbia dalettiensis	?Tree	c. 1200	HA	No information	ACB
Euphorbia nigrispinioides	Tree or shrub	1000-1700	SU	No information	ACB/RV
Euphorbia nigrispina	Shrub	c. 1200	BA HA	No information	ACB
Euphorbia polyacantha	Shrub	800-2250	TU WU BA HA	No information	ACB; DAF/TR
Euphorbia migiurtinorum	Liana	720	HA	No information	ACB
Euphorbia erlangeri	Shrub	300-900	SD	No information	ACB

Euphorbia cryptospinosa	Shrub	1000-1200	SD	No information	ACB
Euphorbia ogadenensis	Tree or shrub	c. 300	BA HA	No information	DSS; ACB
Euphorbia goetzei	Shrub	c. 1250	SD	No information	RV
Euphorbia jatrophoides	Tree or shrub	900-1600	SD BA HA	No information	ACB
Euphorbia doloensis	Shrub	c. 400	SD	No information	DSS; ACB
Euphorbia kelleri var. *kelleri*	Shrub	c. 400	BA HA	No information	DSS; ACB
Euphorbia kelleri var. *latifolia*	Shrub	?	BA	No information	ACB
Euphorbia cuneata subsp. *cuneata*	Tree or shrub	300-600	EE	No information	DSS; ACB
Euphorbia cuneata subsp. *spinescens*	Shrub	900-1250	SD	Somalia-Masai semi-desert grassland and shrubland	ACB
Euphorbia cuneata subsp. *wajirensis*	Shrub	200-600	SD BA HA	Somalia-Masai semi-desert grassland and shrubland	DSS; ACB
Euphorbia cuneata subsp. *lamproderma*	Shrub	325-400	GG SD	Somalia-Masai semi-desert grassland and shrubland	DSS; ACB
Euphorbia betulicortex	Tree	c. 950	SD	No information	ACB
Euphorbia uniglans	Tree	c. 1400	SD	No information	ACB
Euphorbia scheffleri	Tree or shrub	100-1350	SD BA HA	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	ACB
Euphorbia grosseri	Tree or shrub	250-750	BA HA	No information	DSS; ACB
Euphorbia somalensis	Tree or shrub	c. 1100	HA	No information	ACB
Euphorbia tirucalli	Tree or shrub	1300-2000	TU WU SU IL GG SD BA HA	No information	ACB; DAF/SD-TR
Euphorbia nubica	Shrub or liana	400-1900	TU SD BA HA	No information	ACB; DAF/TR
Euphorbia dumalis	Shrub	2400-3600	SU AR KF SD BA	No information	DAF/U-WG; EB; AA
PITTOSPORACEAE					
Pittosporum abyssinicum	Tree or shrub	2300-3200	GD SU BA HA	No information	DAF/U-WG; EB
Pittosporum viriflorum (incl. f. *ripicola*)	Tree or shrub	1400-3000	TU GD WU GJ WG SU AR HA IL KF GG SD	No information	DAF/U; MAF/P-BW

ROSACEAE					
Rubus aethiopicus	Shrub	2600-3000	SU SD	No information	DAF/SD
Rubus erlangeri	Shrub	?-3600	BA SD	No information	DAF/U-SD; EB
Rubus volkensii		2500-3800	GJ SU AR BA KF	No information	DAF/U-WG; EB
Rubus steudneri	Shrub or liana	2300-3000	TU GD WG SU AR HA KF GG SD	No information	DAF/U-WG
Rubus apetalus	Shrub or liana	1500-2500	TU GD WU GJ SU AR HA WG IL KF GG SD	No information	DAF/U-WG
Rosa abyssinica	Shrub or liana	1900-3300	TU GD WU GJ SU AR HA BA	No information	DAF/U-SD-WG; EB
Prunus africana	Tree	1700-2500	GD GJ WG SU AR BA HA IL KF SD	Afromontane rain forest; Undifferentiated Afromontane forest; Afromontane bamboo	DAF/U; MAF/P
Hagenia abyssinica	Tree	2450-3250	TU GD WU GJ WG SU AR BA HA KF SD	*Hagenia abyssinica* forest	DAF/U-SD-WG; EB
DICHAPETALACEAE					
Tapura fischeri	Tree or shrub	c. 500	GG KF IL	No information	TRF; RV
FABACEAE SUBFAM. CAESAPINIOIDEAE					
Delonix elata	Tree	0-2200	AF WU HA KF GG SD	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	DSS; ACB
Delonix baccal	Tree	600-900	HA SD	No information	ACB
Caesalpinia trothae subsp. *erlangeri*	Shrub or liana	c. 800	SD BA	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	ACB
Caesalpinia dauensis	Shrub	c. 900	SD	No information	ACB
Caesalpinia oligophylla	Shrub	?	BA SD	No information	ACB
Caesalpinia erianthera var. *pubescens*	Shrub	250-1000	AF SD	No information	DSS; ACB
Pterolobium stellatum	Liana	750-2500	TU GD WU GJ WG SU AR BA HA KF GG SD	East African evergreen and semi-evergreen bushland and thicket	ACB; DAF/SD-WG
Parkinsonia scioana	Tree or shrub	900-1250	AF SU HA SD	No information	DSS; ACB
Cordeauxia edulis	Tree or shrub	400-500	HA	No information	DSS; ACB

Cassia arereh	Tree or shrub	1200-2000	TU GD GJ SU KF	No information	CTW; DAF/WG
Senna petersiana	Tree or shrub	1200-2000	WU GD WG SU IL KF SD	No information	DAF/WG
Senna singueana	Tree or shrub	1500-2400	TU GD WU GJ SU SD	No information	DAF/WG
Senna baccarinii	Tree or shrub	1150-1500	HA SD	No information	ACB
Senna sophera	Shrub	c. 600	AF	No information	DSS; ACB
Senna didymobotrya	Shrub	1450-2400	WU WG SU AR SD	No information	ACB; DAF/SD-TR
Senna longiracemosa	Tree or shrub	300-1000	AF HA BA SD GG	No information	DSS; ACB
Senna ellisiae	Tree or shrub	400-750	HA	No information	DSS; ACB
Senna alexandrina var. *alexandrina*	Shrub	0-1400	AF EW	No information	DSS; ACB
Senna alexandrina var. *obtusata*	Shrub	0-1000	HA	No information	DSS; ACB
Tamarindus indica	Tree	0-1500	TU GD WU GJ SU HA IL KF GG SD	No information	DSS; ACB; RV
Piliostigma thonningii	Tree	500-2000	TU GD GJ WG SU BA IL KF SD	Sudanian undifferentiated woodland	CTW; WGG
Bauhinia ellenbeckii	Tree or shrub	700-1500	HA SD	No information	ACB
Tylosema fassoglensis		500-1950	GD GJ WG SU HA IL KF GG SD	No information	CTW
Cordyla somalensis	Tree or shrub	500-900	HA	No information	ACB
FABACEAE SUBFAM. MIMOSOIDEAE					
Entada africana	Tree or shrub	450-1100	GD GJ IL	No information	CTW
Entada abyssinica	Tree	1300-2050	TU GJ WG SU HA IL KF GG SD	No information	CTW; DAF/WG
Entada leptostachya	Liana	1150-1450	HA BA SD	No information	ACB
Dichrostachys kirkii	Tree or shrub	c. 700	HA	No information	ACB

Dichrostachys cinerea	Tree or shrub	450-2000	TU WU GJ WG SU AR BA HA KF GG SD	No information	ACB (incl. ACB/RV); CTW; DAF/WG
Mimosa pigra	Shrub or liana	450-2000	GD GJ SU IL KF	No information	RV
Acacia brevispica	Shrub or liana	900-2000	WU SU BA HA KF GG SD	No information	ACB; DAF/WG
Acacia montigena	Shrub or liana	1150-2100	IL KF	No information	MAF/P; TRF; RV
Acacia pentagona	Liana	500-600	IL	No information	TRF; MAF/P
Acacia senegal var. *senegal*	Tree	600-1700	AF WU SU AR BA GG SD	Sahel wooded grassland	ACB; ACB/RV; CTW
Acacia senegal var. *kerensis*	Shrub	700-1300	HA	No information	ACB
Acacia senegal var. *leiorachis*	Tree	1000-1700	SU HA	No information	ACB
Acacia hamulosa	Shrub	c. 750	HA	No information	ACB
Acacia asak	Tree or shrub	400-1900	TU WU HA	No information	ACB; RV
Acacia ogadensis	Tree	500-1250	HA SD	No information	ACB
Acacia condyloclada	Tree	c. 1200	HA BA SD	No information	ACB
Acacia zizyphispina	Shrub	c. 800	HA	No information	ACB
Acacia oliveri	Tree or shrub	0-500	EE	No information	DSS
Acacia mellifera	Tree or shrub	400-2500	WU SU HA BA KF GG SD	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket; Edaphic grassland of the Upper Nile basin	ACB
Acacia laeta	Tree or shrub	?-1800	TU GD	No information	ACB; DAF/WG
Acacia venosa	Tree	1890-2400	TU GD	No information	DAF/WG
Acacia persiciflora	Tree	1700-2100	GD GJ SU HA KF SD	No information	?
Acacia polyacantha subsp. *campylacantha*	Tree	500-1600	TU GD GJ SU IL KF GG SD	No information	CTW; RV
Acacia hecatophylla	Tree	1450-1700	TU GD GJ	No information	CTW
Acacia pseudonigrescens	Tree	c. 300	BA	No information	DSS; ACB
Acacia goetzei subsp. *microphylla*	Tree	1300-1880	GG SD	No information	ACB
Acacia albida	Tree	1500-2600	TU WU GD SU AR HA SD GG	No information	ACB (incl. ACB/RV); DAF/WG
Acacia horrida subsp. *benadirensis*	Shrub	500-1700	HA BA KF SD GG	No information	ACB

Acacia bussei	Tree	330-1800	HA BA SD	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	DSS; ACB
Acacia lahai	Tree or shrub	1700-2600	TU GD WU GJ WG SU HA KF	No information	ACB; DAF/WG
Acacia dolichocephala	Tree	1100-2130	GJ SU AR GG SD	No information	ACB; CTW
Acacia zanzibarica var. *microphylla*	Tree or shrub	300-1000	HA SD	No information	DSS; ACB
Acacia seyal var. *seyal*	Tree	1200-2100	TU WU GD GJ SU AR HA IL KF SD	Transition from undifferentiated woodland to Acacia deciduous bushland and wooded grassland; Edaphic grassland of the Upper Nile basin	ACB; ACB/RV; WGG; CTW; DAF/WG
Acacia seyal var. *fistula*	Tree	500-2000	SU HA IL SD	Edaphic grassland of the Upper Nile basin	ACB; WGG; CTW; DAF/WG
Acacia hockii	Tree or shrub	c. 700	GG	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	CTW
Acacia ehrenbergiana	Tree or shrub	c. 450	AF	No information	DSS; ACB
Acacia amythetophylla	Tree	1300-1450	TU GD	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	CTW
Acacia nilotica subsp. *nilotica*	Tree	c. 600	EW	No information	ACB
Acacia nilotica subsp. *subalata*	Tree	900-1000	GG	No information	WGG; ACB
Acacia nilotica subsp. *kraussiana*	Tree	700-1700	KF GG SD	No information	ACB
Acacia nilotica subsp. *leiocarpa*	Tree	1100-1700	SU AR HA	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	ACB
Acacia tortilis subsp. *tortilis*	Tree	c. 600	EE	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket; Sahel wooded grassland	ACB; CTW
Acacia tortilis subsp. *spirocarpa*	Tree	600-1900	AF TU WU SU AR HA BA	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket; Sahel wooded grassland	DSS; ACB (incl. ACB/RV); CTW
Acacia prasinata	Tree	500-1300	AF SU	No information	DSS; ACB
Acacia etbaica subsp. *uncinata*	Tree	1200-2000	WU AR HA SD	No information	ACB; ACB/RV; DAF/WG

Acacia etbaica subsp. *platycarpa*	Tree	c. 1550	SD	No information	ACB
Acacia reficiens subsp. *misera*	Shrub	c. 500	HA KF SD	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	ACB
Acacia drepanolobium	Tree or shrub	1000-1700	HA GG SD	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	ACB; CTW
Acacia gerrardii	Tree	1500-2000	SU	No information	CTW
Acacia robusta subsp. *usambarensis*	Tree	500-1450	SU AR HA BA SD	No information	RV
Acacia pilispina	Tree or shrub	1650-3100	TU GD WU GJ SU HA	No information	DAF/WG
Acacia abyssinica	Tree	1500-2800	TU GD WU GJ WG SU HA BA IL KF SD	No information	DAF/WG; MAF/BW
Acacia sieberiana var. *sieberiana*	Tree	500-2200	WU SU WG IL KF SD	No information	CTW; DAF/WG
Acacia sieberiana var. *woodii*	Tree	1700-2100	TU GD WU SU KF SD	No information	CTW; DAF/WG
Acacia negrii	Tree or shrub	2000-3100	GD WU GJ SU HA	No information	DAF/WG
Acacia origena	Tree	1700-2600	WU	No information	DAF/WG
Acacia bavazzanoi	Tree	1680-2400	TU GD GJ SU	No information	DAF/WG
Acacia oerfota	Shrub	100-1600	AF TU WU SU BA HA SD	No information	DSS; ACB
Acacia paolii	Shrub	c. 1000	HA KF	No information	ACB
Acacia stuhlmannii	Tree or shrub	?	HA	No information	?
Acacia edgworthii	Shrub	360-700	HA BA SD	No information	DSS; ACB
Acacia brichettiana	Shrub	?	HA	No information	DSS; ACB
Acacia walwalensis	Shrub	?	HA	No information	DSS; ACB
Albizia coriaria	Tree	c. 500	IL	No information	CTW; TRF
Albizia malacophylla var. *malacophylla*	Tree	1400-1900	TU GD	No information	DAF/WG
Albizia malacophylla var. *ugandensis*	Tree	550-2200	GD GJ WG IL	No information	CTW; DAF/WG; RV
Albizia anthelmintica	Tree or shrub	500-1350	TU HA KF GG	No information	ACB; CTW
Albizia amara subsp. *sericocephala*	Tree or shrub	1400-1700	TU GD SU SD	No information	DAF/WG
Albizia isenbergiana	Tree	1850-2400	TU GD GJ SD	No information	DAF/WG
Albizia schimperiana	Tree	1600-2600	GD WU GJ WG SU AR KF IL GG SD	No information	DAF/U-WG; MAF/P-BW; TRF

Albizia gummifera	Tree	1700-2400	GJ WG IL KF	Dry transitional montane forest	DAF/U-WG; MAF/P-BW
Albizia grandibracteatum	Tree	1200-1700	WG SU IL KF SD	No information	MAF/P; TRF; RV
FABACEAE SUBFAM. PAPILIONOIDEAE					
Cadia purpurea	Shrub	1300-2700	TU WU HA BA	East African evergreen and semi-evergreen bushland and thicket	DAF/TR
Dicraeopetalum stipulare	Tree	?	HA	No information	ACB
Platycelyphium voense	Tree or shrub	600-900	HA BA SD	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	ACB
Calpurnia aurea	Tree or shrub	1650-3000	TU GD WU GJ WG SU AR BA KF GG SD	No information	DAF/U-WG; MAF/P-BW
Baphia abyssinica	Tree	500-1250	IL KF GG	No information	TRF; RV
Lonchocarpus laxiflorus	Tree	450-2150	TU GD WG SU BA KF IL	Sudanian undifferentiated woodland	CTW
Pterocarpus lucens	Tree	550-1520	TU GD GJ WG IL	No information	CTW
Dalbergia melanoxylon	Tree or shrub	600-1900	TU GD	Sudanian undifferentiated woodland	CTW
Dalbergia commiphoroides	Shrub	400-850	HA	No information	ACB
Dalbergia microphylla	Shrub	1200-1500	BA SD	No information	ACB
Dalbergia lactea	Tree, shrub or liana	1350-2100	GD GJ WG SU AR IL KF GG SD BA	No information	DAF/U-WG; MAF/P; RV
Abrus precatorius subsp. *africanus*	Liana	500-1300	WG SU KF IL GG SD	No information	CTW
Abrus schimperi subsp. *schimperi*	Liana	550-1700	TU GD WG IL KF GG	No information	CTW; DAF/WG
Abrus pulchellus subsp. *tenuiflorus*	Liana	c. 1300	WG	No information	RV
Abrus canescens	Liana	c. 1300	WG	No information	RV
Millettia ferruginea subsp. *ferruginea*	Tree	1000-2500	TU GD GJ SU WG HA	No information	DAF/U-SD; MAF/P; RV
Millettia ferruginea subsp. *darassana*	Tree	1600-2500	WG SU HA BA IL KF SD	No information	DAF/U; MAF/P
Craibia laurentii	Tree	?	GG	No information	DSS; ACB
Craibia brevicaudata	Tree	c. 1300	BA	No information	ACB

Tephrosia interrupta	Shrub	1350-2800	TU WU GD WG SU AR HA IL KF SD	No information	CTW; DAF/WG
Indigofera rothii	Tree or shrub	2150-2800	SU HA	No information	DAF/WG
Indigofera garckeana	Shrub	500-1950	WU WG BA IL KF GG SD	No information	CTW
Indigofera binderi	Shrub	1500-1800	HA BA GG SD	No information	ACB
Indigofera macrantha	Shrub	1500-1900	BA SD	No information	ACB
Indigofera roseo-coerulea	Shrub	1800-2700	WG SU AR KF SD	No information	DAF/WG
Indigofera emarginella	Shrub	900-1800	TU GD GJ WG KF	No information	CTW; DAF/WG
Indigofera boranica	Shrub	780-1450	SD	No information	ACB
Indigofera curvirostrata	Shrub	c. 900	SD	No information	ACB
Indigofera lupatana	Shrub	1500-1900	BA SD	No information	ACB
Indigofera arrecta	Shrub	400-2700	TU WU GD GJ WG SU AR BA HA IL KF GG SD	No information	ACB; CTW; DAF/WG
Indigofera oblongifolia	Shrub	500-1200	AF HA BA KF GG SD	No information	DSS; ACB
Sesbania dummeri	Tree or shrub	1150-1650	KF IL	No information	RV; FLV/MFS
Sesbania goetzei	Tree or shrub	1150-1650	SU AR GG SD	No information	RV; FLV/MFS
Sesbania sesban var. *nubica*	Tree or shrub	300-2000	AF TU GD WU GJ WG SU AR HA IL KF GG SD	No information	?DSS; ?CTW; ?DAF/WG; RV; FLV/MFS
Sesbania rostrata	Shrub	c. 550	IL	No information	WGG
Sesbania melanocaulis	Tre or shrub	1550-1900	WG KF IL	No information	DAF/WG; MAF/BW
Ormocarpum trichocarpum	Tree or shrub	700-2100	BA IL GG SD	No information	ACB
Ormocarpum trachycarpum	Tree or shrub	1200-1900	HA SD	No information	ACB
Ormocarpum muricatum	Shrub	400-1300	HA SD	No information	ACB
Ormocarpum pubescens	Tree or shrub	1000-2100	TU GD	No information	CTW
Aeschynomene elaphroxylum	Tree or shrub	1200-1850	SU AR GG SD	No information	RV; FLV/MFS
Aeschynomene schimperi	Shrub	1350-2200	TU GD GJ WG SU HA KF GG SD	No information	RV; FLV/MFS
Aeschynomene cristata ver. pubescens	Shrub	c. 1250	GG SD	No information	RV; FLV/MFS
Aeschynomene pfundii	Shrub	c. 1200	SD	No information	RV; FLV/MFS

Aeschynomene abyssinica	Shrub	1300-3300	TU GD GJ WG SU IL KF GG SD	No information	DAF/WG; ?EB; RV; FLV/MFS
Aeschynomene ruspoliana	Shrub	?	SD	No information	?
Kotschya africana	Shrub	1400-2050	WG SU KF GG	No information	CTW; DAF/WG
Kotschya recurvifolia subsp. *aethiopica*	Shrub	1350-2400	BA HA KF SD	No information	CTW; DAF/WG
Desmodium velutinum	Shrub	-1200	WG IL KF GG	No information	CTW
Erythrina brucei	Tree	1400-2600	WU WG GJ SU BA HA IL KFGD GG SD	No information	DAF/U; MAF/P-BW
Erythrina abyssinica	Tree or shrub	1300-2400	TU WU GD GJ WG SU AR KF IL GG SD	Sudanian undifferentiated woodland	CTW; DAF/WG
Erythrina burana	Tree	1350-2100	HA	No information	ACB
Erythrina melanacantha subsp. *melanacantha*	Tree	1200-1300	BA GG SD	No information	ACB
Erythrina melanacantha subsp. *somala*	Tree	600-700	HA	No information	ACB
Mucuna melanocarpa	Liana	1400-2100	TU WG AR HA KF GG SD	No information	CTW; DAF/WG
Mucuna stans	Shrub	1600	WG	No information	CTW
Vatovea pseudlolablab	Liana	600-1500	AF SU HA BA GG SD	No information	ACB
Crotalaria rosenii	Shrub	1350-2800	SU AR BA KF SD	No information	DAF/WG
Crotalaria agathiflora subsp. *erlangeri*	Shrub	2500-3300	SU BA HA GG	No information	DAF/WG; EB
Crotalaria agathiflora subsp. *imperialis*	Shrub	c. 1800	SD	No information	DAF/WG
Crotalaria exaltata	Tree or shrub	3000-3400	SU BA KF SD	No information	DAF/WG; EB; ?AA
Crotalaria mildbraedii	Shrub	1700-2400	WG SU BA KF GG SD	No information	DAF/WG
Adenocarpus mannii	Shrub	2900-3300	SU KF SD	No information	DAF/WG; EB; ?AA
Taverniera abyssinica	Shrub	1700-2150	TU SU	No information	DAF/WG
Taverniera schimperi	Shrub	1000-1300	TU SU	No information	CTW
Colutea abyssinica	Shrub	1600-4000	TU GD WU SU AR BA HA SD	No information	DAF/WG; EB; AA
HAMAMELIDACEAE					
Trichocladus ellipticus subsp. *malosanus*	Tree	1250-3000	WG SU KF GG AR BA HA	Dry transitional montane forest	DAF/U; RV

BUXACEAE					
Buxus hildebrandtii	Tree or shrub	1000-1300	AF HA BA	East African evergreen and semi-evergreen bushland and thicket	ACB; DAF/TR
SALICACEAE					
Salix subserrata	Tree or shrub	1350-2850	TU GD WU GJ SU AR HA BA WG IL KF GG	No information	RV
Salix pedicellata	Shrub	1000-1900	HA	No information	RV
MYRICACEAE					
Morella salicifolia (= Myrica s.)	Tree or shrub	1750-3300	TU GD WU SU AR HA SD	No information	DAF/U-SD-WG; EB
ULMACEAE					
Celtis africana	Tree	1300-2500	TU WU GD GJ WG SU AR HA BA IL KF GG SD	No information	DAF/U; MAF/P; RV
Celtis toka	Tree	375-1000	WU WG SU IL KF GG	No information	TRF; RV
Celtis gomphophylla	Tree	1200	IL	No information	TRF
Celtis zenkeri	Tree	500-1800	IL	No information	TRF
Celtis philippensis	Tree or shrub	900-1320	IL	No information	TRF; RV
Trema orientalis	Tree or shrub	500-1800	GD GJ WG SU AR BA IL KF	No information	DAF/U-WG; MAF/P-BW; RV
BARBEYACEAE					
Barbeya oleoides	Tree or shrub	1200-2500	HA BA SD	East African evergreen and semi-evergreen bushland and thicket	ACB; DAF/TR
MORACEAE					
Morus mesozygia	Tree or shrub	500-1850	WG KF IL	No information	TRF
Milicia excelsa	Tree	500-1600	WG KF IL	No information	TRF
Ficus palmata	Tree or shrub	1000-2400	TU GD GJ WU SU HA AR KF	No information	DAF/WG; RV
Ficus capreaefolia	Tree or shrub	600-2600	AF TU GD SU HA KF GG SD	No information	RV
Ficus exasperata	Tree or shrub	900-2000	?TU GD KF IL	No information	TRF; RV
Ficus asperifolia	Shrub	1000-1200	KF	No information	TRF
Ficus sycomorus subsp. *sycomorus*	Tree	500-2000	TU WU GD GJ SU HA IL KF GG SD	No information	DAF/WG; RV

Ficus sycomorus subsp. *gnaphalocarpa*	Tree	500-1900	TU GD GJ SU HA IL KF SD	No information	DAF/WG; RV
Ficus mucuso	Tree	900-1300	KF IL	No information	TRF
Ficus sur	Tree	1400-2500	TU GD GJ WU WG SU HA AR KF IL SD	No information	DAF/U; MAF/P; TRF; RV
Ficus vallis-choudae	Tree	700-1900	GD SU WG IL KF SD	No information	RV
Ficus dicranostyla	Tree	500-600	IL	No information	TRF
Ficus salicifolia	Tree or shrub	900-2300	TU GD GJ SU HA	No information	CTW; DAF/WG
Ficus ingens	Tree or shrub	600-2050	TU GD GJ SU HA IL SD	No information	?ACB; CTW; DAF/WG
Ficus ovata	Tree	1300-2000	GD GJ WG KF SD GG	No information	DAF/U-WG; MAF/P-BW; RV
Ficus glumosa	Tree or shrub	500-1650	TU GD GJ HA IL SD	No information	ACB; CTW
Ficus lutea	Tree	900-1500	KF IL GG	No information	MAF/P-BW; TRF; RV
Ficus umbellata	Tree	1100-1300	KF IL	No information	TRF
Ficus populifolia	Tree or shrub	600-1600	TU GD GJ SD	No information	?ACB; CTW; DAF/WG
Ficus platyphylla	Tree	600	GG IL	No information	TRF
Ficus abutilifolia	Tree	c. 800	GD	No information	?CTW
Ficus vasta	Tree	1000-2400	TU WU GD GJ WG SU AR HA IL KF GG SD	No information	DAF/WG; RV
Ficus thonningii	Tree or shrub	1300-2200	TU WU GD WG SU AR BA HA IL KF GG SD	No information	DAF/U; MAF/P-BW; RV
Trilepisium madagascariense	Tree	900-1800	WG KF IL	No information	TRF
Antiaris toxicaria subsp. *welwitschii* var. *welwitschii*	Tree	550-1400	KF IL	No information	TRF
URTICACAE					
Urera hypselodendron	Liana	1700-2800	TU GD GJ WG SU HA BA AR KF IL	No information	DAF/U-SD-WG
Urera trinervis	Liana	900-1300	KF IL	No information	TRF
Pouzolzia mixta	Shrub	1300-1500	GD SU HA	No information	ACB; CTW
Debregeasia saeneb	Shrub	1500-2700	TU GD SU HA	No information	DAF/WG; RV
AQUIFOLIACEAE					
Ilex mitis var. *mitis*	Tree or shrub	1575-3000	WG SU IL KF AR BA HA	Undifferentiated Afromontane forest; Afromontane bamboo	DAF/U; MAF/P; RV

CELASTRACEAE					
Maytenus gracilipes subsp. *arguta*	Tree or shrub	1250-2800	GD GJ WG SU BA IL KF GG SD	No information	DAF/U-WG; MAF/P-BW
Maytenus serrata	Tree or shrub	1650-2250	TU GD GJ	No information	DAF/WG
Maytenus parviflora subsp. *eritreana*		450-2000	EW	No information	DAF/WG-TR
Maytenus addat	Tree or shrub	2200-3000	SU AR SD GG	No information	DAF/U; MAF/P
Maytenus obscura	Tree or shrub	1700-3100	TU GD GJ WG SU AR BA IL KF SD	No information	DAF/WG; EB
Maytenus corttii		c. 3500	GD	No information	AA
Maytenus harenensis	Tree or shrub	1600-3050	BA	No information	DAF/U; MAF/P
Maytenus buchananii	Shrub	c. 2000	SD	No information	DAF/WG
Maytenus arbutifolia var. *arbutifolia*	Tree or shrub	1200-3000	TU GD WU GJ WG SU HA AR BA IL KF	No information	DAF/U-WG
Maytenus arbutifolia var. *sidamoensis*	Tree or shrub	1600-2150	SD	No information	DAF/WG
Maytenus putterlickioides	Tree or shrub	1000-1200	SD	No information	ACB
Maytenus senegalensis	Tree or shrub	380-2440	TU GD WU GJ WG SU HA AR BA IL KF GG SD	No information	ACB (incl. ACB/RV); CTW; DAF/WG
Maytenus heterophylla	Tree or shrub	1500-2620	GJ WG SU HA AR BA SD	East African evergreen and semi-evergreen bushland and thicket	DAF/WG
Maytenus undata	Tree or shrub	920-3100	TU GD GJ WG SU HA AR BA KF GG SD	No information	DAF/U-SD; MAF/P; ?EB
Mystroxylon aethiopicum	Tree or shrub	c. 1700	SD	No information	DAF/TR
Catha edulis	Tree or shrub	1400-2100	TU WU WG SU HA SD	No information	DAF/TR
Elaeodendron buchananii	Tree or shrub	1000-2250	KF IL	East African evergreen and semi-evergreen bushland and thicket	MAF/P; TRF
Elaeodendron aquifolium	Shrub	c. 1350	SD	No information	ACB
Hippocratea goetzei	Liana	1750-2100	WG IL KF GG SD	No information	MAF/P; ?TRF
Hippocratea africana var. *schimperiana*	Liana	1700-2300	GD WU WG SU IL KF GG AR HA SD	No information	DAF/U; MAF/P-BW
Hippocratea africana var. *richardiana*	Liana	1100	HA	No information	ACB

Hippocratea parvifolia	Tree, shrub or liana	1350	WG KF	No information	TRF
Hippocratea pallens		400-1700	IL KF GG	No information	MAF/P; TRF
Salacia congolensis	Shrub or liana	920-1400	WG IL KF	No information	MAF/P; TRF
ICACINACEAE					
Apodytes dimidiata var. *acutifolia*	Tree	1350-2600	TU GD SU AR GJ WG IL KF GG SD BA HA	Undifferentiated Afromontane forest; Dry transitional montane forest	DAF/U-WG; MAF/P-BW; RV
Raphiostylis beninensis	Liana	1000-1250	WG IL	No information	TRF
Pyrenacantha malvifolia	Liana	900-1400	HA BA SD	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	ACB
Pyrenacantha sylvestris	Liana	c. 1100	KF	No information	TRF
SALVADORACEAE					
Dobera glabra	Tree or shrub	400-1250	SU GG HA BA SD	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	DSS; ACB
Salvadora persica	Shrub	0-1300	AF SU KF GG SD HA	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	DSS; ACB; RV
OLACACEAE					
Ximenia americana	Tree or shrub	500-2450	TU GD WU SU AR GJ WG IL KF GG SD BA HA	No information	ACB; CTW
Ximenia caffra var. *caffra*	Tree or shrub	1200-1750	IL GG SD BA HA	No information	ACB; CTW
Ximenia caffra var. *natalensis*	Tree or shrub	400-1300	KF GG SD BA	No information	ACB; RV
OPILIACEAE					
Opilia amentacea	Liana	500-1935	WG IL KF GG SD	No information	DAF/WG; RV
Opilia campestris var. *campestris*	Tree or shrub	200-500	BA	No information	?
Opilia campestris var. *strobilifera*	Tree or shrub	c. 1000	HA	No information	ACB

SANTALACEAE					
Osyris quadripartita	Tree or shrub	1600-2900	TU GD WU GJ WG SU KF GG AR HA BA SD	No information	DAF/U-WG
Osyridocarpus schimperianus	Liana	1200-2050	TU GJ SU KF HA SD	No information	DAF/WG
RHAMNACEAE					
Helinus integrifolius	Liana	500-1450	SU GG SD BA HA	No information	ACB
Helinus mystacinus	Liana	750-2600	TU GD WU SU AR GJ WG IL KF GG SD BA HA	No information	?CTW; DAF/WG; RV
Gouania longispicata		1000-2350	GJ SU WG AR IL KF SD BA HA	No information	DAF/U-WG; MAF/P-BW; TRF; RV
Sageretia thea	Shrub	1000-2500	TU WU AR HA	No information	CTW: DAF/SD-TR
Scutia myrtina	Tree, shrub or liana	1500-1900	SU AR SD BA	East African evergreen and semi-evergreen bushland and thicket	DAF/U-WG; RV
Rhamnus prinoides	Tree or shrub	1175-3200	TU GD WU SU AR GJ WG IL KF GG SD BA HA	No information	DAF/ U-SD-WG; MAF/P; EB; RV
Rhamnus staddo	Tree or shrub	1400-2900	TU GD SU AR KF GG SD BA HA	No information	DAF/WG; MAF/BW
Berchemia discolor	Tree	550-1900	WU SU GG BA HA	No information	ACB; DAF/TR; RV
Ziziphus pubescens	Tree	400-650	IL GG	No information	TRF; RV
Ziziphus mucronata	Tree or shrub	100-2100	GD GJ WU SU AR IL KF GG SD BA HA	No information	ACB; CTW; RV
Ziziphus spina-christi	Tree or shrub	0-2400	AF TU GD WU SU GG SD BA	No information	DSS; ACB; DAF/WG
Ziziphus abyssinica	Tree or shrub	450-2000	TU GD SU GJ WG IL KF GG SD BA	No information	CTW; DAF/WG
Ziziphus mauritiana	Tree or shrub	400-1600	IL GG SD BA HA	No information	ACB; RV
Ziziphus hamur	Shrub	250-400	BA HA	No information	DSS; ACB
Ventilago diffusa	Liana	1050-1300	IL KF	No information	TRF
VITACEAE					
Rhoicissus tridentata	Liana	1275-2400	TU GD WU SU GJ WG KF SD BA HA	No information	ACB; CTW; DAF/ SD-WG
Rhoicissus revoilii	Liana	750-1850	WU SU WG IL KF GG SD BA HA	No information	ACB; CTW; RV

Cissus aphylla	Liana	250-600	SD BA HA	No information	DSS; ACB
Cissus aphyllantha	Liana	500-1500	SD BA	No information	ACB
Cissus ellenbeckii	Liana	300-650	SD HA	No information	DSS; ACB
Cissus petiolata	Liana	600-2400	TU GD SU AR GJ WG IL KF GG SD BA HA	No information	ACB; CTW; DAF/WG; RV
Cissus populnea	Liana	650-850	GD IL	No information	CTW
Cissus rotundifolia	Liana	150-1900	AF WU SU KF GG SD BA HA	No information	DSS; ACB; RV
Cyphostemma boranense	Liana	850-1300	SD	No information	ACB
RUTACEAE					
Zanthoxylum chalybeum var. *chalybeum*	Tree	900-1550	GG BA HA	No information	ACB
Zanthoxylum leprieurii	Tree	500-550	IL	No information	TRF
Zanthoxylum usambarense	Tree or shrub	1650-2100	SD HA	No information	DAF/SD-WG
Zanthoxylum gilletii	Tree	c. 1300	WG	No information	?TRF; RV
Fagaropsis hildebrandtii	Tree or shrub	1500-1700	SD HA	No information	ACB; DAF/SD-TR
Fagaropsis angolensis	Tree or shrub	1300-1900	WG IL SD BA	Dry transitional montane forest	DAF/U; MAF/P; TRF
Toddalia asiatica	Liana	550-3300	WU SU AR KF SD HA	No information	DAF/U-WG; EB; RV
Vepris dainellii	Tree or shrub	1050-2500	GJ SU WG IL KF SD BA	No information	DAF/U; MAF/P; TRF
Vepris glomerata var. *glomerata*	Tree or shrub	1350-1550	SD BA HA	No information	ACB
Vepris glomerata var. *glabra*	Tree or shrub	c. 1450	SD	No information	ACB
Vepris eugenifolia	Shrub	500-1400	GG BA	No information	ACB
Teclea nobilis	Tree or shrub	900-2250	SU WG KF GG HA	No information	DAF/U-SD; MAF/P; RV
Teclea boranensis	Tree	800-1250	SD	No information	ACB; RV
Teclea simplicifolia	Tree	1450-2100	WU SU SD BA HA	No information	DAF/U-SD-WG
Clausena anisata	Tree	1500-2300	TU GD GJ SU WG IL KF SD	No information	DAF/U-SD-WG; MAF/P-BW

BALANITACEAE					
Balanites aegyptiaca var. *aegyptiaca*	Tree	700-1800	TU WU SU AR HA IL GG SD	Sudanian undifferentiated woodland; Transition from undifferentiated woodland to Acacia deciduous bushland and wooded grassland; Sahel wooded grassland	ACB; CTW; WGG
Balanites aegyptiaca var. *pallida*	Tree	0-1250	AF SU	No information	DSS; ACB
Balanites glabra	Tree or shrub	1250-1700	HA	No information	ACB
Balanites rotundifolia var. *rotundifolia*	Tree or shrub	300-1500	AF GG SD	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	ACB
Balanites pedicellaris subsp. *somalensis*	Tree or shrub	250-1200	HA BA SD	No information	DSS; ACB
SIMAROUBACEAE					
Harrisonia abyssinica	Tree or shrub	0-1700	SU KF BA IL GG SD	No information	ACB; CTW; WGG
Kirkia tenuifolia	Tree or shrub	?-1000	HA BA SD	No information	ACB
Kirkia burgeri subsp. *burgeri*	Tree or shrub	1100-1400	SD BA HA	No information	ACB
Brucea atidysenterica	Tree or shrub	1650-2800	TU GD WG SU AR IL KF SD BA HA	No information	DAF/U-WG; MAF/P-BW
BURSERACEAE					
Boswellia papyrifera	Tree	950-1800	TU GD GJ SU	Sudanian undifferentiated woodland	CTW
Boswellia pirottae	Tree	1200-1800	GD GJ WU SU KF	No information	CTW
Boswellia rivae	Tree or shrub	250-800	SD BA HA	No information	DSS; ACB
Boswellia ogadensis	Tree	300-400	HA	No information	DSS; ACB
Boswellia neglecta	Tree or shrub	600-1750	GG SD BA HA	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	ACB
Boswellia microphylla	Tree or shrub	400-1300	SD BA HA	No information	ACB
Commiphora erlangeriana	Tree or shrub	250-700	SD BA	No information	DSS; ACB
Commiphora staphyleifolia	Shrub	250-400	SD BA	No information	DSS

Commiphora unilobata	Shrub	c. 250	SD	No information	DSS
Commiphora guidottii	Tree or shrub	250-400	SD BA	No information	DSS
Commiphora longipedicellata	Tree or shrub	250-400	SD BA HA	No information	DSS
Commiphora boiviniana	Tree or shrub	400-1200	GG SD	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	ACB
Commiphora erythraea	Tree	0-1900	AF SU AR GG SD BA HA	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	DSS; ACB
Commiphora sphaerophylla	Tree	400-800	HA	No information	ACB
Commiphora myrrha	Tree or shrub	250-1300	AF SD BA HA	No information	DSS; ACB
Commiphora samharensis	Tree or shrub	150-400	GG	No information	DSS
Commiphora terebinthina	Tree	900-1800	SU KF GG SD BA HA	No information	ACB
Commiphora schimperi	Tree or shrub	900-1850	TU GD WU SU GJ SU KF AR GG SD BA HA	No information	ACB; CTW;
Commiphora obovata	Tree or shrub	750-1050	SD HA	No information	ACB
Commiphora africana var. *africana*	Tree or shrub	150-2100	AF TU GD WU SU KF GG SD BA HA	Sudanian undifferentiated woodland; Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	DSS; ACB; DAF/TR
Commiphora africana var. *rubriflora*	Tree or shrub	700-1900	GG SD	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	ACB; DAF/TR
Commiphora tubuk	Tree or shrub	1100-1500	SU HA	No information	ACB
Commiphora monoica	Tree	1250-1400	BA	No information	ACB
Commiphora pedunculata	Tree or shrub	500-1000	GD GJ WG	No information	CTW
Commiphora hildebrandtii	Tree or shrub	850-1500	SD BA	No information	ACB
Commiphora ogadensis	Tree or shrub	850-1500	SD BA HA	No information	ACB
Commiphora corrugata	Tree or shrub	300-1800	SD BA HA	No information	DSS; ACB
Commiphora truncata	Tree or shrub	600-1050	HA	No information	ACB

Commiphora confusa	Tree	600-1300	GG SD BA	No information	ACB
Commiphora alaticaulis	Tree or shrub	400-1400	SD BA HA	No information	ACB
Commiphora rostrata	Tree or shrub	400-1400	GG SD BA HA	No information	ACB
Commiphora ciliata	Tree	750-1250	SD BA	No information	ACB
Commiphora erosa	Tree or shrub	250-325	SD BA	No information	DSS; ACB
Commiphora sphaero-carpa	Tree or shrub	250-400	SD BA	No information	DSS
Commiphora sp.= Gilbert *et al.* 8170	Tree or shrub	c. 300	BA	No information	DSS
Commiphora mildbraedii	Tree	1300-1400	BA	No information	ACB
Commiphora cyclophylla	Tree or shrub	400-1350	SD BA HA	No information	ACB
Commiphora campestris	Tree	c. 1000	SD	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	ACB
Commiphora serrulata	Tree or shrub	1250-1850	SD BA HA	No information	ACB
Commiphora tenuis	Shrub	1000-1800	SD BA	No information	ACB
Commiphora quadri-cincta	Tree or shrub	600-1000	AF EW	No information	ACB
Commiphora hodal	Tree	400-650	HA	No information	ACB
Commiphora habessinca	Tree or shrub	150-1900	AF TU WU GD GJ SU WG IL GG SD BA HA	No information	DSS; ACB
Commiphora sp. = Corradii 6767, 6768	Tree or shrub	c. 1000	GG	No information	ACB
Commiphora bruceae	Tree or shrub	250-1350	GG SD HA	No information	DSS; ACB
Commiphora ellenbeckii	Tree or shrub	300-1200	SD BA HA	No information	DSS; ACB
Commiphora kua	Tree or shrub	0-1400	AF SD BA HA	No information	DSS; ACB
Commiphora incisa	Tree or shrub	300-1250	SD BA HA	No information	DSS; ACB
Commiphora sp. = Friis *et al.* 3160	Shrub	400-1450	SD HA	No information	ACB
Commiphora gowlello	Shrub	350-1400	SD BA HA	No information	DSS; ACB
Commiphora horrida	Shrub	c. 500	HA	No information	ACB

Commiphora ancistrophora	Tree or shrub	400-1050	SD HA	No information	ACB
Commiphora boranensis	Tree or shrub	850-1500	SD BA HA	No information	ACB
Commiphora sp.= Gilbert *et al.* 7652	Shrub	c. 750	SD	No information	ACB
Commiphora sp.= Gilbert *et al.* 8171	Shrub	c. 300	BA	No information	DSS
Commiphora gileadensis	Tree or shrub	0-750	HA	No information	DSS; ACB
Commiphora albiflora	Tree or shrub	700-1000	SD BA	No information	ACB
Commiphora coronillifolia	Tree or shrub	400-1300	AF SD HA	No information	ACB
Commiphora sp. = Glover & Gilliland 973	Shrub	c. 600	HA	No information	ACB
MELIACEAE					
Pseudocedrela kotschyi	Tree	c. 500	GD IL	No information	CTW
Turraea mombassana	Tree	c. 1450	GG SD	East African evergreen and semi-evergreen bushland and thicket	DAF/TR
Turraea nilotica	Tree or shrub	c. 550	IL	No information	?WGG; CTW
Turraea abyssinica	Tree or shrub	c. 2000	TU	No information	DAF/WG
Turraea holstii	Tree or shrub	1300-2500	GD GJ WG SU AR IL KF SD BA HA	No information	DAF/U-SD; MAF/P; RV
Turraea parvifolia	Shrub	?	?HA	No information	ACB
Trichilia retusa	Tree	600-650	IL	No information	RV
Trichilia prieuriana	Tree	500-1300	IL KF	No information	TRF
Trichilia dregeana	Tree	1150-1900	WG IL KF	No information	MAF/P; TRF
Trichilia emetica	Tree	450-1350	GJ SU IL GG SD HA	No information	RV
Melia volkensii	Tree	c. 1300	SD	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	ACB
Lepidotrichilia volkensii	Tree	1050-2800	GJ WG AR SU IL KF SD BA HA	Afromontane bamboo	DAF/U; MAF/P; RV
Ekebergia capensis	Tree	1680-3000	TU WU GD GJ WG SU AR IL KF SD BA HA	No information	DAF/U-SD; MAF/P-BW

SAPINDACEAE					
Erythrophysa septentrionalis	Tree or shrub	600-800	HA	No information	ACB
Dodonaea angustifolia	Shrub	500-2900	TU GD WUSU AR GJ WG KF GG SD BA HA	East African evergreen and semi-evergreen bushland and thicket	DAF/U-SD-WG-TR
Zanha golungensis	Tree	500-1200	IL KF	No information	TRF; RV
Filicium decipiens	Tree	1500-1800	BA	No information	?MAF/P; RV
Paullinia pinnata	Liana	550-2300	GD GJ SU WG IL KF GG SD BA	No information	DAF/U-WG; RV
Cardiospermum corindum		200-2100	TU GD WU SU GJ GG SD BA HA	No information	DAF/WG; RV
Allophylus abyssinicus	Tree	1450-3000	TU GD WU GJ SU WG AR KF SD BA HA	No information	DAF/U-SU; MAF/P-BW; RV
Allophylus africanus	Tree or shrub	600-1800	SU KF GG	No information	CTW; RV
Allophylus macrobotrys		1400-2500	GJ SU WG IL KF AR SD BA	No information	MAF/P
Allophylus rubifolius	Tree or shrub	400-2000	TU GD SU GJ IL GG SD BA HA	No information	ACB; CTW; DAF/WG
Allophylus sp. = Mooney 9003	Tree or shrub	1600-2075	GD SU AR WG IL KF SD	No information	DAF/U; RV
Deinbollia kilimandscharica	Tree	1150-2000	GJ WG IL KF	No information	DAF/U; MAF/P; TRF
Lepisanthes senegalensis	Tree	400-1600	GD GJ WG IL GG SD	No information	TRF; RV
Bottegoa insignis	Tree or shrub	1150-1300	BA HA	No information	ACB
Lecaniodiscus fraxinifolius subsp. *vaughanii*	Tree	500-1400	GJ IL KF GG	No information	TRF; RV
Haplocoelum foliolosum	Tree	650-2000	IL KF GG SD BA	No information	DAF/TR; RV
Pappea capensis	Tree	1200-2300	SU AR GG SD BA HA	No information	CTW; DAF/TR
Blighia unijugata	Tree	500-1700	IL KF GG	No information	MAF/P; TRF; RV
MELIANTHACEAE					
Bersama abyssinica subsp. *abyssinica*	Tree	1700-2700	TU GD WU WG GJ SU IL KF AR HA BA SD	No information	DAF/U-SD-WG; MAF/P-BW; RV

ANACARDIACEAE					
Lannea triphylla	Tree or shrub	300-1500	TU GG SD BA HA	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	DSS; ACB
Lannea rivae	Tree or shrub	1350-1900	GG SD BA	No information	ACB; DAF/WG
Lannea malifolia	Tree	c. 1000	HA	No information	ACB
Lannea humilis	Tree	1200-1350	WU SU	No information	ACB
Lannea schimperi	Tree	800-2200	TU GD GJ SU WG KF SD BA HA	Sudanian undifferentiated woodland	CTW; DAF/WG
Lannea barteri	Tree	500-1600	GD SU IL KF GG	No information	CTW; RV
Lannea fruticosa	Tree	600-2100	TU GD WU SU KF GG SD	No information	CTW; DAF/WG
Lannea schweinfurthii var. *schweinfurthii*	Tree or shrub	600-1550	IL GG SD BA HA	No information	CTW
Lannea welwitschii var. *welwitschii*	Tree	1100-1250	IL KF	No information	TRF
Sclerocarya birrea subsp. *birrea*	Tree	500-1700	TU SU IL GG SD	No information	CTW
Ozoroa insignis subsp. *insignis*	Tree or shrub	1350-2000	TU GD SU GG SD BA HA	No information	ACB; CTW; DAF/WG
Ozoroa pucherrima	Shrub	650-1400	GJ WG IL	No information	CTW
Rhus natalensis	Shrub	700-2500	TU GD WU SU AR IL GG SD BA HA	East African evergreen and semi-evergreen bushland and thicket	ACB; CTW; DAF/SD-WG
Rhus tenuinervis	Shrub	1200-1650	GG SD BA	No information	ACB; CTW
Rhus quartiniana var. *quartiniana*	Shrub	900-1800	TU GD GJ SU WG IL KF BA	No information	DAF/WG; RV
Rhus sp. = Friis *et al.* 1147	Shrub	c. 1650	SU	No information	DAF/WG
Rhus longipes var. *longipes*	Shrub	1200-1650	IL BA SD	No information	CTW; RV
Rhus ruspolii	Tree or shrub	1200-2150	SU GJ WG IL KF GG SD BA	No information	CTW; DAF/WG
Rhus glutinosa subsp. *abyssinica*	Tree or shrub	1500-2600	TU	No information	DAF/WG
Rhus glutinosa subsp. *glutinosa* var. *glutinosa*	Tree or shrub	1800-3300	TU GD GJ	No information	DAF/WG; EB
Rhus glutinosa subsp. *glutinosa* var. *unifoliolata*	Tree or shrub	c. 2400	GJ	No information	DAF/WG
Rhus glutinosa subsp. *neoglutinosa*	Tree or shrub	1500-2700	WU SU AR BA HA	No information	DAF/WG

Rhus retinorrhoea	Tree or shrub	1450-2700	TU WU SU HA	No information	ACB; DAF/WG
Rhus vulgaris	Tree or shrub	1500-2800	GD WU GJ SU AR WG KF SD BA HA	No information	ACB; CTW; DAF/WG
Pistacia aethiopica	Tree or shrub	1350-2550	GG SD BA	East African evergreen and semi-evergreen bushland and thicket	DAF/TR
Pistacia falcata	Tree	1100-2600	SU	No information	DAF/TR
ALANGIACEAE					
Alangium chinense	Tree	c. 2000	BA	No information	MAF/P
ARALIACAEAE					
Polyscias fulva	Tree	?800-2450	SU IL KF AR SD	No information	MAF/P; TRF
Polyscias farinosa	Tree	1700-2000	TU GD SU KF	No information	CTW
Cussonia arborea	Tree	1000-2300	TU GD WG KF AR	No information	CTW; DAF/WG
Cussonia holstii	Tree	1500-2600	SU KF AR HA BA SD	East African evergreen and semi-evergreen bushland and thicket	DAF/U-TR-WG
Cussonia ostinii	Tree	1500-2100	GD GJ WG KF	No information	CTW; DAF/WG
Schefflera volkensii	Tree	1600-3200	SU AR IL KF GG	No information	DAF/U; MAF/P
Schefflera myriantha		1600-3400	WG SU BA IL KF	No information	DAF/U; MAF/P
Schefflera abyssinica	Tree	1450-2800	TU GD WG SU AR HA IL KF SD	No information	DAF/U; MAF/P
APIACAE					
Steganotaenia araliacea	Tree	1300-2100	GD GJ AR WG SU SD HA	No information	ACB; CTW; DAF/WG
Heteromorpha arborescens var. *abyssinica*	Shrub	1500-2500	GD GJ WU SU GG SD HA	No information	DAF/U-SD-WG-TR
ERICACEAE					
Erica arborea	Tree or shrub	2200-3900	GD GJ WU SU AR KF SD BA HA	Afromontane evergreen bushland and thicket; Afromontane and Afroalpine shrubland	DAF/U-SD; EB; AA
Erica trimera	Tree or shrub	3200-4200	GJ SU AR GG BA	Afromontane evergreen bushland and thicket; Afromontane and Afroalpine shrubland	DAF/SD; EB; AA
Agarista salicifolia	Tree or shrub	1600-3200	SU AR KF	No information	DAF/U-WG

EBENACEAE					
Diospyros abyssinica subsp. *abyssinica*	Tree	500-2500	TU GD GJ SU AR WG KF SD BA HA	Afromontane rain forest; Dry transitional montane forest	DAF/U; MAF/P; TRF; RV
Diospyros mespeliformis	Tree	300-2000	TU GD GJ SU WG IL KF SD BA	No information	CTW; RV
Diospyros scabra	Tree	650-1000	GG SD	No information	RV
Euclea racemosa subsp. *schimperi*	Tree or shrub	700-2900	TU GD GJ WU SU KF SD BA HA	East African evergreen and semi-evergreen bushland and thicket	DAF/SD-TR-WG
Euclea divinorum	Tree or shrub	1000-2400	SU AR WG KF GG SD	Dry transitional montane forest; East African evergreen and semi-evergreen bushland and thicket	ACB; DAF/U-SD-TR-WG
SAPOTACEAE					
Mimusops kummel	Tree	550-2500	TU GD GJ WU SU AR WG IL KF GG SD BA HA	No information	DAF/U; MAF/P; RV
Mimusops laurifolia	Tree	750-1850	TU WU SU HA	No information	DAF/SD-TR; RV
Vitellaria paradoxa	Tree	500-1000	IL	No information	CTW
Manilkara butugi	Tree	1200-2150	WG IL KF SD	No information	MAF/P; TRF
Sideroxylon oxyacanthum	Tree or shrub	1250-2800	TU GD SU AR BA HA	No information	ACB; DAF/U; DAF/SD-TR
Sideroxylon mascatense	Tree or shrub	1200-2150	SD HA	East African evergreen and semi-evergreen bushland and thicket	ACB; DAF/SD-TR
Pouteria alnifolia	Tree	550-1600	IL KF GG	No information	MAF/P; TRF
Pouteria adolfi-friederici	Tree	1350-2450	SU AR WG IL KF GG SD BA	Afromontane rain forest	MAF/P
Pouteria altissima	Tree	1000-1500	WG IL KF	No information	TRF
MYRSINACEAE					
Maesa lanceolata	Tree or shrub	1350-3000	TU GD GJ WU SU AR WG IL KF SD BA HA	No information	DAF/U-SD-WG; MAF/BW; RV
Myrsine africana	Tree or shrub	1900-3800	TU GD GJ WU SU AR KF SD BA HA	No information	DAF/U; EB; AA
Myrsine melanophloeos	Tree or shrub	2500-3750	TU GD GJ SU AR WG GG BA	Undifferentiated Afromontane forest; Afromontane bamboo	DAF/U-SD; EB; AA
Embelia schimperi	Tree or liana	1700-2800	GD GJ SU AR WG IL KF GG SD BA	No information	DAF/U; RV

LOGANIACEAE					
Anthocleista schweinfurthii	Tree	1000-1350	IL KF	No information	TRF
Buddleja polystachya	Tree or shrub	700-3300	TU GD GJ WU SU AR WG KF SD BA HA	No information	DAF/SD-WG; EB
Nuxia congesta	Tree or shrub	1100-3800	TU GD GJ WU SU AR WG IL KF SD BA HA	Undifferentiated Afromontane forest; Afromontane bamboo	DAF/U-SD-WG; MAF/P-BW; EB; ?AA
Nuxia oppositifolia	Tree or shrub	800-2400	TU SU AR GG SD HA	No information	RV
Strychnos henningsii	Tree or shrub	550-1550	IL SD BA	No information	CTW
Strychnos innocua	Tree or shrub	600-1600	TU GD GJ SU WG IL GG SD	No information	CTW
Strychnos mitis	Tree	1250-2100	IL KF GG SD BA	No information	MAF/P;TRF; RV
Strychnos spinosa	Tree or shrub	600-650	TU IL	No information	CTW; RV
OLEAEAE					
Olea europaea subsp. *cuspidata*	Tree or shrub	1250-3000	AF TU GD WU SU KF GG SD BA HA	Dry transitional montane forest; East African evergreen and semi-evergreen bushland and thicket	DAF/U-SD-TR-WG
Olea capensis subsp. *macrocarpa*	Tree	1350-3200	GD SU AR IL KF SD BA	Afromontane rain forest	DAF/U; MAF/P; ?EB
Olea welwitschii	Tree	1350-2200	SU WG IL KF SD BA HA	Afromontane rain forest	?DAF/U; MAF/P
Chionanthus mildbraedii	Tree or shrub	950-2500	GD WG SU AR IL KF SD BA	No information	DAF/U; MAF/P
Schrebera alata	Tree or shrub	1500-2500	TU GD SU AR IL KF SD BA HA	Dry transitional montane forest; East African evergreen and semi-evergreen bushland and thicket	DAF/U-SD-TR-WG
Jasminum dichotomum	Liana	?	TU GD	No information	DAF/WG
Jasminum schimperi	Liana	1200-2050	GD SU KF GG SD HA	No information	DAF/WG; RV
Jasminum streptopus	Liana	550-1700	TU GJ SU IL GG SD	No information	?WGG; CTW; DAF/WG
Jasminum abyssinicum	Liana	1700-2800	TU GD GJ SU AR WG IL KF SD BA HA	No information	DAF/U-WG

Jasminum fluminense subsp. *gratissimum*	Liana	1300-2000	AF SU KF HA	No information	ACB; DAF/WG
Jasminum grandiflorum subsp. *floribundum*	Liana	1600-2800	TU GD GJ WU SU AR GG SD HA	No information	ACB; DAF/WG
Jasminum stans	Shrub	2400-2900	SU AR	No information	DAF/U-SD
APOCYNACEAE					
Acokanthera schimperi	Tree or shrub	800-2100	TU GD GJ WU SU AR SD BA HA	East African evergreen and semi-evergreen bushland and thicket	ACB; DAF/SD-TR-WG
Adenium obesum	Tree or shrub	300-1400	KF GG SD BA HA	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	DSS; ACB
Alstonia boonei	Tree	1000-1200	IL KF	No information	TRF
Carissa spinarum	Shrub	550-2500	AF TU GD GJ WU SU AR WG KF GG SD BA HA	East African evergreen and semi-evergreen bushland and thicket	ACB; DAF/U-SD-WG; MAF/BW; RV
Landolphia buchananii	Liana	1300-2000	SU AR WG IL KF SD BA	No information	?DAF/WG; MAF/P; RV
Oncinotis tenuiloba	Liana	?-1800	SU AR IL KF	No information	TRF; RV
Saba comorensis	Liana	550-2000	GD SU WG IL KF GG BA	No information	ACB; CTW; RV
Wrightia demartiniana	Tree or shrub	300-1100	SD HA	No information	DSS; ACB
ASCLEPIADACAE					
Buckollia volubilis	Liana	400-1300	KF GG SD HA	No information	ACB; CTW
Buckollia tomentosa	Liana	1400-1800	GG	No information	ACB
Periploca linearifolia	Liana	600-2900	TU GD WU SU AR WG IL KF SD HA	No information	ACB; ?CTW; DAF/U-WG
Periploca visciformis	Shrub	1200-1700	HA	No information	ACB
Tacazzea apiculata	Liana	0-2000	GD SU WG IL KF GG SD	No information	RV
Tacazzea conferta	Liana	1300-3000	GD SU AR KF SD	No information	DAF/WG; MAF/P; RV
Tacazzea venosa	Shrub	800-1500	TU GD GJ	No information	RV
Secamone punctulata	Shrub or liana	900-2000	IL KF GG SD HA	No information	RV
Secamone parvifolia	Liana	900-1700	SU GD SD BA HA	No information	ACB

Calotropis procera	Shrub	0-2250	AF TU GJ WU SU AR IL GG SD BA HA	No information	DSS; ACB; RV
Kanahia laniflora	Shrub	600-2500	AF TU GD GJ SU AR IL KF GG SD BA HA	No information	RV
Kanahia carlsbergiana	Shrub	1300-1900	AR BA	No information	RV
Gomphocarpus semilunatus	Shrub	1300-2000	TU GD GJ SU AR WG IL KF GG SD	No information	RV
Gomphocarpus fruticosus subsp. *flavidus*	Shrub	1200-2000	WU SU AR GG SD BA HA	No information	ACB; ?CTW; DAF/WG
Gomphocarpus fruticosus subsp. *setosus*	Shrub	?	TU	No information	?
Gomphocarpus purpurascens	Shrub	1500-2500	TU GD GJ SU AR KF HA	No information	?ACB; DAF/WG
Gomphocarpus abyssinicus	Shrub	1500-2500	TU GD GJ WG KF	No information	?ACB; DAF/WG
Gomphocarpus integer	Shrub	800-1800	AF SU AR GG SD BA HA	No information	?ACB; DAF/WG
Gomphocarpus stenophyllus	Shrub	1800-2000	GG SD	No information	DAF/WG
Pergularia daemia	Liana	700-1900	AF TU GJ SU KF GG SD HA	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	ACB
Tylophora heterophylla	Liana	2200-3670	TU GJ SU	No information	DAF/U-WG; ?EB; RV
Tylophora oblonga	Liana	C. 1500	KF	No information	RV
Tylophora sylvatica	Liana	600-1500	IL KF	No information	RV
Pentarrhinum abyssinicum subsp. *abyssinicum*	Liana	700-2000	TU KF SD	No information	ACB; DAF/WG
Pentarrhinum insipidum	Liana	700-2200	TU SU AR GG SD HA	No information	ACB; DAF/WG
Pentarrhinum balense	Liana	C. 3260	BA	No information	?MAF/P; ?EB
Pentarrhinum somaliense	Liana	350-1700	SU SD BA HA	No information	ACB
Pentarrhinum gonoloboides	Liana	c. 3000	SD	No information	DAF/SD
Cynanchum garrardii	Liana	0-1500	AF SU IL GG SD BA	No information	DSS; ACB
Cynanchum lennewtonii	Liana	c. 1400	SD	No information	ACB
Cynanchum abyssinicum	Liana	1700-3000	TU GD GJ SU AR WG IL GG HA	No information	DAF/WG
Cynanchum altiscandens	Liana	1000-2600	GD SU SD BA HA	No information	ACB; DAF/WG
Cynanchum clavidens subsp. *clavidens*	Liana	250-1400	HA	No information	DSS; ACB

Cynanchum clavidens subsp. *hastifolium*	Liana	200-1600	TU SU GG SD	No information	DSS; ACB
Sarcostemma vanlessenii	Liana	1500-2300	SD	No information	?ACB: DAF/WG
Sarcostemma viminale subsp. *viminale*	Liana	0-1000	EE	East African evergreen and semi-evergreen bushland and thicket; Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	DSS; ACB
Sarcostemma viminale subsp. *stipitaceum*	Liana	200-2000	SD HA	East African evergreen and semi-evergreen bushland and thicket; Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	DSS; ACB; DAF/WG
Sarcostemma viminale subsp. *suberosum*	Liana	1000-2000	TU	East African evergreen and semi-evergreen bushland and thicket; Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	ACB; DAF/WG
Sarcostemma viminale subsp. *odontolepis*	Liana	c. 760	HA	East African evergreen and semi-evergreen bushland and thicket; Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	DSS; ACB
Dregea abysinica	Liana	0-1650	TU GD SU IL KF GG SD HA	No information	RV
Dregea rubicunda	Liana	0-1350	AF GG SD HA	No information	DSS; ACB
Dregea schimperi	Liana	1600-2400	GD SU WG AR KF SD BA HA	No information	DAF/WG
Dregea stelostigma	Liana	800-1200	SD HA	No information	ACB
Gongonema angolense	Liana	1300-1700	GJ KF	No information	DAF/WG; RV
Gymnema sylvestre	Liana	0-1600	TU GD IL GG	No information	RV
Stigmatorhynchus sp. = J. de Wilde 7216	Shrub	c. 1500	HA	No information	ACB
Leptadenia pyrotechnica	Shrub	0-700	AF HA	Sahel wooded grassland	DSS; ACB
Leptadenia arborea	Shrub or liana	250-1400	AF TU GD GJ SU SD BA HA	No information	DSS; ACB
Leptadenia hastata	Liana	300-1600	TU GD GJ SU IL KF GG SD BA	No information	DSS; ACB

RUBIACEAE					
Psychotria capensis subsp. *riparia* var. *puberula*	Tree or shrub	1150-1300	IL BA	No information	RV
Psychotria sp. = Mooney 9252	Shrub	c. 1350	KF	No information	TRF
Psychotria orophila	Tree or shrub	1600-2700	SU AR WG IL KF GG SD BA HA	No information	DAF/U; MAF/P
Psychotria kirkii var. *nairobiensis*	Shrub	920-1920	SU WG KF GG SD	No information	CTW; DAF/WG
Psychotria kirkii var. *tarambassica*	Shrub	1200-1800	IL SD BA	No information	ACB
Chazaliella abrupta	Shrub	c. 600	IL	No information	TRF
Pentas schimperiana subsp. *schimperiana*	Shrub	1800-3200	TU GD GJ SU AR IL KF GG SD BA HA	No information	DAF/WG; MAF/P-BW; EB
Pentas lanceolata subsp. *lanceolata*	Shrub	700-2300	TU GD IL KF GG SD BA HA	No information	?CTW; DAF/WG; MAF/P-BW
Pentas lanceolata subsp. *quartiniana*	Shrub	1200-2800	TU GD GJ SU WG IL KF GG SD BA	No information	?CTW; DAF/WG; MAF/P-BW
Carphalea glaucescens	Shrub	400-1450	SD BA HA	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	ACB
Pentanopsis fragrans	Shrub	800-1450	SD BA HA	No information	ACB
Paederia pospischilii	Liana	400-1450	SD BA HA	No information	ACB
Breonadia salicina	Tree	1150-1550	GD GJ WG SD BA	No information	RV
Sarcocephalus latifolius	Tree or shrub	500-1500	GJ IL KF	No information	CTW
Hallea rubrostipulata	Tree	1350-2150	IL KF	Afromontane rain forest	MAF/P-BW; TRF
Uncaria africana subsp. *lacus-victoriae*	Liana	1050-1550	IL KF	No information	MAF/BW; TRF; RV
Hymenodictyon floribundum	Tree or shrub	1100-2100	TU GD GJ SU WG IL GG SD	No information	CTW; DAF/WG
Crossopteryx febrifuga	Tree or shrub	500-1300	WG IL	No information	CTW
Mussaenda arcuata	Shrub or liana	750-1700	GD WG KF GG SD	No information	DAF/WG; RV
Pseudmussaenda flava	Shrub	900-1200	GJ WG IL	No information	CTW; RV

Macrosphyra longistyla	Shrub or liana	c. 1200	IL	No information	CTW
Catunaregam nilotica	Tree or shrub	400-1700	GD GJ	No information	CTW
Gardenia fiorii	Shrub	400-800	BA HA	No information	ACB
Gardenia volkensii var. *volkensii*	Tree or shrub	500-1300	GG SD	No information	ACB; CTW; RV
Gardenia ternifolia subsp. *ternifolia*	Tree	900-1500	WG IL KF	No information	CTW
Gardenia ternifolia subsp. *jovis-tonantis*	Tree	900-2250	TU GD GJ WU SU AR WG IL KF SD BA HA	Sudanian undifferentiated woodland	CTW; DAF/WG
Rothmannia urcelliformis	Tree or shrub	1200-2500	GD GJ SU AR WG IL KF SD	No information	DAF/U; MAF/P; TRF; RV
Oxyanthus speciosus subsp. *stenocarpus*	Tree or shrub	1350-2400	GD SU WG IL KE GG SD BA	No information	DAF/U; MAF/P; RV
Oxyanthus speciosus subsp. *globosus*	Tree or shrub	1000-1200	IL KF	No information	TRF
Oxyanthus lepidus var. *lepidus*	Shrub	c. 1050	KF	No information	TRF
Oxyanthus lepidus var. *unyorensis*	Shrub	500-1000	KF	No information	TRF
Tricalysia niamniamensis var. *niamniamensis*	Shrub	700-1400	IL KF GG	No information	RV
Tricalysia niamniamensis var. *djurensis*	Shrub	c. 950	IL	No information	CTW
Galiniera saxifraga	Tree or shrub	1350-3000	GD SU AR WG IL KF GG SD BA HA	No information	DAF/U-SD-WG; MAF/P
Feretia apodanthera subsp. *apodanthera*	Shrub	600-1500	TU WG	No information	RV
Polysphaeria aethiopica	Shrub	800-1350	SD BA	No information	RV
Polysphaeria parvifolia	Shrub	600-920	IL KF SD	No information	RV
Tarenna graveolens subsp. *graveolens*	Tree or shrub	1000-2100	SU GG SD BA HA	No information	ACB; DAF/TR
Pavetta oliveriana	Tree or shrub	1150-2450	GD GJ WU SU AR WG IL KF GG SD BA HA	No information	CTW; DAF/WG; RV
Pavetta aethiopica	Shrub	c. 2050	SD	No information	?DAF/WG
Pavetta abyssinica var. *abyssinica*	Tree or shrub	1350-2850	GD GJ WU SU AR WG KF SD BA HA	No information	DAF/SD-WG; RV

Pavetta abyssinica var. *dolichosiphon*	Tree or shrub	1600-2700	GD	No information	DAF/WG; RV
Pavetta abyssinica var. *bremekampiana*	Tree or shrub	?	?	No information	?
Pavetta crassipes	Tree or shrub	900-1500	KF GG SD	No information	?ACB; ?CTW
Pavetta gardeniifolia var. *gardeniifolia*	Tree or shrub	800-2100	TU SU KF GG SD BA HA	No information	?ACB; CTW; DAF/TR-WG
Pavetta subcana var. *longiflora*	Shrub	730-1500	GG SD	No information	ACB; RV
Coffea arabica	Tree or shrub	1000-1900	IL KF ?BA	No information	MAF/P; TRF
Psilanthus leroyi	Shrub	600-750	KF GG	No information	CTW; RV
Craterispermum schweinfurthii	Tree or shrub	1350-1500	WG KF	No information	MAF/P; RV
Canthium lactescens	Tree or shrub	1450-1900	SD	No information	?ACB; DAF/TR-WG
Canthium oligocarpum subsp. *oligocarpum*	Tree or shrub	1350-3000	GD SU AR WG IL KF GG SD BA	No information	?ACB; DAF/TR-WG; MAF/P-BW
Canthium pseudosetiflorum	Shrub	850-1900	GG SD BA HA	No information	ACB; DAF/WG
Keetia gueinzii	Shrub	1200-1950	WG IL KF	No information	DAF/U-WG; MAF/P-BW; RV
Keetia zanzibarica subsp. *gentilii*	Tree, shrub or liana	1450-2150	TU GD WG IL KF	No information	DAF/WG; MAF/BW; RV
Psydrax parviflora subsp. *parviflora*	Tree	1400-1750	WG IL KF GG SD	No information	?CTW; RV
Psydrax schimperiana subsp. *schimperiana*	Tree or shrub	900-2600	TU GD WU SU AR GG SD BA HA	No information	ACB; CTW; DAF/WG
Pyrostria phyllanthoidea	Tree or shrub	1150-1800	AR SD BA HA	No information	ACB; DAF/WG
Meyna tetraphylla subsp. *tetraphylla*	Shrub	550-1500	IL GG	No information	CTW; RV
Rytigynia neglecta var. *neglecta*	Shrub	1200-2600	GD GJ SU AR WG IL KF SD BA HA	No information	DAF/U-WG; MAF/P-BW; RV
Rytigynia neglecta var. *vatkeana*	Shrub	1200-2600	GD WG GG SD BA	No information	DAF/U-WG; MAF/BW; RV
Vangueria madagascariensis var. *madagascariensis*	Tree or shrub	1000-1600	TU GD SU GG SD BA	No information	ACB; DAF/SD-TR

Vangueria madagascariensis var. *abyssinica*	Tree or shrub	450-1300	TU	No information	ACB
Vangueria apiculata	Tree or shrub	1200-2100	GD WG IL GG SD BA HA	No information	DAF/U-WG; RV
Vangueria volkensii var. *volkensii*	Tree or shrub	1250-2300	GD SU SD BA HA	No information	ACB; DAF/SD
ASTERACEAE					
Tarchonanthus camphoratus	Tree or shrub	1300-2500	TU GD BA SD	East African evergreen and semi-evergreen bushland and thicket	DAF/SD-TR
Echinops hoehnelii	Shrub	2050-3750	SU GG BA	No information	DAF/SD-WG; EB; AA
Echinops longisetus	Tree or shrub	2000-4000	GD GJ WU SU AR WG KF GG SD BA HA	No information	DAF/SD-WG; EB; AA
Echinops ellenbeckii	Tree or shrub	2200-2950	SU AR HA	No information	DAF/WG
Vernonia amygdalina	Tree or shrub	650-3000	TU WU GD GJ SU WG IL KF GG SD BA HA	No information	DAF/U-SD-WG; MAF/BW; RV
Vernonia biafrae	Shrub or liana	1500-2410	IL SD	No information	RV
Vernonia thomsoniana	Shrub	1700-2200	GJ SU IL KF SD BA	No information	CTW; DAF/WG
Vernonia brachycalyx	Shrub	1300-1850	SD	No information	CTW; DAF/WG
Vernonia theophrastifolia	Shrub	900-2000	TU GD SU IL KF GG	No information	DAF/WG; RV
Vernonia ischnophylla	Shrub	1450-2000	GD GJ WG KF SD BA	No information	CTW; DAF/WG; RV
Vernonia myriantha	Tree or shrub	1750-2900	GJ SU AR KF GG SD BA HA	No information	DAF/WG; ?MAF/BW; RV
Vernonia auriculifera	Tree or shrub	1200-2200	WG IL KF SD	No information	DAF/WG; ?MAF/BW
Vernonia cylindrica	Shrub	1300-1700	TU GD GJ WG	No information	CTW
Vernonia rueppellii	Tree or shrub	2150-3000	TU WU GD SU AR KF SD BA HA	No information	DAF/WG; ?MAF/BW
Vernonia bipontinii var. *bipontinii*	Shrub	1000-2900	TU WU GD GJ SU	No information	DAF/WG
Vernonia bipontinii var. *gonderensis*	Shrub	2090-3300	GD SU	No information	DAF/WG; EB; ?AA; RV
Vernonia bipontinii var. *caccaensis*	Shrub	2700-3350	SU AR KF	No information	DAF/WG; EB; ?AA
Vernonia leopoldii	Shrub	1850-2850	TU GD GJ WU SU WG KF HA GG	No information	DAF/WG
Vernonia karaguensis	Shrub	1400-2750	GJ WU SU AR WG IL KF GG SD BA HA	No information	ACB; CTW; DAF/WG
Vernonia dalettiensis	Shrub	c. 1300	HA	No information	ACB

Vernonia cinerascens	Shrub	500-1450	TU AF WU SU GG SD BA HA	No information	?DSS; ACB
Vernonia thulinii	Shrub	1000-1200	GJ WG	No information	CTW
Vernonia wollastonii	Shrub	1500-2450	SU WG KF GG SD BA	No information	DAF/U-WG; MAF/P-BW; RV
Vernonia hildebrandtii	Shrub	c. 1700	SD	No information	ACB
Vernonia hochsterri var. *hochstetteri*	Shrub	1200-2500	TU GD GJ SU WG IL KF GG SD BA HA	No information	DAF/WG
Vernonia tewoldei	Shrub	1600-2150	KF BA	No information	MAF/P-BW
Vernonia schimperi	Shrub	1050-2400	TU GD WU SU SD BA HA	No information	CTW; DAF/WG
Vernonia filigera	Shrub	1935-2850	TU GD SU KF SD	No information	DAF/WG; RV
Vernonia hymenolepis	Shrub	1200-3000	GJ SU AR WG IL KF GG SD BA HA	No information	CTW; DAF/WG; MAF/BW; RV
Vernonia lasiopus var. *lasiopus*	Shrub	c. 2800	SD HA	No information	DAF/WG
Vernonia lasiopus var. *acuta*	Shrub	1200-2450	GD WG IL SD BA	No information	DAF/WG; RV
Distephanus plumosus	Shrub	750-900	GG SD	No information	ACB
Distephanus divaricatus	Shrub or liana	c. 1700	GG SD	No information	ACB; RV
Bothriocline schimperi	Shrub	1300-2800	GD GJ SU AR WG IL KF GG SD BA	No information	?CTW; DAF/U; MAF/BW; RV
Inula arbuscula	Shrub	3200-3600	GD	No information	DAF/WG; EB; AA
Inula confertiflora	Shrub	2500-3750	WU SU AR BA HA	No information	DAF/WG; EB; AA
Pluchea dioscoridis	Shrub	1000-2400	TU GD WU SU KF GG HA	No information	RV
Pluchea somaliensis	Shrub	200-500	SU SD HA	No information	RV
Athrixia rosmarinifolia	Shrub	1900-2800	TU GD GJ SU AR KF GG SD BA HA	No information	DAF/WG; RV
Helichrysum horridum	Shrub	2500-3600	GD SU	No information	DAF/WG; EB; AA
Helichrysum traversi	Shrub or liana	2100-3350	GD SU AR KF GG BA HA	No information	DAF/WG; EB; ?AA
Psiadia punctulata	Shrub	1300-2650	TU WU SU AR SD	East African evergreen and semi-evergreen bushland and thicket	ACB; DAF/TR
Psiadia incana	Shrub	500-1520	SU GG SD BA HA	No information	ACB
Microglossa densiflora	Shrub or liana	2900-3200	SD BA	No information	DAF/SD

Microglossa pyrifolia	Shrub or liana	1200-2860	WU SU AR WG IL KF GG SD	No information	DAF/U; MAF/P-BW; RV
Conyza vernonioides subsp. *vernonioides*	Shrub	3000-3600	GD WU SU	No information	DAF/SD-WG; EB; ?AA
Conyza vernonioides subsp. *arborea*	Shrub	c. 3200	BA	No information	DAF/SD-WG
Conyza hypoleuca	Tree or shrub	2400-3200	TU GD WU SU AR BA HA	No information	DAF/WG; ?EB
Conyza pyrrhopappa	Shrub	1300-2700	TU GD GJ WU SU WG IL KF GG SD HA	No information	ACB; DAF/WG
Conyza newii	Shrub	1900-3600	SD BA	No information	DAF/WG; EB; AA
Conyza abyssinica	Shrub	1600-3300	TU GD GJ SU WG KF GG SD BA HA	No information	DAF/WG; EB; AA
Senecio myriocephalus	Shrub	2250-3900	TU GD WU SU AR KF SD BA HA	No information	DAF/SD-WG; EB; AA
Senecio lyratus	Liana	1000-2800	TU WU SU AR SD BA HA	No information	ACB; DAF/WG
Senecio hadiensis	Liana	1700-2400	TU SU SD HA	No information	ACB; DAF/WG
Solanecio gigas	Tree or shrub	1750-3350	GD GJ WU SU AR SD IL KF BA HA	No information	DAF/U; DAF/WG; MAF/P-BW; EB
Solanecio mannii	Shrub or liana	1300-2450	SU AR WG IL KF SD BA	No information	DAF/WG; MAF/P-BW; RV
Mikaniopsis clematoides	Shrub or liana	2000-3300	TU GD WU SU AR KF BA HA	No information	DAF/SD-WG; MAF/P-BW; EB; ?AA
Kleinia squarrosa	Shrub or liana	900-2100	SU GG SD HA	No information	ACB
Kleinia odora	Shrub	600-1650	SU SD HA	No information	ACB
Kleinia negrii	Shrub or liana	100-1400	WU GG SD HA	No information	ACB
Kleinia kleinioides	Shrub	1500-2400	TU	No information	ACB; DAF/WG; RV
Blepharispermum obovatum	Shrub	500-1000	BA	No information	ACB
Blepharispermum ellenbeckii	Shrub	300-600	GG SD HA	No information	ACB
Blepharispermum fruticosum	Shrub	400-1000	HA	No information	ACB
Blepharispermum villosum	Shrub	400-1300	SD BA	No information	ACB

Aspilia mossambicensis	Shrub or liana	550-2650	TU GJ WU SU WG IL KF GG SD BA HA	East African evergreen and semi-evergreen bushland and thicket	ACB; CTW; DAF/WG
Guizotia arborescens	Shrub	1900-2450	IL KF	No information	MAF/BW
Bidens hildebrandtii	Shrub	450-1700	SD	No information	ACB
Stomatanthes meyeri	Shrub	2200-2400	KF	No information	MAF/BW
PLUMBAGINACEAE					
Plumbago truncata	Liana	c. 1300	WG IL	No information	RV
LOBELIACEAE					
Lobelia gibberoa	Shrub	1700-2800	TU GD SU WG IL KF GG SD HA BA	No information	DAF/U-SD-WG; MAF/P-BW
Lobelia rhynchopetalum	Shrub	3000-4350	GD GJ SU AR BA HA	Mixed Afroalpine communities	?DAF/SD; EB; AA
Lobelia achrochilus	Shrub	2650-3250	AR SD BA HA	No information	DAF/U-SD-WG; EB
BORAGINACEAE					
Cordia suckertii	Tree or shrub	200-300	HA	No information	DSS; ACB
Cordia sinensis	Tree or shrub	450-1500	AF TU GD SU GG SD BA HA	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	ACB; RV
Cordia quercifolia	Tree or shrub	1000-1350	AF SU GG HA	No information	ACB
Cordia africana	Tree	700-2550	TU GD GJ WU SU AR WG IL KF GG SD BA HA	No information	CTW; DAF/U; MAF/P-BW; TRF
Cordia monoica	Tree or shrub	500-1900	TU GD GJ WU SU AR WG IL GG SD BA HA	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	ACB; DAF/WG; RV
Cordia ellenbeckii	Shrub	850-1800	AF WU SD	No information	ACB
Cordia uncinulata	Shrub or liana	1050-1100	KF	No information	TRF
Cordia crenata	Tree or shrub	900-1100	AF GG HA	No information	ACB; RV
Ehretia cymosa var. *cymosa*	Tree or shrub	900-2350	TU GJ WU SU AR WG IL KF GG SD BA HA	No information	DAF/U-SD-WG; MAF/P-BW; RV
Ehretia cymosa var. *divaricata*	Tree or shrub	c. 1500	SD	No information	DAF/U-SD-WG; MAF/P-BW; RV
Ehretia cymosa var. *sylvatica*	Tree or shrub	1000-1300	SU HA	No information	DAF/U-SD-WG; MAF/P-BW; RV
Ehretia braunii	Tree	1000-1300	SU HA	No information	ACB

Ehretia obtusifolia	Tree or shrub	1150-1900	WU SU HA	No information	ACB; DAF/WG
Bourreria orbicularis	Shrub	600-1200	HA	No information	ACB
SOLANACEAE					
Lycium shawii	Tree or shrub	0-1600	WU SU KF GG SD HA	Somalia-Masai semi-desert grassland and shrubland	DSS; ACB
Solanum terminale	Liana	1800-2450	TU GD GJ WG SU IL KF GG SD BA	No information	DAF/U-SD-WG; MAF/P-BW
Solanum welwitschii	Liana	900-1300	IL KF	No information	TRF
Solanum benderianum	Liana	2300-3500	add regions!	No information	DAF/U-SD; EB; AA
Solanum giganteum	Tree or shrub	1100-2300	GD GJ WG IL KF SD BA	No information	DAF/U; MAF/BW; TRF; RV
Solanum tettense var. *renschii*	Shrub	800-1800	GG SD BA HA	No information	ACB
Solanum somalense	Shrub	200-1800	WU AF SU GG SD HA	No information	ACB
Solanum jubae	Shrub	300-1500	SD BA HA	No information	DSS; ACB
Solanum anguivi	Shrub	500-2800	GD GJ WU SU WG IL KF HA	No information	CTW; DAF/WG; TRF
Solanum macracanthum	Shrub	2100-3300	GD SU AR BA HA	No information	DAF/WG; EB
Solanum hastifolium	Shrub or liana	800-1500	AF GD SU KF GG SD BA HA	No information	ACB
Solanum dennekense	Shrub	800-1300	AF GG SD BA HA	No information	ACB
Solanum marginatum	Shrub	2000-3000	TU GD GJ SU AR GG SD BA	No information	DAF/WG
Solanum campylacanthum	Shrub	500-2300	AF TU GD GJ WU SU AR WG IL KF GG SD HA	No information	ACB; CTW; DAF/WG
Discopodium penninervium	Tree	1500-3500	TU GJ WU SU WG AR KF SD BA HA	No information	DAF/U-SD-WG; EB; AA
Discopodium eremanthum	Tree or shrub	2900-3500	SU AR GG SD	No information	DAF/U-WG; EB; AA
Withania somnifera	Shrub	600-2700	AF TU GD GJ WU SU KF GG SD HA	No information	ACB; DAF/WG
CONVOLVULACEAE					
Hildebrandtia africana subsp. *africana*	Shrub	300-1850	SD HA	No information	ACB
Hildebrandtia obcordata var. *obcordata*	Shrub	200-1600	GG SD HA	No information	ACB
Hildebrandtia obcordata var. *puberula*	Shrub	1100-1600	SD HA	No information	ACB

Hildebrandtia diredawensis	Shrub	1100-1700	HA	No information	ACB
Hildebrandtia sepalosa	Shrub	900-1150	HA	No information	ACB
Hildebrandtia somalensis	Shrub or liana	150-1300	SD HA	No information	DSS; ACB
Hildebrandtia aloysii	Shrub	850-1550	BA HA	No information	ACB
Cladostigma dioicum	Shrub	900-1800	WU SU HA	No information	ACB; DAF/TR
Cladostigma hildebrandtioides	Liana	300-1800	SD HA	No information	ACB
Cladostigma nigistiae	Liana	750-1450	SD	No information	ACB
Merremia pterygocaulos	Liana	1000-2200	TU GD GJ	No information	CTW
Merremia kentrocaulos	Liana	950-1500	TU GD GJ SU	No information	CTW
Astripomoea nogalensis	Liana	550-750	HA	No information	ACB
Ipomoea donaldsonii	Shrub	330-1800	GG SD BA	No information	DSS; ACB
Ipomoea citrina	Shrub	600-800	HA	No information	ACB
Ipomoea shupangensis	Liana	550-1200	TU GJ WG IL	No information	CTW
Ipomoea pogonantha	Liana	850-1800	SD	No information	ACB
Ipomoea marmorata subsp. *marmorata*	Shrub	1300-1700	GG SD	No information	ACB
Ipomoea marmorata subsp. *somalica*	Shrub	1500-1850	HA	No information	ACB
Ipomoea spathulata	Shrub or liana	1000-1850	GG SD BA HA	No information	ACB
Ipomoea kituiensis var. *kituensis*	Shrub or liana	800-1930	SU KF GG SD	No information	ACB; DAF/WG
Ipomoea chrysosperma	Shrub or liana	c. 1100	HA	No information	ACB
Ipomoea cicatricosa	Shrub	600-1800	SD BA HA	No information	ACB
Stictocardia beraviensis	Liana	1150-1800	WG IL KF GG SD	No information	MAF/P-BW; TRF
SCROPHULARIACEAE					
Halleria lucida	Tree or shrub	2200-3100	WU SU WG KF AR HA	Undifferentiated Afromontane forest	DAF/U-SD; EB
Lindenbergia awashensis	Shrub	600-1500	AF SU	No information	ACB
Ghikea speciosa	Shrub or liana	700-1450	GG SD BA HA	No information	ACB

BIGNONIACEAE					
Stereospermum kunthianum	Tree or shrub	500-1950	TU GD GJ SU WG IL KF SD BA HA	Sudanian undifferentiated woodland; Transition from undifferentiated woodland to Acacia deciduous bushland and wooded grassland	CTW; DAF/WG
Rhigozum somalense	Tre or shrub	150-650	AF	No information	DSS; ACB
Kigelia africana	Tree	500-2000	GD GJ IL GG	No information	RV
PEDALIACEAE					
Sesamothamnus busseanus	Tree or shrub	250-750	SD HA	No information	DSS; ACB
Sesamothamnus rivae	Tree or shrub	850-1100	GG SD BA HA	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	ACB
ACANTHACEAE					
Acanthus eminens	Shrub	1500-2800	WG IL KF SD BA HA	No information	DAF/U; MAF/P; RV
Acanthus pubescens	Shrub	1300-2400	KF GG SD	No information	?CTW; DAF/WG
Acanthus polystachius	Shrub	900-2800	GD GJ SU WG IL KF	No information	DAF/WG; MAF/BW; RV
Acanthus sennii	Shrub	1700-3200	GD GJ WU SU AR WG KF GG SD BA HA	No information	DAF/U-WG; ?EB
Crossandra infundibuliformis subsp. *boranensis*	Shrub	600-1300	SD	No information	ACB
Crossandra baccarinii	Shrub	?	SD	No information	?DSS
Ruellia discifolia	Shrub	400-1000	SD BA HA	No information	ACB
Satanocrater somalensis	Shrub	?	HA	No information	ACB
Satanocrater paradoxus	Shrub	800-1600	SD	No information	ACB
Whitfieldia elongata	Shrub	600-1800	WG IL KF	No information	?CTW; MAF/P; TRF; RV
Asystasia excellens	Shrub	1000-1600	GG SD BA HA	No information	ACB
Barleria prionitis subsp. *induta*	Shrub	950-2400	TU GD	No information	CTW; DAF/WG
Barleria grandis	Shrub	900-1800	TU GD SU WG KF	No information	CTW
Lepidagathis speciosa	Shrub	c. 300	SD BA HA	No information	DSS; ACB
Ruspolia hypocrateriformis	Shrub	800-1400	SD BA HA	No information	ACB

Ruttya fruticosa	Shrub	1100-1850	GG SD BA HA	No information	DAF/TR; ACB
Ruttya speciosa	Shrub or liana	1700-2400	TU GD GJ	No information	DAF/SD; RV
Ecbolium gymnostachyum	Shrub	900-1500	AF HA	No information	ACB
Ecbolium boranense	Shrub	1100-1500	SD BA	No information	ACB
Megalochlamys violacea	Shrub	650-1600	AF GG SD BA HA	No information	ACB
Justicia scandens	Liana	600-2400	TU GD GJ SU AR WG IL KF GG SD BA	No information	DAF/U-WG; MAF/BW; TRF; RV
Justicia cordata	Shrub	900-2400	TU GJ SU GG SD BA HA	No information	ACB; DAF/WG
Justicia rendlei	Shrub	300-1500	SD BA HA	No information	ACB
Justicia potamophila	Shrub	C. 1300	SD	No information	ACB
Justicia grisea	Shrub or liana	800-1500	SD HA	No information	ACB
Justicia schimperiana	Shrub	1300-2700	TU GD GJ WU SU WG IL KF SD BA HA	No information	DAF/WG; MAF/BW; RV
Justicia phillpsiae	Shrub	700-1500	GG SD HA	No information	ACB
Anisotes involucratus	Shrub	c. 900	SD	No information	ACB
Anisotes trisulcus subsp. *webi-schebelensis*	Shrub	150-500	HA	No information	ACB
Anisotes tanensis	Shrub	300-700	SD	No information	ACB
Metarungia pubinervia	Shrub	1000-1600	IL KF	No information	MAF/P; TRF
Rungia grandis	Shrub	1000-1100	KF	No information	TRF
Ichtyostoma thulinii	Shrub	750-900	SD	No information	ACB
Isoglossa somalensis	Shrub	1600-2900	SU AR IL KF GG SD BA	No information	DAF/U-WG
VERBENACEAE					
Lantana trifolia	Shrub	1800-2100	GJ SU KF SD HA	No information	DAF/WG
Lantana ukambensis	Shrub	2000-2100	TU KF HA	No information	DAF/WG
Lantana viburnoides var. *viburnoides*	Shrub	800-1700	SU GG SD HA	No information	ACB
Lippia adoensis var. *adoensis*	Shrub	1600-3000	TU GD GJ WU SU AR WG KF GG SD HA	No information	DAF/WG
Lippia abyssinica	Shrub	1600-1900	SU WG KF GG SD	No information	DAF/WG
Lippia carviodora	Shrub	700-1100	SD	No information	ACB

LAMIACEAE					
Premna schimperi	Tree or shrub	1350-2400	TU GD GJ WG KF SU AR SD HA	No information	DAF/WG; RV
Premna oligotricha	Shrub	1000-1800	SU SD BA	No information	ACB
Premna resinosa	Shrub	400-1800	WU SD HA	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	ACB
Vitex doniana	Tree	500-1960	GJ WG KF SD	No information	CTW
Clerodendrum cephalanthum	Shrub or liana	600-1800	IL KF GG	No information	CTW
Clerodendrum johnstonii	Tree or shrub	c. 1400	KF	No information	TRF
Clerodendrum umbellatum	Shrub or liana	1600-1950	GD GJ WG SU IL KF SD	No information	CTW; DAF/WG
Clerodendrum myricoides	Shrub	700-2600	TU GD WU SU AR WG IL KF GG SD HA	No information	CTW; DAF/U-SD-TR-WG
Clerodendrum robecchii	Shrub	700-1200	HA	No information	ACB
Tinnea aethiopica subsp. *aethiopica*	Shrub	800-2100	KF GG SD	East African evergreen and semi-evergreen bushland and thicket	CTW; DAF/WG
Tinnea somalensis	Shrub	1100-1900	AR SD BA	No information	ACB; DAF/WG
Otostegia tomentosa subsp. *tomentosa*	Shrub	2000-3000	TU	No information	DAF/WG
Otostegia tomentosa subsp. *steudneri*	Shrub	2100-3300	GD WU	No information	DAF/WG; ?EB
Otostegia tomentosa subsp. *ambigens*	Shrub	1200-3000	GD GJ SU AR WG KF SD BA HA	No information	CTW; DAF/WG
Otostegia erlangeri	Shrub	1000-1700	SD BA	No information	ACB; DAF/TR
Otostegia fruticosa subsp. *fruticosa*	Shrub	500-3000	TU GD SU	No information	CTW; DAF/WG
Otostegia fruticosa subsp. *schimperi*	Shrub	0-1000	EE	No information	ACB
Otostegia integrifolia	Shrub	1300-2800	TU GD GJ WU SU KF HA	No information	ACB; DAF/WG
Leucas stachydiformis	Shrub	1700-3200	TU GD GJ WU SU AR SD BA HA	No information	DAF/WG; RV
Leucas tomentosa	Shrub	200-1600	GG SD	No information	DSS; ACB
Leucas abyssinica var. *abyssinica*	Shrub	700-3000	TU GD	No information	ACB; DAF/WG
Leucas abyssinica var. *brachycalyx*	Shrub	1200-2000	SU AR SD HA	No information	ACB; DAF/WG

Leucas abyssinica var. *argyrophylla*	Shrub	300-2000	HA	No information	ACB; DAF/WG
Leucas abyssinica var. *sidamoensis*	Shrub	1300-2300	GG SD BA	No information	ACB; DAF/WG
Leucas discolor var. *discolor*	Shrub	1400-2200	SD	No information	ACB; DAF/TR-WG
Leucas discolor var. *ellipticifolia*	Shrub	400-1500	BA HA	No information	ACB; DAF/TR-WG
Leucas jamesii	Shrub	1000-1400	GG HA	No information	ACB
Leucas calostachys	Shrub	1000-2500	SU WG KF SD	No information	CTW; DAF/WG
Leucas argentea var. *argentea*	Shrub	1300-2000	GG SD BA	No information	ACB; DAF/WG
Leucas argentea var. *neumannii*	Shrub	1700-3100	SU GG SD	No information	DAF/WG
Leonotis ocymifolia var. *raineriana*	Shrub	500-3700	TU GD WU GJ SU AR WG IL KF GG SD BA HA	No information	CTW; DAF/WG; EB; AA
Meriandra dianthera	Shrub	1800-3000	TU WU	No information	DAF/WG
Tetradenia riparia	Shrub	1500-2000	TU GD GJ KF GG SD	No information	DAF/WG; RV
Erythrochlamys specabilis	Shrub	400-1600	SD BA HA	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket	ACB
Ocimum cufodontii	Shrub	700-2000	SD BA HA	No information	ACB; ?DAF/TR
Ocimum urticifolium	Shrub	600-2100	TU GD WU SU WG IL KF GG SD HA	No information	ACB; CTW; DAF/WG
Ocimum lamifolium	Shrub	1200-2900	TU GD GJ SU AR WG IL KF GG SD HA	No information	ACB; DAF/WG
Becium ellenbeckii	Shrub	1000-1700	SD HA	No information	ACB
Becium grandiflorum	Shrub	1600-3100	TU GD WU SU WG SD	No information	?ACB; DAF/WG
Hoslundia opposita	Shrub	600-1700	TU GD SU IL KF GG SD	No information	ACB; DAF/WG
Plectranthus grandicalyx	Shrub	c. 3000	SD	No information	DAF/WG
Plectranthus barbatus	Shrub	950-2750	TU SU WG GG SD HA	No information	ACB; DAF/WG
Plectranthus defoliatus	Shrub	1750-3000	TU GD GJ SU SD HA	No information	DAF/WG
Plectranthus lactiflorus	Shrub	1550-2200	GG SD HA	No information	ACB; DAF/WG
Plectranthus igniarius	Shrub	350-1650	TU GG SD HA	No information	ACB
Plectranthus gillettii	Shrub	1000-1600	SD HA	No information	ACB

Plectranthus puberulentus	Shrub	1400-2000	GG SD BA HA	No information	ACB; DAF/WG
Plectranthus hadiensis	Shrub	1350-3000	TU SU AR GG SD HA	No information	ACB; DAF/WG
Plectranthus marrubatus	Shrub	1350-3200	GD GJ WU SU AR IL WG KF GG SD HA	No information	DAF/WG; ?EB
CYCLOCHEILACEAE					
Asepalum eriantherum	Shrub	800-1600	SU SD BA HA	No information	ACB
DIOSCOREACEAE					
Dioscorea quartiniana	Liana	1200-2650	TU GD GJ WU SU AR WG IL GG SD BA HA	No information	ACB; CTW; DAF/WG
Dioscorea cochleari-apiculata	Liana	900-950	TU	No information	CTW
Dioscorea dumetorum	Liana	900-1525	TU GD WG	No information	CTW
Dioscorea bulbifera	Liana	600-1500	GD GJ KF IL GG SD	No information	CTW; RV
Dioscorea schimperiana	Liana	1600-2000	TU GD GJ WU SU AR WG IL KF GG SD	No information	ACB; CTW; DAF/WG
Dioscorea abyssinica	Liana	1000-1800	TU GD GJ WG KF GG SD	No information	CTW
Dioscorea praehensilis	Liana	550-1600	IL	No information	CTW
SMILACACEAE					
Smilax anceps	Liana	1150-1700	WG KF	No information	MAF/P; TRF
Smilax aspera	Liana	1900-3200	SU AR KF SD HA	No information	DAF/WG; ?EB
ASPARAGACEAE					
Asparagus africanus	Liana	700-3800	TU GD GJ WU SU AR WG KF GG SD BA HA	No information	ACB; DAF/WG; EB; ?AA
Asparagus scaberulus	Liana	400-1500	TU GD KF GG SD BA	No information	ACB
Asparagus setaceus	Liana	550-2400	SU WG IL KF BA	No information	MAF/P; RV
Asparagus flagellaris	Shrub	550-1800	TU GD GJ WG IL GG SD	No information	CTW
Asparagus falcatus var. *falcatus*	Shrub or liana	1200-1350	KF	No information	?TRF; ?RV
Asparagus aridicola [*Asparagus falcatus* var. *ternifolius*]	Shrub or liana	1100-1900	GG SD HA	No information	ACB; CTW; DAF/WG
Asparagus racemosus	Liana	1350-3100	TU GD GJ WU SU AR WG KF GG SD BA HA	No information	DAF/WG; MAF/P-BW; ?EB; RV
Asparagus leptocladodius	Liana	850-1650	SD BA	No information	ACB
Aspargus aspergillus	Shrub or liana	1050-1200	SD	No information	ACB

DRACAENACEAE					
Dracaena afromontana	Tree or shrub	1500-3000	TU SU WG IL KF HA	No information	DAF/U; MAF/P
Dracaena ellenbeckiana	Tree or shrub	1000-1500	SD BA HA	East African evergreen and semi-evergreen bushland and thicket	ACB; DAF/TR
Dracaena fragrans	Tree or shrub	1200-2100	WG IL KF	No information	MAF/P; TRF
Dracaena ombet subsp. *ombet*	Tree or shrub	?	TU	No information	ACB; DAF/TR
Dracaena ombet subsp. *schizantha*	Tree or shrub	1450-1750	SD BA HA	East African evergreen and semi-evergreen bushland and thicket	?ACB; DAF/TR
Dracaena steudneri	Tree or shrub	1300-2500	TU GD GJ SU WG IL KF SD HA	No information	DAF/U-WG; MAF/P-BW; TRF
ALOACEAE					
Aloe ankoberensis	Shrub	3000-3500	SU	No information	DAF/WG; EB; AA
Aloe pulcherrima	Shrub	2480-2700	SU WU	No information	DAF/WG
Aloe megalacantha subsp. *megalacantha*	Shrub	1100-1850	BA HA	No information	ACB; DAF/WG
Aloe megalacantha subsp. *alticola*	Shrub	2100-2150	HA	No information	DAF/WG
Aloe gilbertii subsp. *gilbertii*	Shrub	1300-1900	SU GG SD	No information	ACB/RV; DAF/WG
Aloe gilbertii subsp. *megalacanthoides*	Shrub	1200-1350	GG	No information	ACB
MUSACEAE					
Ensete ventricosa	Tree	1000-2000	TU GD GJ SU WG IL KF	No information	DAF/U-WG; MAF/P-BW; RV
ARECACEAE					
Phoenix reclinata	Tree	100-2500	GD GJ SU KF WG IL GG SD HA	No information	DAF/WG; MAF/P-BW; RV; FLV/MFS
Hyphaene thebaica	Tree	100 BELOW SEA-1000	AF GD GJ IL	Edaphic grassland of the Upper Nile basin; Hyphaene communities	DSS; ACB; WGG; CTW; RV
Hyphaene compressa	Tree	500-550	GG	No information	?ACB
Borassus aethiopum	Tree	400-950	GJ IL	Edaphic grassland of the Upper Nile basin; Valley and flood-plain grassland	?WGG; CTW

POACEAE					
Olyra latifolia	Shrub	1000-1400	WG IL KF	No information	TRF; RV
Oxytenanthera abyssinica	Tree or shrub	1200-1800	TU GD GJ WG	No information	CTW
Arundinaria alpina	Tree or shrub	2200-4000	GJ SU IL KF GG SD BA	Afromontane bamboo	DAF/U-SD; MAF/P-BW; EB; ?AA

APPENDIX 4

Development of classification system criteria and their implementation in GRASS GIS script for the Atlas of the Potential Vegetation of Ethiopia

The definitions of the classification criteria and rules

Primarily, the atlas of the potential vegetation of Ethiopia has been developed on a set of classification criteria defining the altitudinal and rainfall limits for each of the vegetation types that have been recognized in the the main part of this work.

Data on altitude was obtained from the SRTM 90 x 90 metres digital elevation data of CGIAR-CSI (2008), which comes at a resolution of 0.0008333 degrees (approximately 90 metres). The mean annual precipitation data was obtained from the WorldClim database (Hijmans *et al.,* 2005a), which comes at a resolution of approximately 0.00833 degrees (approximately 1 kilometre). Additionally, the Global Wetlands Database (in the following referred to as GLWD; see Lehner & Döll, 2004) and the AEON river database (de Wit & Stankiewicz, 2006) were used to define the boundaries of water bodies and related vegetation types.

Thus, the classification rules were primarily based on altitude and rainfall and secondarily on data of water bodies. In addition, maps (Figs 36-41, p. 245-250) have been prepared where specific areas were marked that could not otherwise be defined by the primary data from altitude or rainfall or from the secondary data. These maps were based on field observations of the authors, supplemented by forest maps of the southwest Ethiopia Forest Inventory Project (Chaffey, 1978a, b, c, d, 1979).

Further details are given in the following sections that specify the classification rules in more detail and indicate how these rules have been translated into a GIS script. The names of the vegetation types and subtypes and their acronyms can be found in Table 1 (p. 40) and on the legend to the map plates.

When the following conventions are translated into a script it should be noted that the earlier listed criteria and rules are always overruled by subsequently listed criteria and rules.

Criteria and classification rules

Desert and semi-desert scrubland (DSS) has been defined as areas with an altitude < 400 metres within Ethiopia.

Acacia-Commiphora **woodland and bushland proper (ACB)** has been defined as areas between 400 and 1800 metres altitude that fall within the area marked as II ("correction zone 2") in Fig. 36 (p. 245).

Acacia **wooded grassland of the Rift Valley (ACB/RV)** has been defined as areas between 400 and 1800 metres altitude that fall within the area marked as III ("correction zone 3") in Fig. 36.

Wooded grassland of the western Gambela region (WGG) has been defined as the areas marked by the GLWD as "Freshwater Marsh and Floodplains" within the IL floristic region (Fig. 3, p. 16), now in the western Gambela region.

Combretum-Terminalia **woodland and wooded grassland (CTW)** has been defined as areas between 400 and 1800 metres altitude that fall within the area marked as I ("correction zone 1") in Fig. 36.

Dry evergreen Afromontane forest and grassland complex (DAF) has been defined as areas between 1800 and 3000 metres altitude and with rainfall < 1700 millimetres/year. Areas that meet this criterion have been indicated as "Criteria a" in Fig. 37 (p. 246) and 38 (p. 247). However, the following exceptions on these rules apply:

- in the floristic region GJ all areas with an altitude between 1800 and 3000 metres altitude that fall within the boundaries of "correction zone 3" (see Fig. 37) were classified as DAF, including areas with rainfall > 1700 millimetres/year.
- when classification rules for vegetation zones described below conflict with the classification rules for DAF, the former supersedes the latter.

Moist evergreen Afromontane forest (MAF) has been defined as areas between 1800 and 3000 metres altitude and rainfall > 1700 millimetres/year. Areas that meet this have been indicated as "Criteria b" in Fig. 37 and 38. However, see the first exception under DAF above. Other exceptions that apply are:

- The areas between 1800 and 3000 metres altitude, but with a rainfall < 1700 millimetres, that fall within II (correction zone 2) in Fig. 37, were also classified as MAF.
- In the floristic regions SD and BA within the areas marked as "correction zone 1" in Fig. 38 all areas between 1600 and 3000 metres altitude were classified as MAF too, irrespective of rainfall (see Fig. 38, where areas between the contours indicating 1600 and 1800 metres altitude have been indicated as "Criteria c").
- The areas between the upper extent of TRF (correction zone 4 in Fig. 37) and 1800 metres altitude are all classified as MAF too ("correction zone 2" in Fig. 37).

Transitional rain forest (TRF) has been defined as areas between 500 and 1500 metres altitude and falling within "correction zone 4" in Fig. 37. "Correction zone 4" defines the northern and southern limits of this vegetation type according to the observations by the authors.

Ericaceous belt (EB) has been defined as areas between the contours indicating 3000 and 3200 metres altitude

Afroalpine belt (AA) has been defined as areas at altitudes > 3200 m

Riverine vegetation (RV) has been defined as vegetation found along perennial and non-perennial rivers below 1800 metres altitude. Width of the area along the rivers with RV can vary considerably depending on topography and edaphic conditions, but typically is 20-50 metres wide. This zone is not mapped separately. Instead the AEON database was used to map the distribution of perennial and non-perennial rivers, which gives an indication of where riverine vegetation can be found in non forested habitats. Rivers are also indicated as such on the map also at altitudes above 1800 metres, but the vegetation along rivers at these altitudes will mostly be similar to that of the forests of similar altitudes (MAF or DAF).

Freshwater lakes - open water vegetation (FLV/OW) has been defined as areas identified in the GLWD as lakes or reservoirs (Figs 39-41).

- For exceptions, see criteria under *Salt lake open water vegetation* (SLV/OW) below.

Freshwater marshes and swamps, floodplains and lake shore vegetation (FLV/MFS) has been defined as areas identified in the GLWD database as freshwater marsh and floodplains (Figs 39-41) as well as all shorelines of the freshwater lakes. However:

- See criteria under *Salt pans, saline/brackish and intermittent wetlands and Salt-lake shore vegetation* (SLV/SSS).
- All shorelines of the freshwater lakes

- Based on field observations by the authors areas with *Freshwater marshes and swamps, floodplains and lake shore vegetation* (FLV/MFS) were identified east and north of Lake Tana. These areas are missing in the GLWD database and were therefore added (see "correction zone 6" in Fig. 41).

Salt lake open water vegetation (SLV/OW). In the GLWD database there is no category identifying salt- or saline lakes. However, in Wood and Talling (1988) the salinity of the principle lakes of Ethiopia is given and a suitable salinity criterion established for salt- or saline lakes. Based on this information all principle lakes were classified as either freshwater or salt lakes open water vegetation.

- Figs 39-40 give the lakes that were (re)classified as salt lake open water vegetation.

Salt pans, saline/brackish and intermittent wetlands and salt-lake shore vegetation (SLV/SSS) has been defined as:

- All shorelines of the lakes classified here as salt- or saline lakes.

- Areas identified by the GLWD database as *Pan, brackish/saline wetlands or intermittent wetland/lakes* and marked as such in Figs 39-40.

The GRASS GIS scripts

The map of the potential vegetation of Ethiopia (PVE) map was developed using the classification scheme described in the previous. These classification rules have been translated in GRASS GIS (GRASS Development Team 2009) scripts in steps, which are described below.

The work can be reconstructed from a zip archive which contains the different input data layers used to develop the vegetation map. The zip archive *work_eth.zip* is available in electronic form on request. The following layers used to develop the map are included in the zip file:

Data layer	Description	Resolution
mask_eth	a raster file defining the area of Ethiopia	0.0008333 deg
prec_an	mean annual precipitation raster	0.008333 deg
glwd_3	global wetland database raster layer, cut out for Ethiopia	0.008333 deg

Some additional layers were added which were used to produce the final paper/pdf version of the map:

Data layer	Description
rivers	Vector layer with the perennial and seasonal rivers (from the AEON data base)
towns	Vector layer with a number of towns and cities of Ethiopia – these have been selected to be helpful in establishing the geographical position of the vegetation boundaries in relation to man-made topographical features
roads	Road and tracks for Ethiopia – all roads and tracks are shown, even some that may not be encountered in the field

All these layers are contained in a GRASS GIS database (GRASSdb), in the location *latlon* and the mapset *work_eth*. For the code below to run you need to unzip the data file 'work_eth.zip' and make sure to maintain the folder structure. The digital elevation model (dem) raster layer is not included to reduce the size of the file. Before running the script below it is assumed that this layer, with a resolution of 0.0008333 degrees is imported in the mapset work_eth. The scripts below have to be run with the GRASS GIS database opened in the mapset *work_eth*. Note the notation convention that lines preceded with # (and here printed in italics) are not executed by GRASS GIS and are therefore used for short explanations of the code. The actual code is printed in normal font.

 # Step 1 - settings and preparations of input data layers

 # The first steps are specific to GRASS GIS and are needed to determine the region (extent, resolution) for the analysis and create a MASK (to limit the calculations to Ethiopia).

```
g.region region=ethiopia_90m@PERMANENT
r.mask -o input=mask_ethiopia@PERMANENT
```

 # Step 2 - prepare the required input data layers

 # Resample the glwd data layer to 0.000833 degrees resolution

```
r.mapcalc "glwd_3=glwd"
```

 # Classification rules were primarily based on altitude, rainfall and secondary data of water bodies. For some of the vegetation types there are specific areas that do not follow the general classification rules, that is, they could not be adequately defined by simple rules based on altitude or rainfall. These areas are indicated in the vector map 'veg_ethiopia_corrections'. For the different steps these need to be converted into the rasterfiles 'corrections1', 'corrections2', and 'correction4'. Further details are given in the previous section 'Criteria and classification rules.'

```
v.to.rast input=veg_ethiopia_corrections output=
corrections1 use=attr column=id1 type=area layer=1
rows=4096
r.patch input="corrections1,MASK" output=correc-
tions1 --overwrite
v.to.rast input=veg_ethiopia_corrections output=
corrections2 use=attr column=id2 type=area layer=1
rows=4096
r.patch input="corrections2,MASK" output= corrections2
--overwrite
v.to.rast input=veg_ethiopia_corrections output=
corrections4 use=attr column=id4 type=area layer=1
rows=4096
r.patch input="corrections4,MASK" output=correc-
tions4 --overwrite
```

 # Reclassify the rainfall layer in two classes with <1700mm and >1700mm rainfall.

```
r.mapcalc "b1=if(prec_an>=1700,1,0)"
```

 # Smooth the 1700 mm boundary through reiterative converting the raster to vector and back again using a increasing higher resolution. As the last step, use v.generalize to decrease number of nodes and remove the temporary data layers.

```
r.to.vect -s input=b1 output=b1 feature=area
g.region res=0.004
v.to.rast input=b1 output=b2 column=value
labelcolumn=label
r.to.vect -s input=b2 output=b2 feature=area
g.region res=0.002
v.to.rast input=b2 output=b3 column=value
labelcolumn=label
r.to.vect -s input=b3 output=b3 feature=area
g.region res=0.001
v.to.rast input=b3 output=b4 column=value
labelcolumn=label
r.to.vect -s input=b4 output=b4 feature=area
g.region -p region=ethiopia_90m@PERMANENT
v.to.rast input=b4 output=b5 column=value
labelcolumn=label
r.to.vect -s input=b5 output=b5 feature=area
v.generalize input=b5 output=b5 method=distance_
weighting look_ahead=7 slide=1 --overwrite
v.to.rast input=b5 output=prec_1700mm column=value
labelcolumn=label
g.mremove -f rast=b* vect=b*
```

 # The GLWD data layer was used to determine water bodies and water related vegetation types. For the lakes and large water bodies we used the vector maps of the GLWD (data glwd_1 and glwd_2), which depicts the boundaries more accurately than the raster layer (glwd_3). These lakes were marked in the raster layer

'corrections3', which was used to remove them from the GLWD raster layer.

```
g.region region=ethiopia_90m@PERMANENT
r.mapcalc "a1=if(corrections3==1 && glwd==1,0,glwd)"
```

 # The boundaries of the mapping units of the resulting adapted glwd_3 raster layer were smoothed by reiterative conversion to vector, with smoothing effect and conversion back to raster. This is repeated four times, each time using a smaller resolution.

```
g.region -p region=ethiopia@PERMANENT
r.to.vect -s input=a1 output=a1 feature=area
g.region res=0.004
v.to.rast input=a1 output=a2 column=value labelcolumn=label
r.to.vect -s input=a2 output=a2 feature=area
g.region res=0.002
v.to.rast input=a2 output=a3 column=value labelcolumn=label
r.to.vect -s input=a3 output=a3 feature=area
g.region res=0.001
v.to.rast input=a3 output=a4 column=value labelcolumn=label
r.to.vect -s input=a4 output=a4 feature=area
g.region region=ethiopia_90m@PERMANENT
v.to.rast input=a4 output=a5 column=value labelcolumn=label
r.to.vect -s input=a5 output=a5 feature=area
v.to.rast input=a5 output=glwd_ethiopia column=value labelcolumn=label
g.mremove -f rast=a* vect=a*
```

 # Step 3 – classification

 # Note that later reclassifications will overwrite earlier ones. This is done by design and means that in some cases vegetation types are defined too broadly and only in a next step further limitations are applied.

 # Define the vegetation type Desert and semi desert scrubland (DSS, code 1), Acacia-Commiphora woodland and bushland proper (ACB), Acacia wooded grassland of the Rift Valley (ACB/RV), and Combretum-Terminalia woodland and wooded grassland (CTW).

```
r.mapcalc "vegmap=if(dem<=400,1,if(dem>400&&dem<=1800&&corrections1==2,2,if(dem>400&&dem<=1800&&corrections1==3,3,5)))"
```

 # Define the vegetation type Dry evergreen Afromontane forest and grassland complex (DAF) and Moist evergreen Afromontane forest (MAF).

```
r.mapcalc "vegmap=if(dem>1800 && dem<=3000,6,vegmap)"
r.mapcalc "vegmap=if(dem>1800 && dem<=3000 && prec_1700mm==1 && corrections2!=3,7,vegmap)"
r.mapcalc "vegmap=if((dem>1600 && dem<=3000 && corrections2==1) || corrections2==2,7,vegmap)"
r.mapcalc "vegmap=if((dem>1800 && dem<=3000) && corrections2==11,7,vegmap)"
```

 # Define the vegetation type Transitional rain forest (TRF).

```
r.mapcalc "vegmap=if(corrections2==4,8,vegmap)"
```

 # Define the vegetation types Ericaceous belt (EB) and Afroalpine belt (AA)

```
r.mapcalc "vegmap=if(dem>3000 && dem<=3200,9,vegmap)"
r.mapcalc "vegmap=if(dem>3200,10,vegmap)"
```

 # Define the vegetation types Wooded grassland of the western Gambela region (WGG), Freshwater lakes – open water vegetation (FLV/OW), Freshwater marshes and swamps, floodplains and lake shore vegetation (FLV/MFS), Salt lake open water vegetation (SLV/OW) and Salt pans, saline/brackish and intermittent wetlands and salt-lake shore vegetation (SLV/SSS).

```
r.mapcalc "vegmap=if(glwd_ethiopia==4 && corrections2==7,4,vegmap)"
r.mapcalc "vegmap=if(glwd_ethiopia==1 || glwd_ethiopia==2,12,vegmap)"
r.mapcalc "vegmap=if((glwd_ethiopia==4 && corrections2!=6 && corrections2!=7) || glwd_ethiopia==8,13,vegmap)"
r.mapcalc "vegmap=if(glwd_ethiopia==1 && corrections2==5,14,vegmap)"
r.mapcalc "vegmap=if(glwd_ethiopia==9 || (glwd_ethiopia==4 && corrections2==6) || glwd_ethiopia==7,15,vegmap)"
```

```
v.extract input=lakes_africa output=saltlake type=area
list=495,494,623
v.to.rast input=saltlake@work_eth output=saltlake
use=val value=1
r.null map=saltlake@work_eth null=0
v.extract input=lakes_africa output=freshlake type=area
list=567,36,493,496,622
v.to.rast input=freshlake@work_eth output=freshlake
use=val value=1
r.null map=freshlake@work_eth null=0

r.mapcalc “vegmap=if(freshlake==1,12,vegmap)”
r.mapcalc “vegmap=if(saltlake==1,14,vegmap)”
r.mapcalc “vegmap=if(corrections4==1 &&
vegmap!=12,13,vegmap)”
g.remove rast=saltlake@work_eth,freshlake@work_eth
vect=saltlake@work_eth,freshlake@work_eth
```

 # Create labels using reclass. The identical numbers before and after the equal sign both represent the raster value, followed by the raster labels. The labels include, between brackets, the vegetation code as used in the text (see Table 1, p. 40), followed by the name of the vegetation type and acronym between brackets.

```
r.reclass vegmap out=veg_ethiopia title="Map of the
Potential Vegetation of Ethiopia" \
<<EOF
    1 = 1    (1) Desert and semi-desert scrubland (DSS)
    2 = 2    (2a) Acacia-Commiphora woodland and
             bushland proper (ACB)
    3 = 3    (2b) Acacia wooded grassland of the Rift
             Valley (ACB/RV)
    4 = 4    (3) Wooded grassland of the western
             Gambela region (WGG)
    5 = 5    (4) Combretum-Terminalia woodland and
             wooded grassland (CTW)
    6 = 6    (5) Dry evergreen Afromontane forest and
             grassland complex (DAF)
    7 = 7    (6) Moist evergreen Afromontane forest (MAF)
    8 = 8    (7) Transitional rain forest (TRF)
    9 = 9    (8) Ericaceous belt (EB)
    10 = 10  (9) Afroalpine belt (AA)
    11 = 11  (10) Riverine vegetation (RV)
    12 = 12  (11a) Freshwater lakes – open water
    vegetation (FLV/OW)
    13 = 13  (11b) Freshwater marshes and swamps,
             floodplains and lake shore vegetation (FLV/
             MFS)
    14 = 14  (12a) Salt lake open water vegetation (SLV/
             OW)
    15 = 15  (12b) Salt pans, saline/brackish and
             intermittent wetlands and salt-lake shore
             vegetation (SLV/SSS)
EOF
g.remove rast=vegmap
```

 # Define color table for the raster map.

```
cat > rules.file <<EOF
1 255:235:190
2 255:193:166
3 233:255:190
4 174:241:176
5 252:207:119
6 112:168:0
7 114:178:114
8 152:230:0
9 214:133:137
10 232:190:255
12 46:154:230
13 150:220:240
14 253:255:155
15 223:95:232
EOF
r.colors map=veg_ethiopia rules=rules.file
```

Step 4 – Create vector layer

 # On the map one will find many very small areas, especially along boundaries between vegetation types. Given the resolution of the input data (90 m for the DEM), it is impossible to say whether these small 'islands' are artifacts or reflecting the real fussiness of the boundaries between vegetation types. However, removing them gives a much clearer cartographic result and results in much less polygons. The code below removes all areas smaller than 3.24 hectare (approximately 4 raster cells), resulting in a reduction of 81% in the number of polygons. The labels are the ones created above.

```
r.reclass.area input=veg_ethiopia output=vegmap1
greater=3.24
r.neighbors vegmap1 out=vegmap2 method=mode
size=5
```

```
r.reclass vegmap2 out=vegmap3 title="Map of the
Potential Vegetation of Ethiopia" \
 <<EOF
    1 = 1     (1) Desert and semi-desert scrubland (DSS)
    2 = 2     (2a) Acacia-Commiphora woodland and
              bushland proper (ACB)
    3 = 3     (2b) Acacia wooded grassland of the Rift
              Valley (ACB/RV)
    4 = 4     (3) Wooded grassland of the western
              Gambela region (WGG)
    5 = 5     (4) Combretum-Terminalia woodland and
              wooded grassland (CTW)
    6 = 6     (5) Dry evergreen Afromontane forest and
              grassland complex (DAF)
    7 = 7     (6) Moist evergreen Afromontane forest
              (MAF)
    8 = 8     (7) Transitional rain forest (TRF)
    9 = 9     (8) Ericaceous belt (EB)
    10 = 10 (9) Afroalpine belt (AA)
    11 = 11 (10) Riverine vegetation (RV)
    12 = 12 (11a) Freshwater lakes – open water
              vegetation (FLV/OW)
    13 = 13 (11b) Freshwater marshes and swamps,
              floodplains and lake shore vegetation (FLV/
              MFS)
    14 = 14 (12a) Salt lake open water vegetation (SLV/
              OW)
    15 = 15 (12b) Salt pans, saline/brackish and
              intermittent wetlands and salt-lake shore
              vegetation (SLV/SSS)
EOF

g.region -p region=ethiopia_90m@PERMANENT
r.to.vect -s input=vegmap3 output=veg_ethiopia
feature=area
g.remove -f rast=vegmap3,vegmap1,vegmap2
```

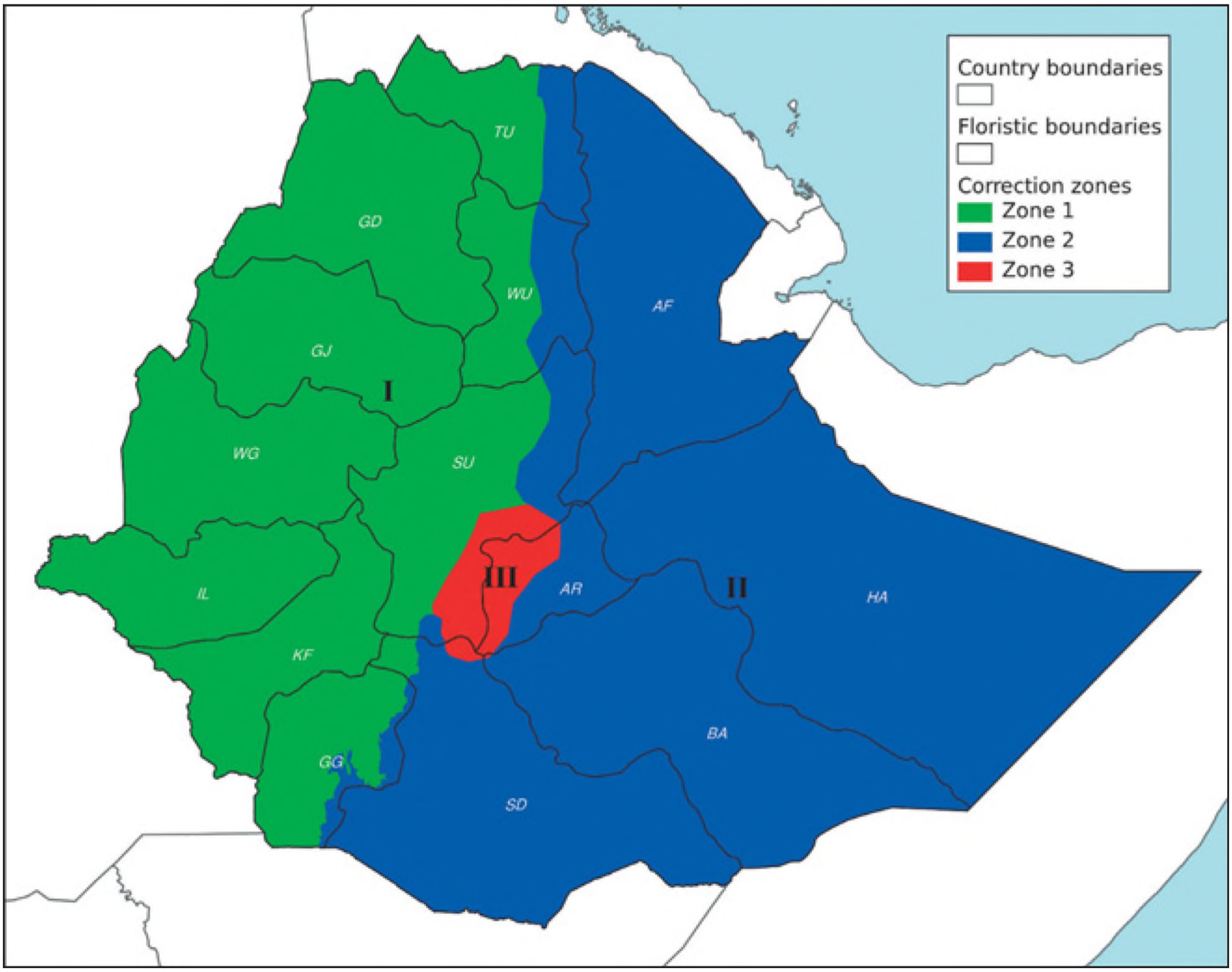


FIG. 36. The three zones indicating areas where special rules have been made to apply in the GIS work. I (correction zone 1): In this zone land between 400 and 1800 metres has been indicated as *Combretum-Terminalia* woodland (unless other, more specific criteria apply). II (correction zone 2): In this zone land between 400 and 1800 metres has been indicated as *Acacia-Commiphora* woodland and bushland (unless other, more specific criteria apply). III (correction zone 3): In this zone land below 1800 metres has been indicated as *Acacia* wooded grassland; this zone is equivalent to the central part of the Rift Valley. In south-western Ethiopia, where the *Acacia-Commiphora* woodland and bushland (ACB – in zone II) meets with *Combretum-Terminalia* woodland and wooded grassland (CTW – in zone I), a boundary has been manually defined, based on field observations of the authors. To the south the boundary follows the 750 metres contour starting at the border with Sudan in the south-east corner of the GG floristic region. Further north it moves towards the 1250 metres contour, which it follows up to the area southwest of the mountain bridge across the Rift Valley to the south of Lake Awasa, where the boundary between *Acacia-Commiphora* woodland and bushland (ACB) and Combretum-Terminalia woodland and wooded grassland (CTW) gradually moves up until it coincides with the 1800 metres contour.

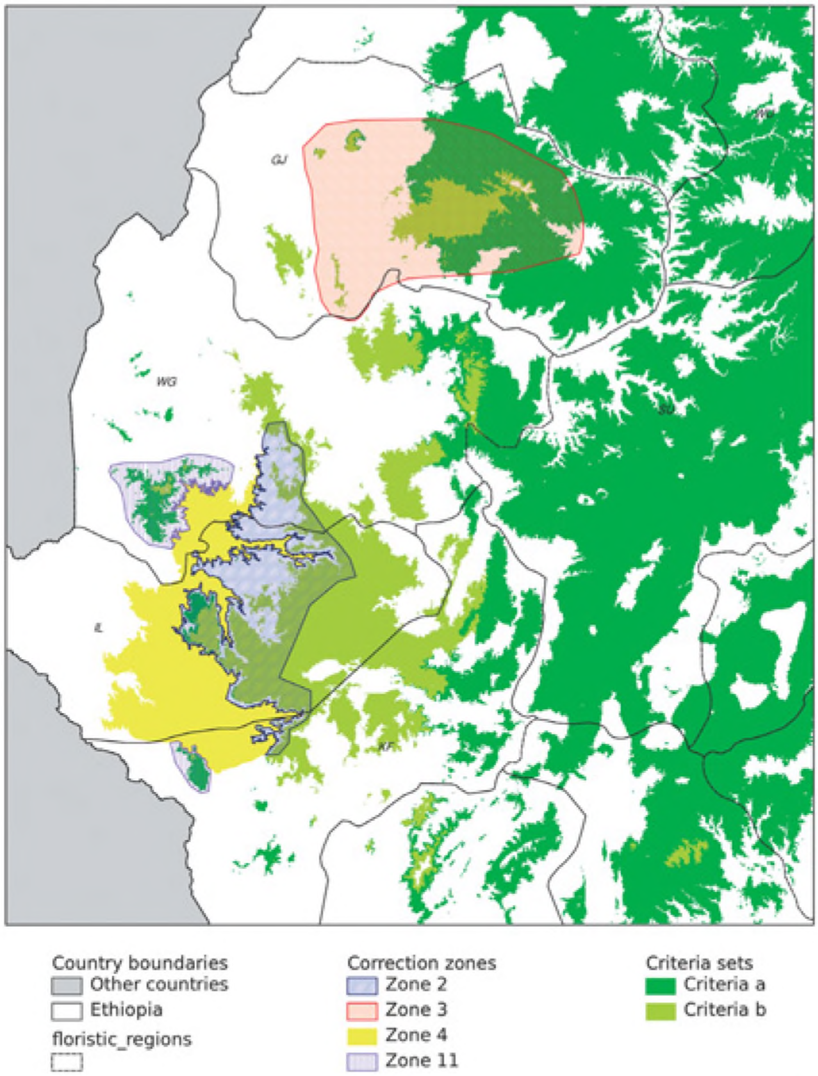


FIG. 37. Correction made in the GIS work to the vegetation types *Dry evergreen Afromontane forest and grassland complex* (DAF – with unmapped subtypes), *Moist evergreen Afromontane forest* (MAF – with unmapped subtypes) and *Transitional rain forest* (TRF) indicated for the adjacent parts of the floristic regions GJ, WG, IL and KF. See further in the text under Criteria and Classification Rules.

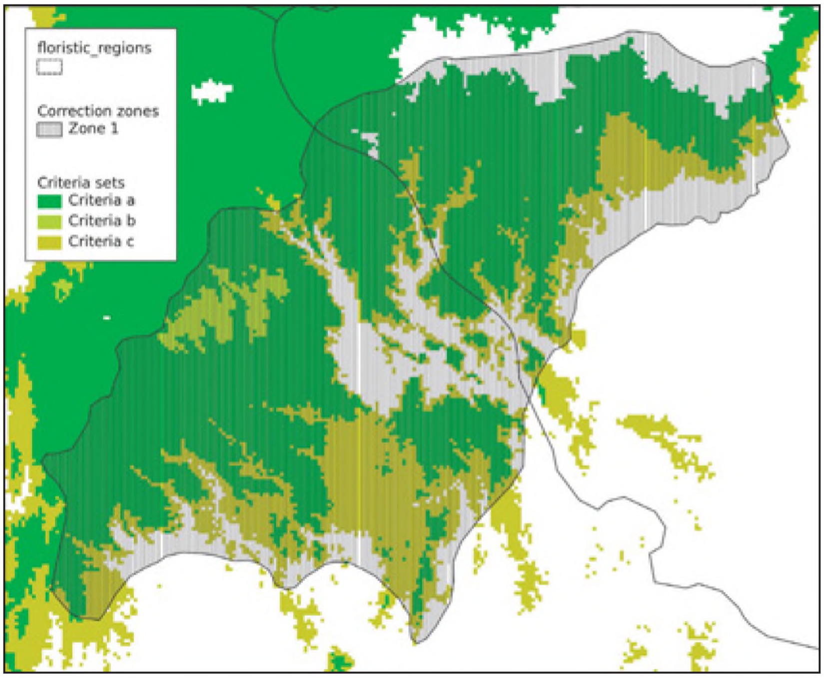


FIG. 38. Correction made in the GIS work to the forest types indicated for the adjacent parts of the floristic regions BA and SD. See further in the text under Criteria and Classification Rules.

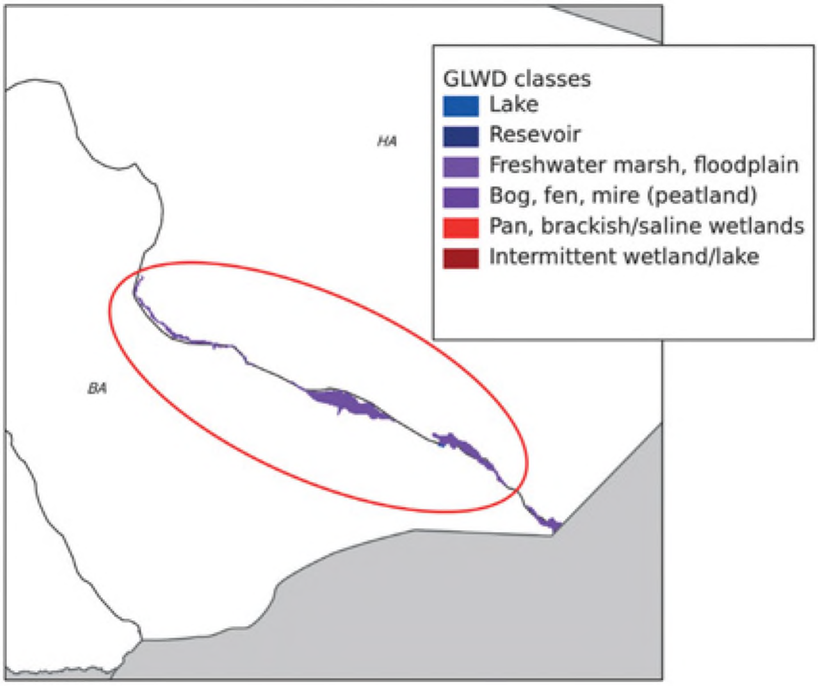


FIG. 39. Corrections made in the GIS work to the GLWD database in south-eastern Ethiopia. The floodplains indicated within the red outline have been marked as salt pans in this atlas, based on observations by the authors.

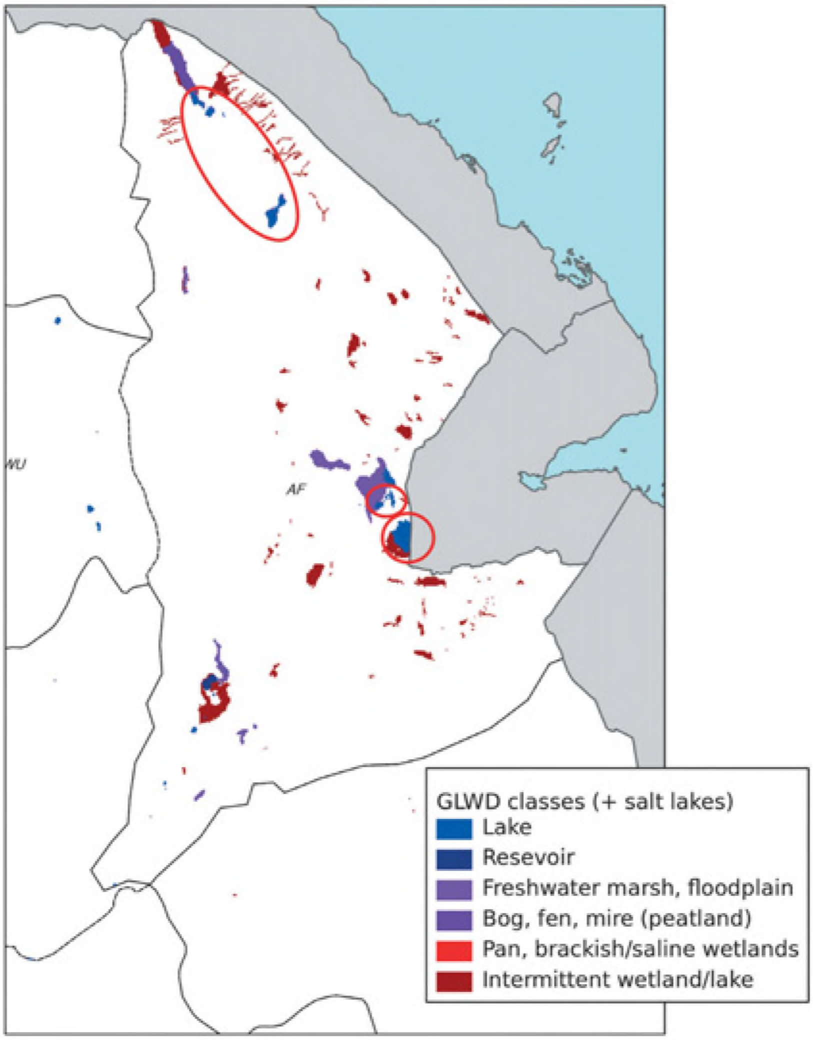


FIG. 40. Corrections made to the GLWD database in north-eastern Ethiopia. In agreement with the definitions indicated in the text, mainly from Wood and Talling (1988), the lakes indicated within the red outlines have been marked as salt lakes in this atlas.

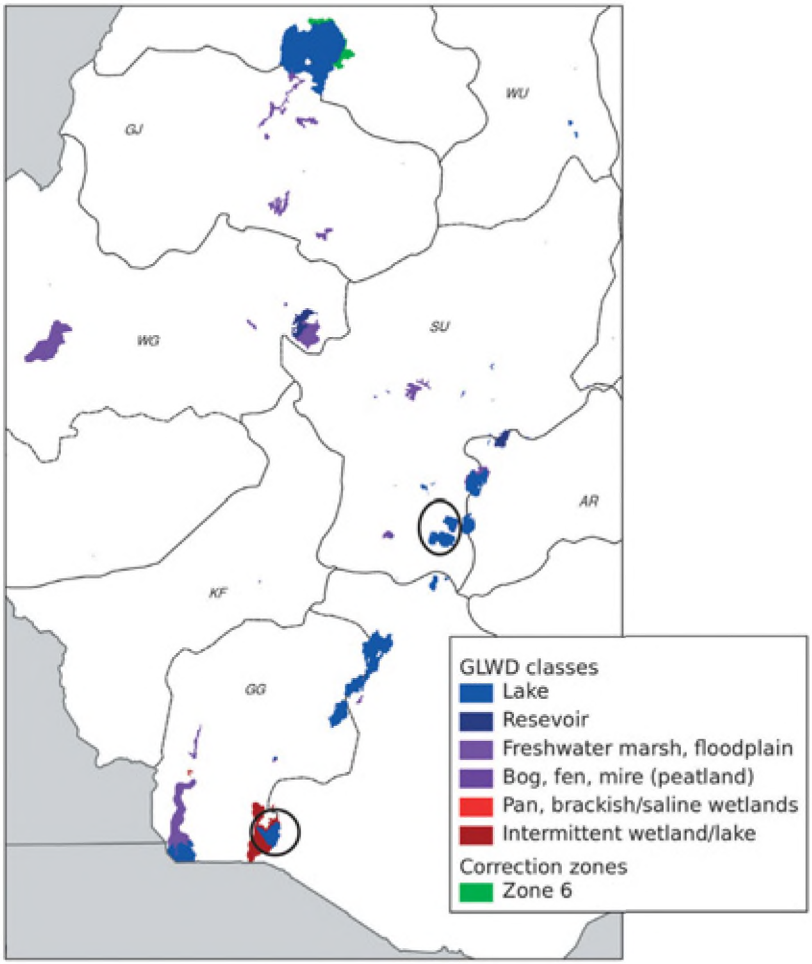


FIG. 41. Corrections made in the GIS work to the GLWD database in western Ethiopia. In agreement with the definitions indicated in the text, mainly from Wood and Talling (1988), the lakes indicated within the black outlines have been marked as salt lakes in this atlas. The area around Lake Tana in the North has been adjusted manually, based on the field experience of the authors.

APPENDIX 5

Officially recognised classification of the ecosystems of Ethiopia

This is an almost verbatim rendering of the official classification and description of the ecosystems of Ethiopia, as presented on the web site of the official Ethiopian Clearing House Mechanism (CHM) for the Convention of Biological Diversity (http://www.biodiv.be/ethiopia/implementation/ibc/str_ap/fol219304/doc254397), released on 22/03/2006. Only the introductory definitions and the paragraph about vegetation have been cited. A rather similar classification and presentation has been found on the web site of the Ethiopian Institute of Biodiversity Conservation (http://www.ibc-et.org/ibc/ecosm/).

The purpose of this Appendix is to facilitate the comparison between the official Ethiopian classification of the ecosystems of the country with the new classification of the vegetation as presented in this work.

In these texts the new names of the regional states have been used mixed with the names of the old administrative regions of Ethiopia (transliterated as: "Arsi," "Bale," "Gamo-Gofa," "Gojam," "Gonder," "Hararge," "Illubabor," "Kefa," "Shewa," "Sidamo," "Tigray," "Wellega" and "Welo") as they were before the establishment of the Federal Democratic Republic of Ethiopia on 21 August 1995, and they have not here been abbreviated as elsewhere in this work in agreement with the *Flora of Ethiopia and Eritrea* (see Fig. 3).

Note that the highest level in the Ethiopian administrative system is now based on major traditional ethnic areas (Tigray, Amhara, Oromia, Somalia, Afar, Southern Nations, Nationalities and Peoples, Benshangul-Gumuz and Gambella, etc.; these administrative units are called regions or regional states). These administrative entities are divided into units of lower rank, called zones and weredas.

1. Afroalpine and Subafroalpine Ecosystem

The ecosystem includes areas, which on the average are higher than 3200 metres altitude. The subafroalpine areas occur between 3200 and 3500 metres altitude, while the afroalpine areas occur between 3500 and 4620 metres altitude. The ecosystem is characterised by the most conspicuous giant *Lobelia*, *Lobelia rhynchopetalum*, and evergreen shrubs including the heather, *Erica arborea* and perennial herbs such as *Helichrysum* species.

2. Dry Evergreen Montane Forest and Grassland complex

This ecosystem represents a complex system of successions involving extensive grasslands rich in legumes, shrubs and small to large-sized trees to closed forest with a canopy of several strata occurring between (1600-) 1900 and 3300 metres altitude. This ecosystem covers much of highland areas and mountainous chains of Ethiopia in Oromia region (Shewa, Arsi, northern Bale and western Hararge), Amhara Region (Gojam, Welo, Gonder), Tigray Region (Tigray) and SNNP region (Shewa, Sidamo and Gamo-Gofa).

The areas with Dry Evergreen Afromontane forest have canopies usually dominated by Tid/Gatira (*Juniperus procera*) as a dominant species, followed by Weira/Ejersa (*Olea europaea* subsp. *cuspidata*), etc. Zigba/Birbirsa (*Podocarpus falcatus*) is also found in sheltered valleys.

The areas with Afromontane woodland, wooded grassland and grassland include the woodlands and wooded grasslands of the plateau with *Acacia abyssinica* and *A. negrii*.

The grasslands occur in the areas where human activity has been largest and most intense, and found at altitudes between 1500 and 3000 metres. The montane grassland in most places is derived from forest and other woody vegetation types. There exists also some edaphic grassland.

The evergreen scrub vegetation occurs in the highlands of Ethiopia either as an intact scrub in association with the dry evergreen montane forest or usually as secondary growth after deforestation of the dry evergreen montane forest.

3. Moist Evergreen Montane Forest Ecosystem

This ecosystem is in most cases characterised by one or more closed strata of evergreen trees, which may reach a height of 30 to 40 metres. The vegetation type in this ecosystem can be further divided into two (Friis, 1992; Sebsebe Demissew *et al.*, 2004). One type includes what is traditionally referred as the Afromontane rainforest. These forests occur in the south-western part of the Ethiopian highlands at between 1500 and 2600-mm elevation and the Harenna Forest on the southern slopes of the Bale mountains. The forests characteristically contain a mixture of Zigba (*Podocarpus falcatus*) and broad-leaved species as emergent trees in the canopy including Kerero (*Pouteria* (*Aningeria*) *adolfi-friederici*). Kerkha (the mountain bamboo – *Arundinaria alpina*) is also one of the characteristic species, although not uncommon is found locally. There are also a number of medium-sized trees, and large shrubs. The second type includes the *Transitional rain forest* (TRF), which includes forests known from the western escarpment of the Ethiopian highlands, in the WG, IL and KF floristic regions. The forest type occurs between 500 and 1500 metres elevation. The characteristic species in the canopy includes *Pouteria* (*Aningeria*) *altissima*, *Anthocleista schweinfurthii*, *Ficus mucuso* and species of *Garcinia*, *Manilkara* and *Trilepisium*.

4. *Acacia-Commiphora* Woodland Ecosystem

This ecosystem is characterised by drought resistant trees and shrubs, either deciduous or with small, evergreen leaves occurring between 900 and 1900 metres altitude. This vegetation type occurs in the northern, eastern, central and southern part of the country mainly in Oromia, Afar, Harari, Somali, and Southern Nations, Nationalities and Peoples Regional States. The trees and shrubs form an almost complete stratum and include species of Grar/Lafto (*Acacia senegal*, *A. seyal*, *A. tortilis*), Bedeno (*Balanites aegyptiaca*), Kerbe (*Commiphora africana*, *C. boranensis*, *C. ciliata*, *C. monoica* and *C. serrulata*). The ground-cover is rich in subshrubs, including species of *Acalypha*, *Barleria*, *Aerva*, and succulents with a number of Ret/Argessa (*Aloe*) species.

5. *Combretum-Terminalia* Woodland Ecosystem

This ecosystem is characterised by small to moderate-sized trees with fairly large deciduous leaves. These include Yetan Zaf (*Boswellia papyrifera*), *Anogeissus leiocarpa* and *Stereospermum kunthianum* and species of Weyba (*Terminalia*), *Combretum* and *Lannea*. The solid-stemmed lowland bamboo, Shimel (*Oxytenanthera abyssinica*) is prominent in river valleys [and locally on the escarpment] of western Ethiopia.

The vegetation type occurs along the western escarpment of the Ethiopian plateau, from the border region between Ethiopia and Eritrea to western Kefa and the Omo Zone (in the SNNP Region); it is the dominant vegetation in Benshangul-Gumuz and Gambela Regions, and the Didesa valley [Dedesa valley] in WG in Oromia Region, where it occurs between 500 and 1900 metres altitude. The vegetation in this ecosystem has developed under the influence of fire. The soil erosion rate is high, especially at the onset of rains.

6. Lowland, Semi-evergreen Forest Ecosystem

This ecosystem includes forests that are restricted to the Western lowlands in the IL floristic region in Abobo and Gog Weredas. They occur between 450 and 650 metres on sandy soils. They are semi-deciduous, with a 15-20 metres tall, more or less continuous canopy in which *Baphia abyssinica* is dominant, mixed with less common species including *Celtis toka*, *Diospyros abyssinica*, *Pouteria (Malacantha) alnifolia*, and *Zanha golungensis* and species of *Lecaniodiscus*, *Trichilia* and *Zanthoxylum*.

7. Desert and Semi-desert Scrubland Ecosystem

This ecosystem is characterised by highly drought tolerant species of Grar/Lafto (*Acacia brichettiana*, *A. stuhlmanii* and *A. walawlensis*), Etan (*Boswellia ogadensis*) Kerbe (*Commiphora longipedicellata* and *C. staphyleifolia*), as well as succulents, including species of *Euphorbia* and *Aloe*. The doum palm (*Hyphaene thebaica*), grasses such as *Dactyloctenium aegyptium* and *Panicum turgidum* are also characteristic species. … This ecosystem type occurs in the Afar Depression, the Ogaden, around Lake Chew Bahir and the delta of the Omo river below an altitude of 500 metres.

The semi-desert parts are found in the northern, western and north-eastern parts of the country (Amhara, Tigray and Afar), southern (Oromia and Southern Nations and Nationalities and Peoples Region) and the south-eastern and eastern (Somali) parts. The northern parts of Afar and north-eastern Tigray are predominantly desert.

8. Aquatic Ecosystem

This ecosystem consists of both running (lotic) and standing (lentic) inland water bodies, including rivers, lakes, reservoirs, swamps, wetlands and aquatic bodies with transient water contents during some time of the year. The strict IUCN definition of wetlands has been slightly modified to include all types of lakes in this document. …Although the floristic composition of the riverine vegetation varies depending on altitude and geographical location, in general it is mainly characterised by species of *Celtis africana*, *Mimusops kummel*, *Tamarindus indica*, etc. The swamps, reservoirs and shores of lakes are dominated by species of sedges and grasses.

References

Ethiopian personal names are referred to in agreement with the Ethiopian tradition. According to this, the first name is the important one that is used for alphabetizing. The second name has also been written in full, in order to avoid confusion, as it has been done in the authoritative refernce work R.K. Brummitt & C.E. Powell, *Authors of Plant Names*. Royal Botanical Gardens, Kew. 1992

Anonymous (1988). **National Atlas of Ethiopia**. Addis Abeba, Ethiopia Mapping Authority.

Anonymous (1997). **Ethiopia. 1:2,000,000.** [Map.] Addis Abeba, Ethiopia Mapping Authority.

Asfawossen Asrat, Metasebia Demissie and Aberra Mogessie (2008). **Geoturism in Ethiopia**. Addis Abeba, Shama Books.

Atkins, J. & Edwards, S. (2009). The vegetation of Ethiopia and Eritrea. Pp. 27-34 in: Ash, J. & Atkins, J. **Birds of Ethiopia and Eritrea – an atlas of distribution**. Christopher Helm, London.

Breitenbach, F. von (1963). **The Indigenous Trees of Ethiopia. 2nd revised and enlarged edition**. Ethiopian Forestry Association, Addis Abeba.

Chaffey, D. R. (1978a). **Southwest Ethiopia forest inventory project. A glossary of vernacular names of plants in southwest Ethiopia with special reference to forest trees**. Ministry of Overseas Development. Land Resources Development Centre. Project Report 26: 1–75 & map.

Chaffey, D. R. (1978b). **Southwest Ethiopia forest inventory project. An inventory of Magada forest**. Ministry of Overseas Development. Land Resources Development Centre. Project Report 28: 1–52 & map.

Chaffey, D. R. (1978c). **Southwest Ethiopia forest inventory project. An inventory of forest at Munessa and Shashemane**. Ministry of Overseas Development. Land Resources Development Centre. Project Report 29: 1–97 & maps.

Chaffey, D. R. (1978d). **Southwest Ethiopia forest inventory project. An inventory of Tiro Forest**. Ministry of Overseas Development. Land Resources Development Centre. Project Report 30: 1–60 & maps.

Chaffey, D. R. (1979). **Southwest Ethiopia forest inventory project. A reconnaissance inventory of forest in southwest Ethiopia**. Ministry of Overseas Development. Land Resources Development Centre. Project Report 31: 1–316 & maps.

CGIAR-CSI. (2008). CGIAR-CSI SRTM 90m DEM Digital Elevation Database, version 4. Available on http://csi.cgiar.org/.

CSE. (1997). The Conservation Strategy of Ethiopia (CSE). **The Resource Base, its utilization and planning for sustainability**. Federal Democratic Republic of Ethiopia, Environmental Protection Authority, Addis Abeba.

de Wit, M. J. & Stankiewicz, J. M. (2006). Changes in Surface Water Supply across Africa with Predicted Climate Change. **Science 311 (no. 5769)**: 1917 – 1921.

Elizabeth Kebede, Zinabu G.-Mariam & Ahlgren, I. (1994). The Ethiopian Rift Valley lakes: chemical characteristics of a salinity-alkalinity series. **Hydrobiologia 288**: 1-12.

Engler, A. (1882). **Versuch einer Entwichlungsgeschichte der Pflanzenwelt, inbesondere der Florengebiete seit der Tertiärperiode. 2. Theil. Die extratropischen Gebiete der südlichen Hemisphäre und die tropischen Gebiete**. W. Engelmann, Leipzig.

Engler, A. (1908). Pflanzengeographische Gliederung von Afrika. **Sitzungsber. königl. preuss. Akad. d. Wiss. 1908**: 781-837.

Engler, A. (1910). Die Pflanzenwelt Afrikas, inbesondere seiner tropischen Gebiete. I. Allgemeiner Ueberblick über die Pflanzenwelt Afrikas und ihrer Existenzbedingungen: Allgemeiner Ueberblick über die Vegetationsverhältnisse von Afrika. In A. Engler and O. Drude (editors). **Die Vegetation der Erde. Vol. IX, 1, 1.**: 1870. W. Engelmann, Leipzig.

Friis, I. (1992). Forests and forest trees of northeast tropical Africa – their natural habitats and distribution patterns in Ethiopia, Djibouti and Somalia. **Kew Bull. Additional Series, No 15 (pp. i-iv & 1-396)**. HMSO, London.

Friis, I. (2006). Distribution Patterns of Solanum in the Horn of Africa. Pp. 279-289 in Ghazanfar S.A. & Beentje, H. (eds.), **Taxonomy and Ecology of African Plants, their Conservation and Sustainable Use –**

Proceedings of the 17th AETFAT Congress, Addis Abeba. Royal Botanic Gardens, Kew.

Friis, I., Rasmussen, F.N. and Vollesen, K. (1982). Studies in the Flora and vegetation of southwest Ethiopia. **Opera Bot.** 63: 1-70.

Friis, I. & Ryding, O. [eds.] (2001). Biodiversity Research in the Horn of Africa Region. Proceedings of the Third Intarnational Symposium on the Flora of Ethiopia and Eritrea at the Carlsberg Academy, Copenhagen, August 25-27, 1999. **Biol. Skrifter** 54.

Friis, I. & Sebsebe Demissew (2001). Vegetation maps of Ethiopia and Eritrea. A review of existing maps and the need for a new map for the Flora of Ethiopia and the need for a new map for the Flora of Ethiopia and Eritrea. In: I. Friis & O. Ryding (eds). Biodiversity Research in the Horn of Africa Region, Proceedings of the 3rd International Symposium on the Flora of Ethiopia and Eritrea. **Biol. Skrifter** 54: 399-439.

Friis, I. & Vollesen, K. (2005). Flora of the Sudan-Uganda border area east of the Nile. II. Catalogue of vascular plants, 2nd part, vegetation and phytogeography. **Biol. Skrifter** 51:2: 300-855.

Friis, I. & Vollesen, K. (2010). *Zanthoxylum gilletii* (Rutaceae) – a mainly Guineo-Congolian forest tree with a newly discovered disjunction to western Ethiopia. Pp. 191–199 in: X. van der Burgt, J. van der Maesen & J.-M. Onana (eds.), **Systematics and conservation of African plants – Proceedings of the 18th AETFAT Congress, Yaoundé, Cameroon.** Royal Botanic Gardens, Kew.

Gillett, J.B. (1941). The plant formations of Western British Somaliland and the Harar Province of Ethiopia. **Kew Bulletin** 1941: 37-75.

GRASS Development Team (2009). Geographic Resources Analysis Support System. Available on http://grass.osgeo.org/

Hahn, J. (1908). **Handbuch der Klimatologie. 1. Band. Allgemeine Klimalehre.** Dritte, wesentlich umarbeitete und vermehrte Auflage. J. Engelhorn, Stuttgart.

Harrison, M.N. & Jackson, J.K. (1958) Ecological classification of the vegetation of the Sudan. **Forest Bulletin for the Sudan, n.s.,** 2: 1-45 and coloured vegetation map.

Hastings, D.A., Dunbar, P.K Elphingstone, G.M., Bootz, M., Hiroshi Murakami, Hiroshi Maruyama, Hiroshi Masaharu, Holland, P., Payne, J., Bryant, N.A., Logan, T.L., Muller, J.P., Schreier, G., and MacDonald, J.S. (eds.) (1999). The Global Land One-kilometer Base Elevation (GLOBE) Digital Elevation Model, Version 1.0. National Oceanic and Atmospheric Administration, National Geophysical Data Center, 325 Broadway, Boulder, Colorado 80305-3328, U.S.A. (URL: http://www.ngdc.noaa.gov/mgg/topo/globe.html).

Hedberg, O. (1951). Vegetation belts on the East African mountains. **Svensk Bot. Tidskr.** 45: 140-202.

Hedberg, O. (1961). The phytogeographical position of the afroalpine flora. **Rec. Adv. Bot.** 1, 914-919.

Hedberg, O. (1964a). Études écologiques de la flore afroalpine. **Bull. Soc. Bot. Belgique** 97(5), 5-18.

Hedberg, O. (1964b). Features of Afroalpine plant ecology. **Acta Phytogeogr. Suecc.** 49, 1-144.

Hijmans, R.J., Cameron, S.E., Parra, J.L., Jones, P.G. & Jarvis, A. (2005a) Very high resolution interpolated climate surfaces for global land areas. **International Journal of Climatology** 25, 1965-1978.

Hijmans, R.J., Guarino, L., Jarvis, A., O'Brien, R. Mathus, P. Bussink, C., Cruz, M., Barrantes, I. & Rojas, E. (2005b). DIVA-GIS, Version 5.2. Manual. (Available on http://www.diva-gis.org/docs/DIVA-GIS5_manual.pdf).

Hurni, H. & Messerli, B. (2003). **Semien Mountains – Ethiopia. 1:100 000. World Heritage Site.** [Map.] Centre for Development and Environment, Institute of Geography, University of Berne, Berne.

IBC [Institute of Biodiversity Conservation (of Ethiopia)]. 2005. **National Biodiversity Strategy and Action Plan.** 103 pp. Addis Abeba.

Jackson, J.K. (1956). The vegetation of the Imatong Mountains, Sudan. **Journ. Ecology** 44: 341-374.

Last, G. (2009). The geology and soils of Ethiopia and Eritrea. Pp. 25-26 in: Ash, J. & Atkins, J., **Birds of Ethiopia and Eritrea – an atlas of distribution.** Christopher Helm, London.

Lehner, B. & Döll, P. (2004). Development and validation of a global database of lakes, reservoirs and wetlands. **Journal of Hydrology** 296: 1–22.

Liljequist, (1986). Some aspects of the climate of Ethiopia. **Symb. Bot. Upsal.** 26,2: 19-30.

Mohr, P.A. (1971). **The Geology of Ethiopia.** 2. Edition. University College of Addis Ababa Press, Addis Abeba.

Mooney, H.F. (1963). An account of two journeys to the Araenna Mountains in Bale Province (southeast Ethiopia) in 1958 and 1959-60. **Proc. Linn. Soc. London** 172: 127-142.

Negri, G. (1940). Per uno schema cartografico della vegetazione dell'Africa Orientale Italiana. **Rivista Geografica Italiana** 47: 2-16.

Pichi Sermolli, R.E.G. (1955). Tropical East Africa (Ethiopia, Somaliland, Kenya, Tanganyika). Pp. 202-260 in **UNESCO, Arid Zone Research, VI. Plant Ecology. Reviews of Research.**

Pichi Sermolli, R.E.G. (1957). Una carta geobotanica dell'Africa Orientale (Eritrea, Ethiopia, Somalia). **Webbia 13: 15-132 & 1 map.**

Sebsebe Demissew, Cribb, P. & Rasmussen, F. (2004). **Field guide to Ethiopian Orchids**. Royal Botanic Gardens, Kew.

Sebsebe Demissew & Friis, I. (2009). The vegetation types in Ethiopia. In: I. Hedberg, I. Friis & E. Persson (eds.). **The Flora of Ethiopia and Eritrea, , Volume 8**: 27-32. National Herbarium, Addis Abeba University, Addis Abeba & Uppsala University, Uppsala.

Sebsebe Demissew, Mengistu Wondafrash & Yilma Dellellegn (1996). Ethiopia's natural resource base. In Sue Edwards (ed)., **Important Bird Areas of Ethiopia. A First Inventory**. Ethiopian Wildlife and Natural History Society, Addis Abeba. pp. 36-53.

Sebsebe Demissew, Nordal, I. & Stabbetorp, O. (2003). **Flowers of Ethiopia and Eritrea: aloes and other lilies.** Shama Books, Addis Abeba.

Stankiewicz, J., and M. de Wit. (2005). Fractal river networks of Southern Africa. **South African Journal of Geology 108**: 333-344.

Talling, J. F., Wood, R.B., Prosser, M.V. & Baxter, R.M. (1973). The upper limit of photosynthetic productivity by phytoplankton: evidence from Ethiopian soda lakes. **Freshwater Biol.** 3: 53–76.

Tenalem Ayenew (2009). **Natural Lakes of Ethiopia.** Addis Abeba University Press, Addis Abeba.

White, F. (1983). The vegetation of Africa. A descriptive memoir to accompany the UNESCO/AETFAT/UNSO vegetation map of Africa. With 4 coloured vegetation maps (1:5 000 000). **Natural Resources Research 20**, 1-356.

Wild, H. & Grandvaux Barbosa, L.A. (1967). **Vegetation map (1:2,500,000 in colour) of the Flora Zambesiaca Area (Map & Descriptive memoir). Flora Zambesiaca Supplement.** Collins, Salisbury.

Williams, W. D. (1964). A contribution to lake typology in Victoria, Australia. **Verh. Int. Ver. Limnol.** 15: 158-168.

Wood, R.B. & J.F. Talling (1988). Chemical and algal relationships in salinity series of Ethiopian inland waters. **Hydrobiologia 158: 29-67.**

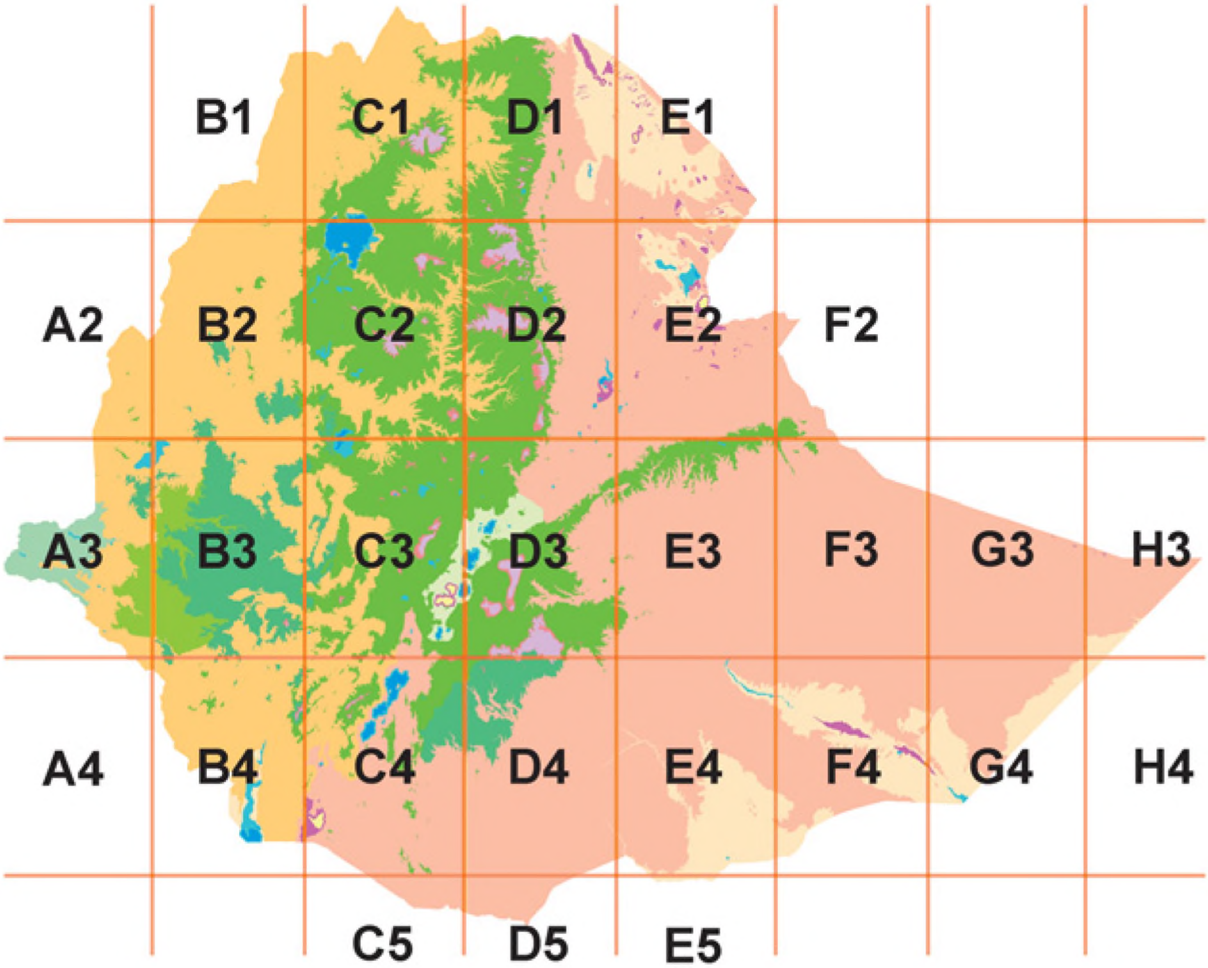
Zerihun Woldu (1999). Forests in the vegetation types of Ethiopia and their status in the geographical contex. Pp. 1-36 in: Edwards, S., Abebe Demissie, Yaye Bekele & G.Haase (eds.), **Forest Genetic Resources - Conservation: Principles Strategies and Action**. Addis Abeba.

Map plates of the potential vegetation of Ethiopia

1:2,000,000

Map plates of the potential vegetation of Ethiopia

1:2,000,000



This part of the work contains a key (above) and a legend (following page) to all map plates in the atlas and 29 map plates of the potential vegetation of Ethiopia. The plates are in the geographic coordinate system (GCS) WGS 1984 and come at a scale of 1:2,000,000. The colour scheme of the key above follows that of the legend. The legend also includes a scale bar, which gives the approximate distances in kilometres on the map. The map plates are ordered in sequence first according to columns (A - H), then according to rows (1 - 5). The individual map plates are marked according to the key. All map plates are drawn with North towards the top of the map.

The full map (c. 90 × 70 centimetres) can be printed out from a pdf-file available on request from the authors.

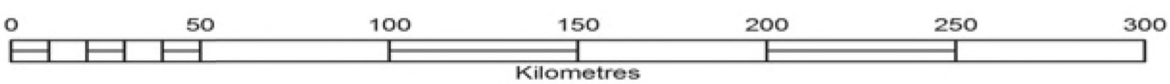
Legend

- Cities and towns
- Roads and tracks
- Floristic regions
- Non perennial river
- Perennial river

Potential Natural Vegetation of Ethiopia

- Desert and semi-desert scrubland (DSS)
- Acacia-Commiphora woodland and bushland proper (ACB)
- Acacia wooded grassland of the Rift Valley (ACB/RV)
- Wooded grassland of the Western Gambela region (WGG)
- Combretum-Terminalia woodland and wooded grassland (CTW)
- Dry evergreen Afromontane forest and grassland complex (DAF)
- Moist evergreen Afromontane forest (MAF)
- Transitional rain forest (TRF)
- Ericaceous belt (EB)
- Afroalpine belt (AA)
- Freshwater lakes - open water vegetation (FLV/OW)
- Freshwater marshes and swamps, floodplains and lake shore vegetation (FLV/MFS)
- Salt lakes - open water vegetation (SLV/OW)
- Salt pans, saline/brackish and intermittent wetlands and salt-lake shore vegetation (SLV/SSS)

Scale 1:2,000,000



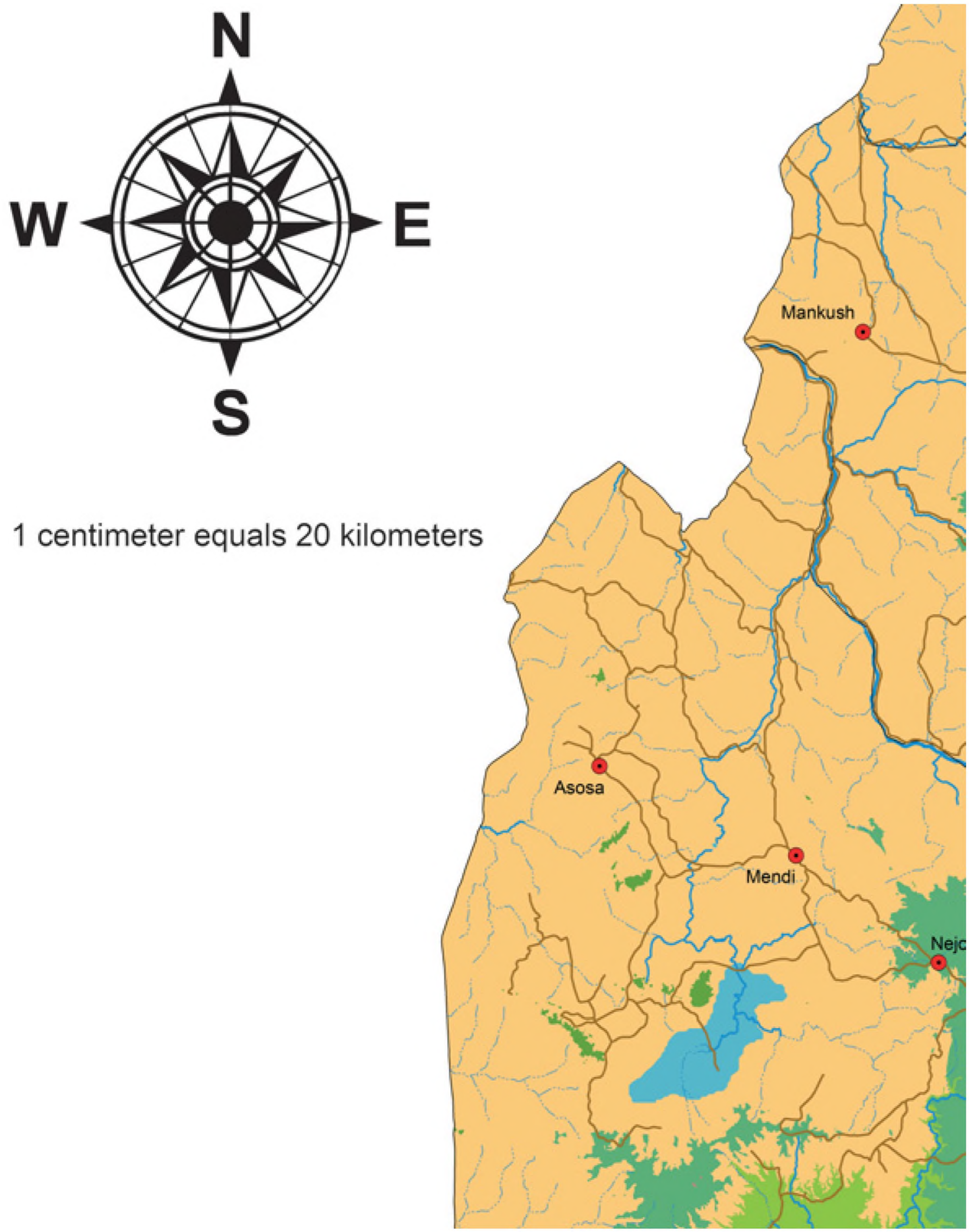

N
W
E
S
1 centimeter equals 20 kilometers
Mankush
Asosa
Mendi
Nejc

PLATE A2

plate a3

PLATE A4

PLATE BI

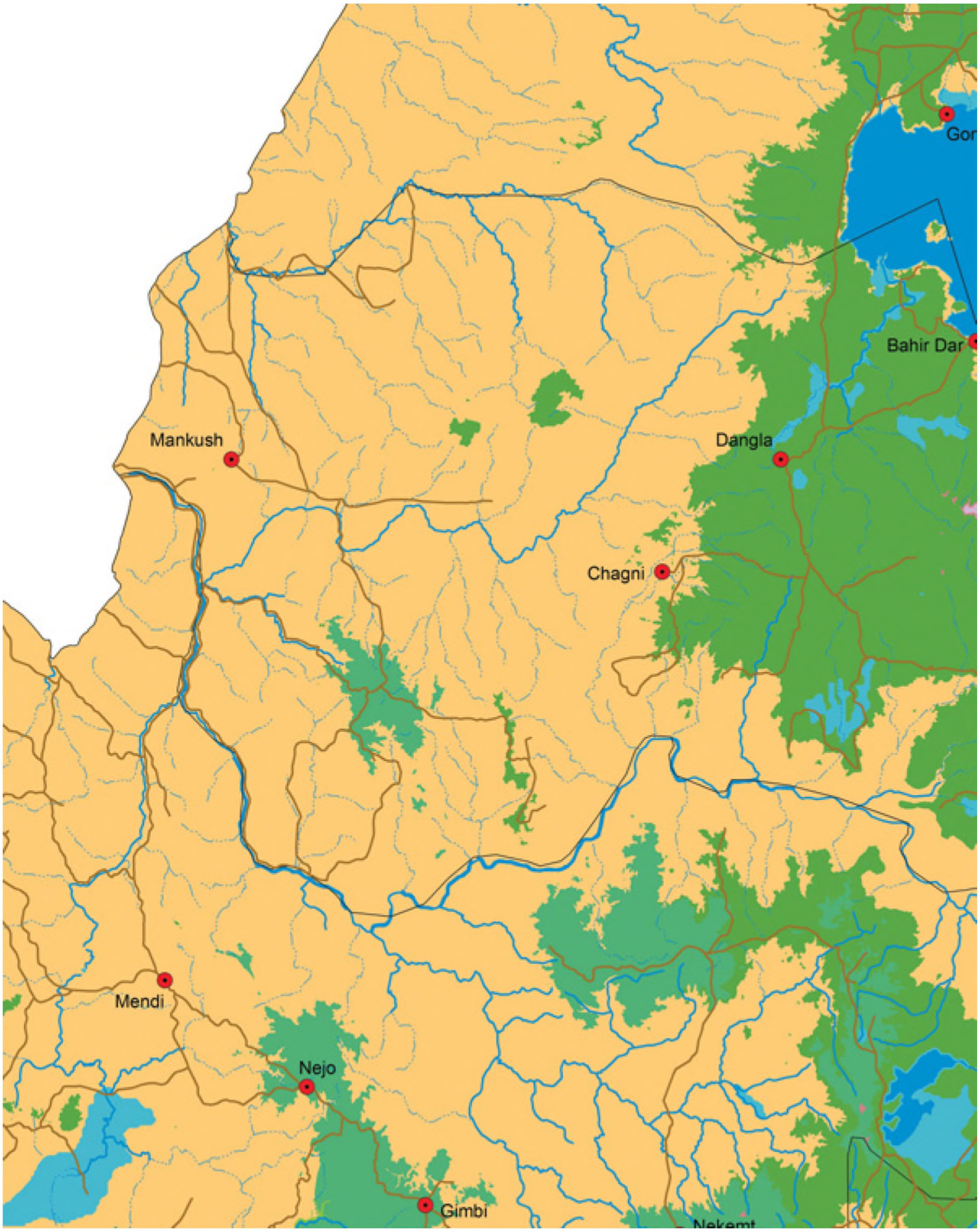

Gor
Bahir Dar
Mankush
Dangla
Chagni
Mendi
Nejo
Gimbi
Nekemt

PLATE B2

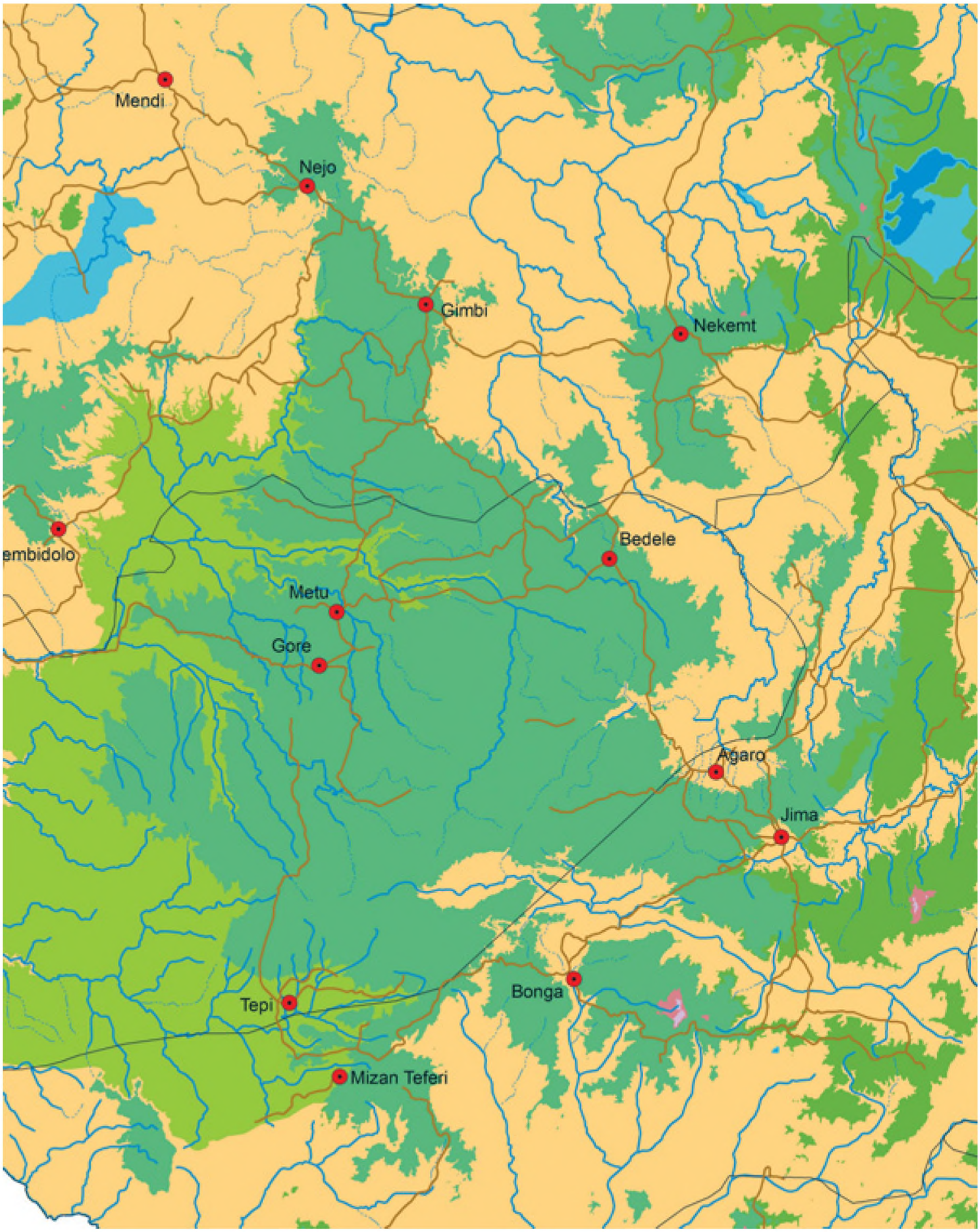

Mendi
Nejo
Gimbi
Nekemt
embidolo
Bedele
Metu
Gore
Agaro
Jima
Bonga
Tepi
Mizan Teferi

PLATE B3

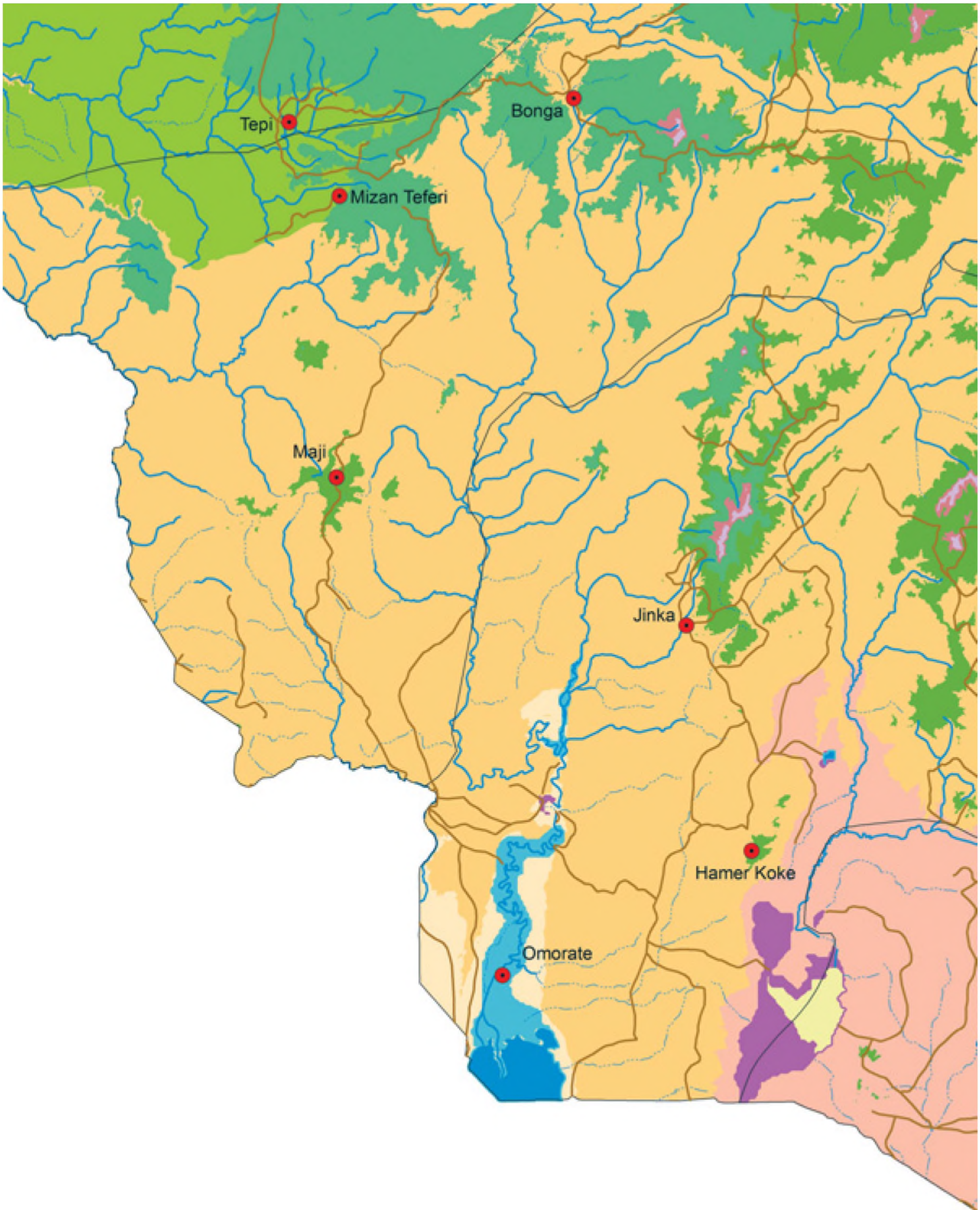


PLATE B4

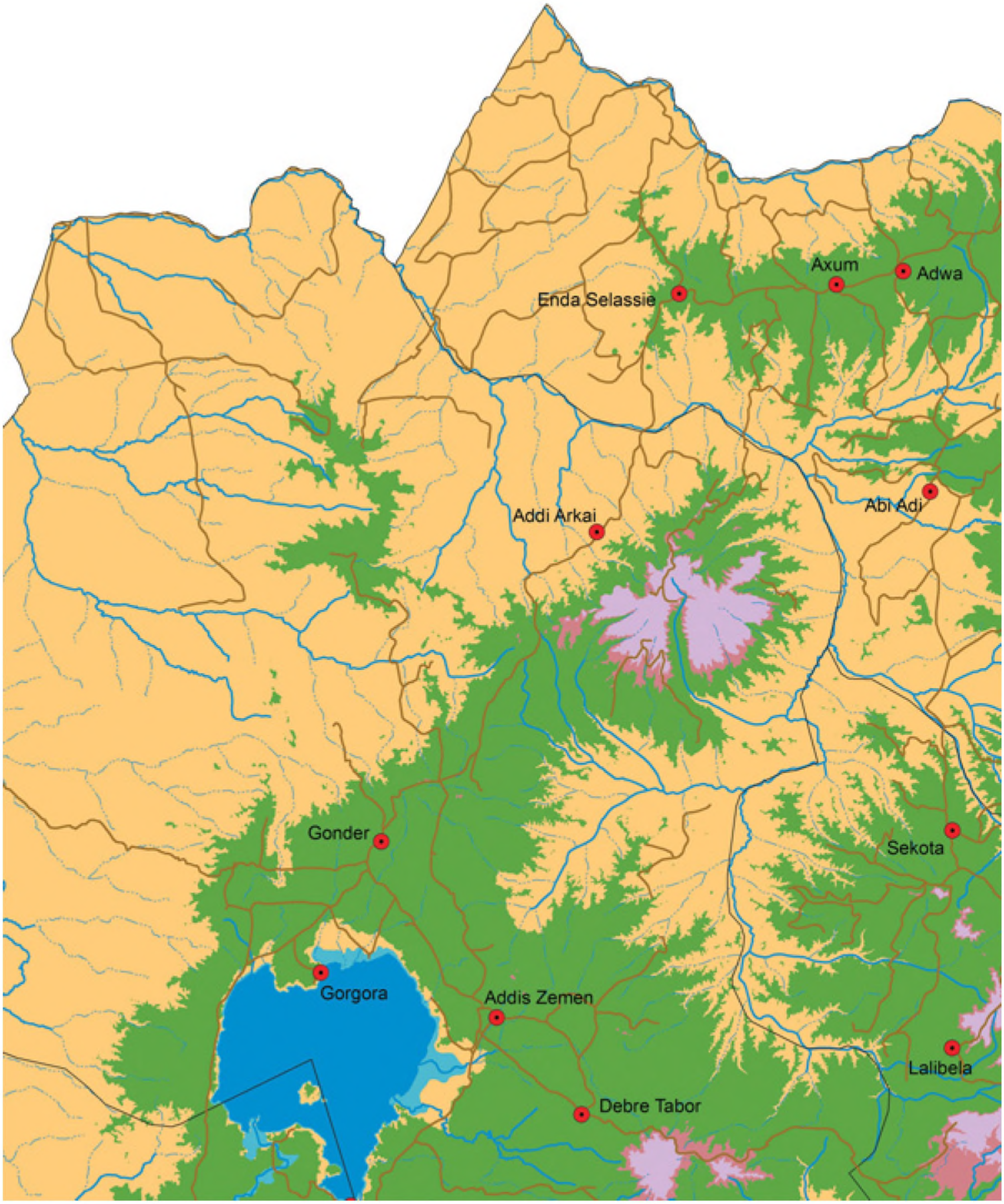

Enda Selassie
Axum
Adwa
Addi Arkai
Abi Adi
Gonder
Sekota
Gorgora
Addis Zemen
Lalibela
Debre Tabor

PLATE CI

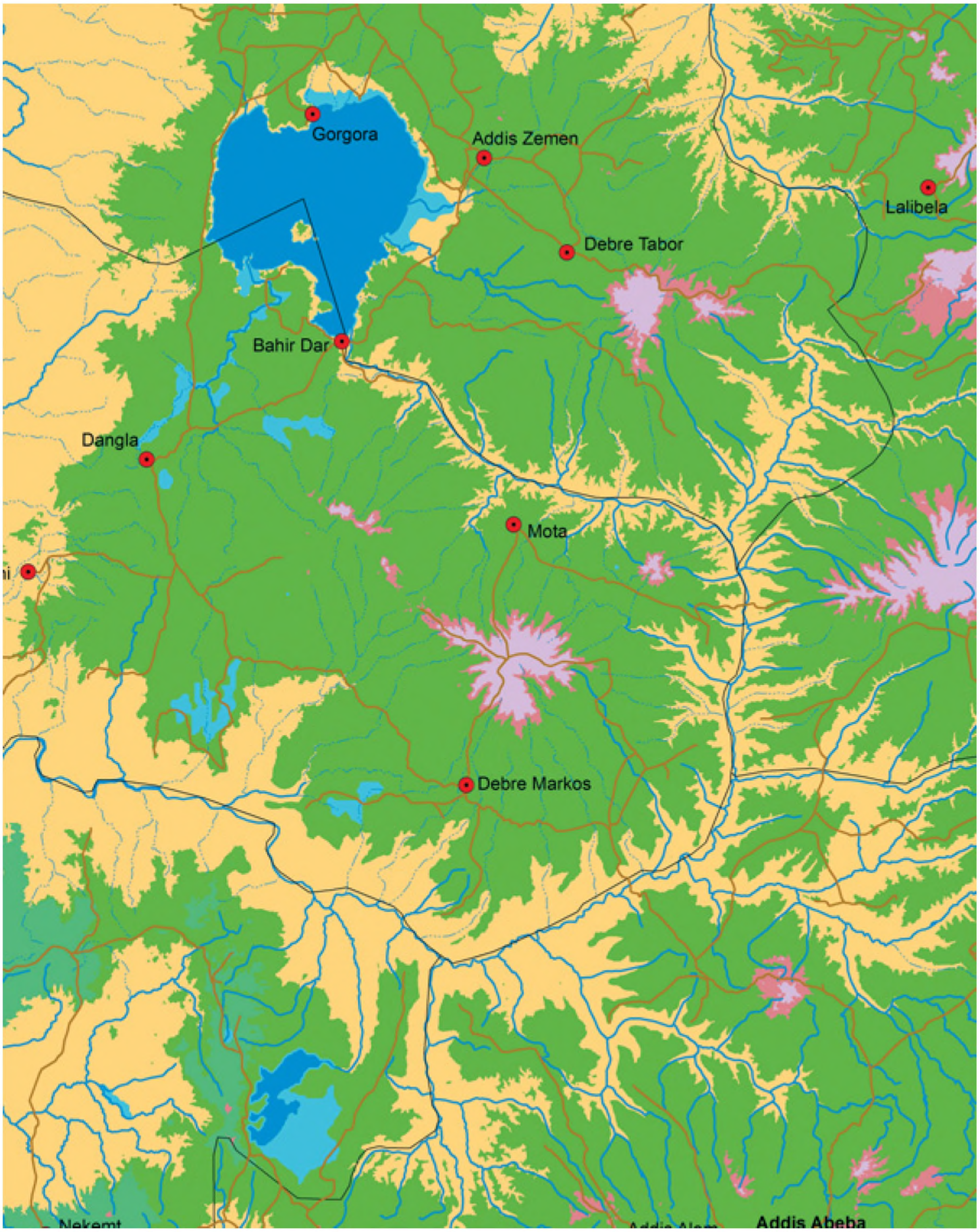

Gorgora
Addis Zemen
Lalibela
Debre Tabor
Bahir Dar
Dangla
Mota
Debre Markos
Addis Abeba

PLATE C2

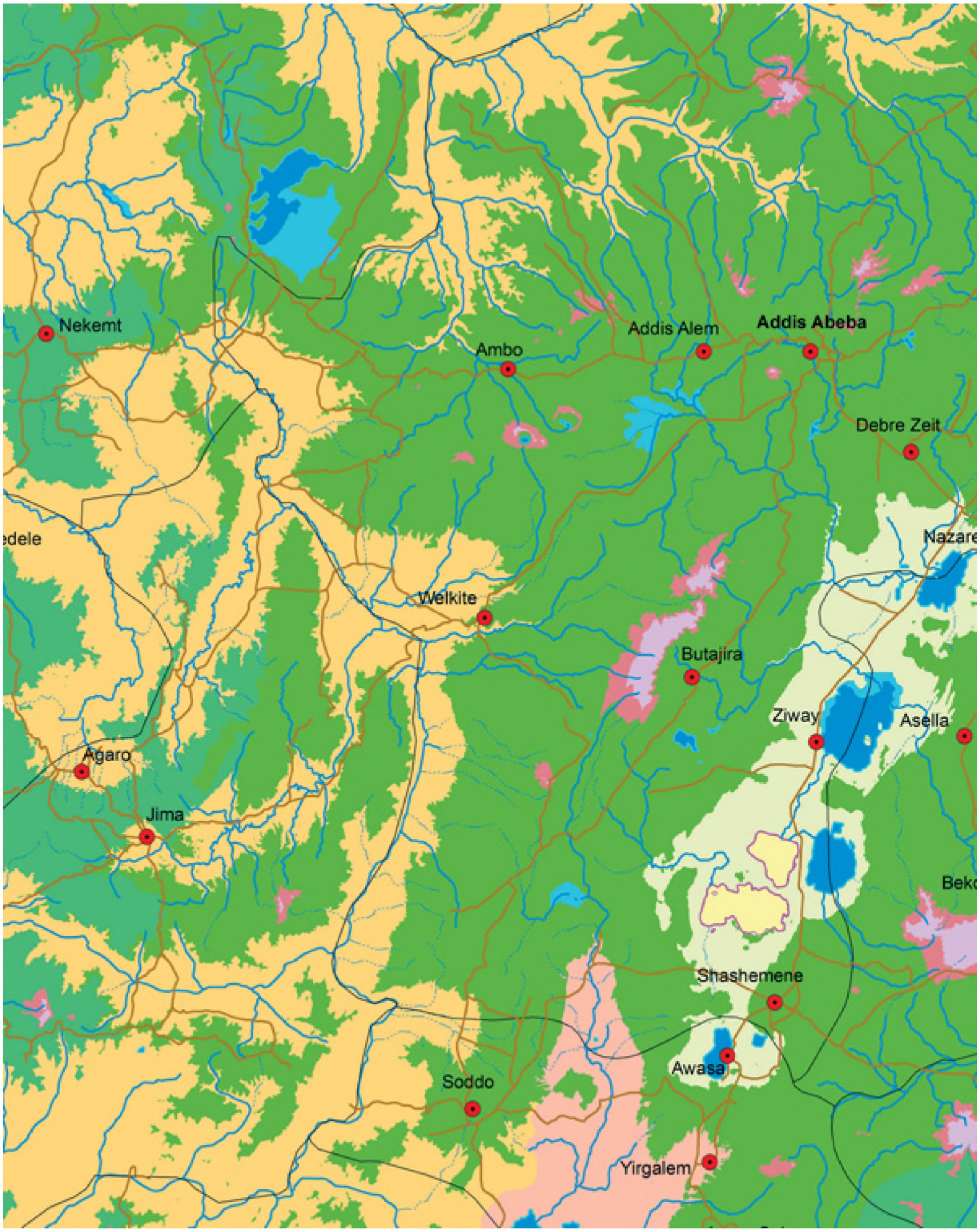

Nekemt
Ambo
Addis Alem
Addis Abeba
Debre Zeit
edele
Nazare
Welkite
Butajira
Ziway
Asella
Agaro
Jima
Beko
Shashemene
Awasa
Soddo
Yirgalem

PLATE C3

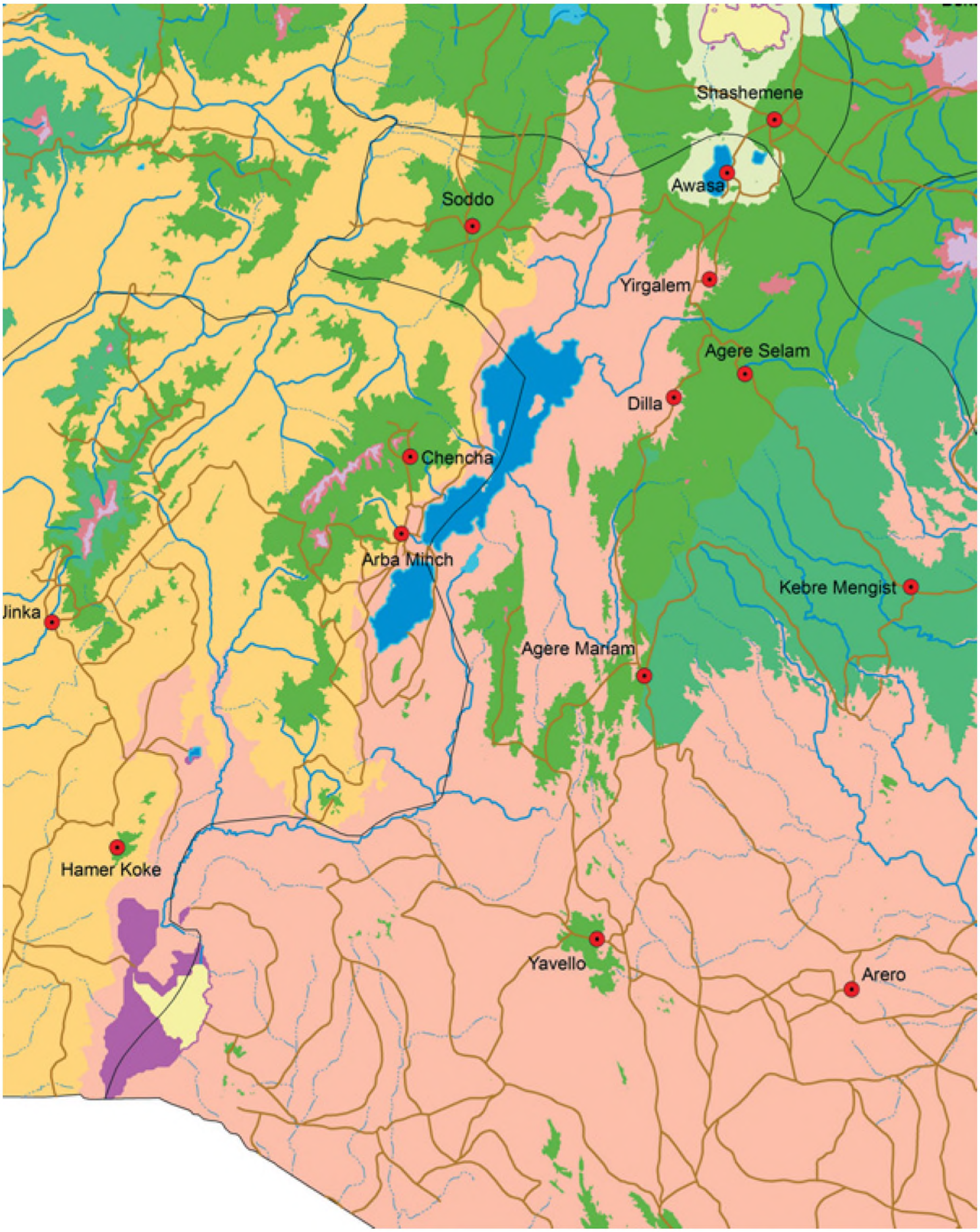

Shashemene
Awasa
Soddo
Yirgalem
Agere Selam
Dilla
Chencha
Arba Minch
Kebre Mengist
Jinka
Agere Mariam
Hamer Koke
Yavello
Arero

PLATE C4

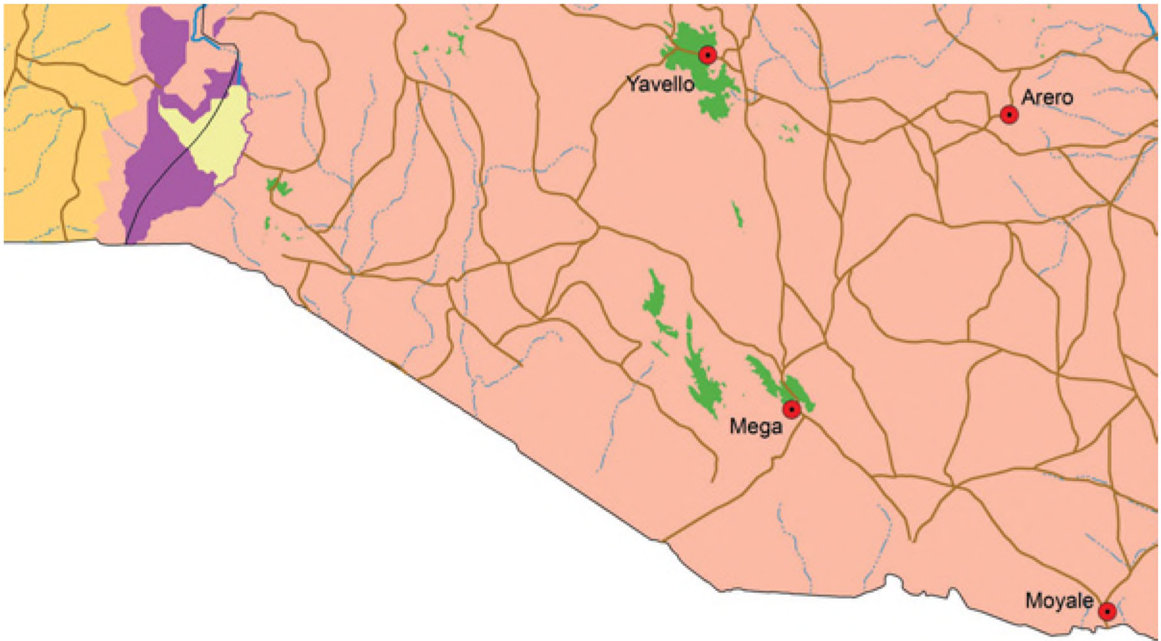


plate c5

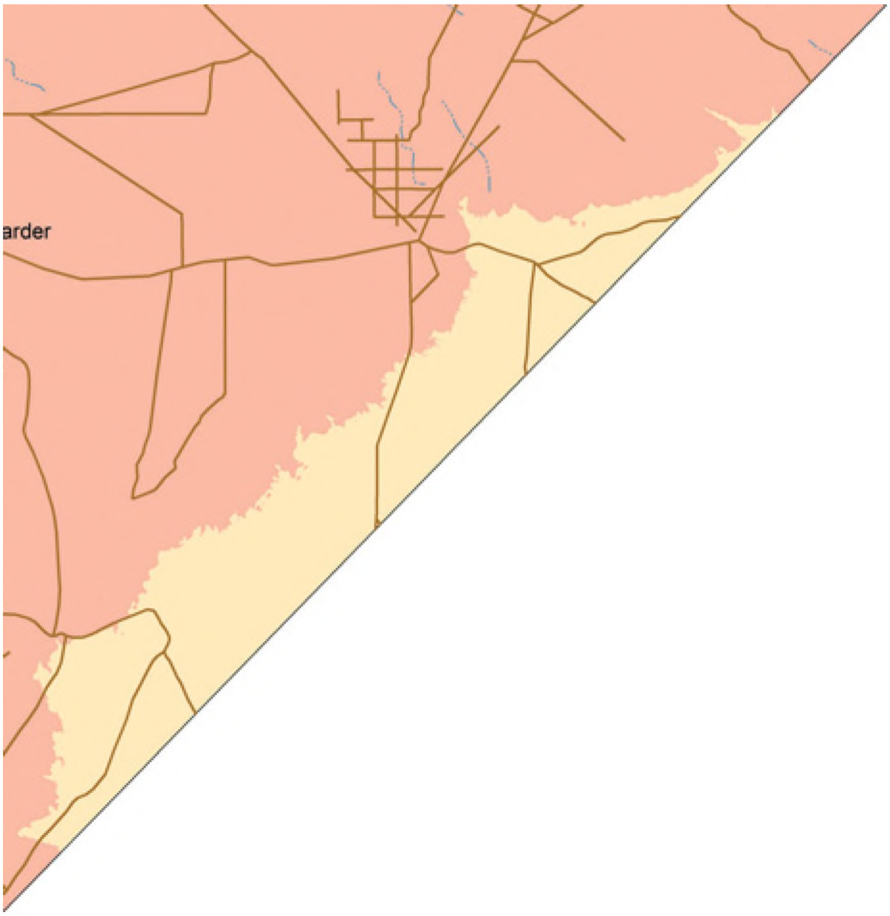


PLATE H4

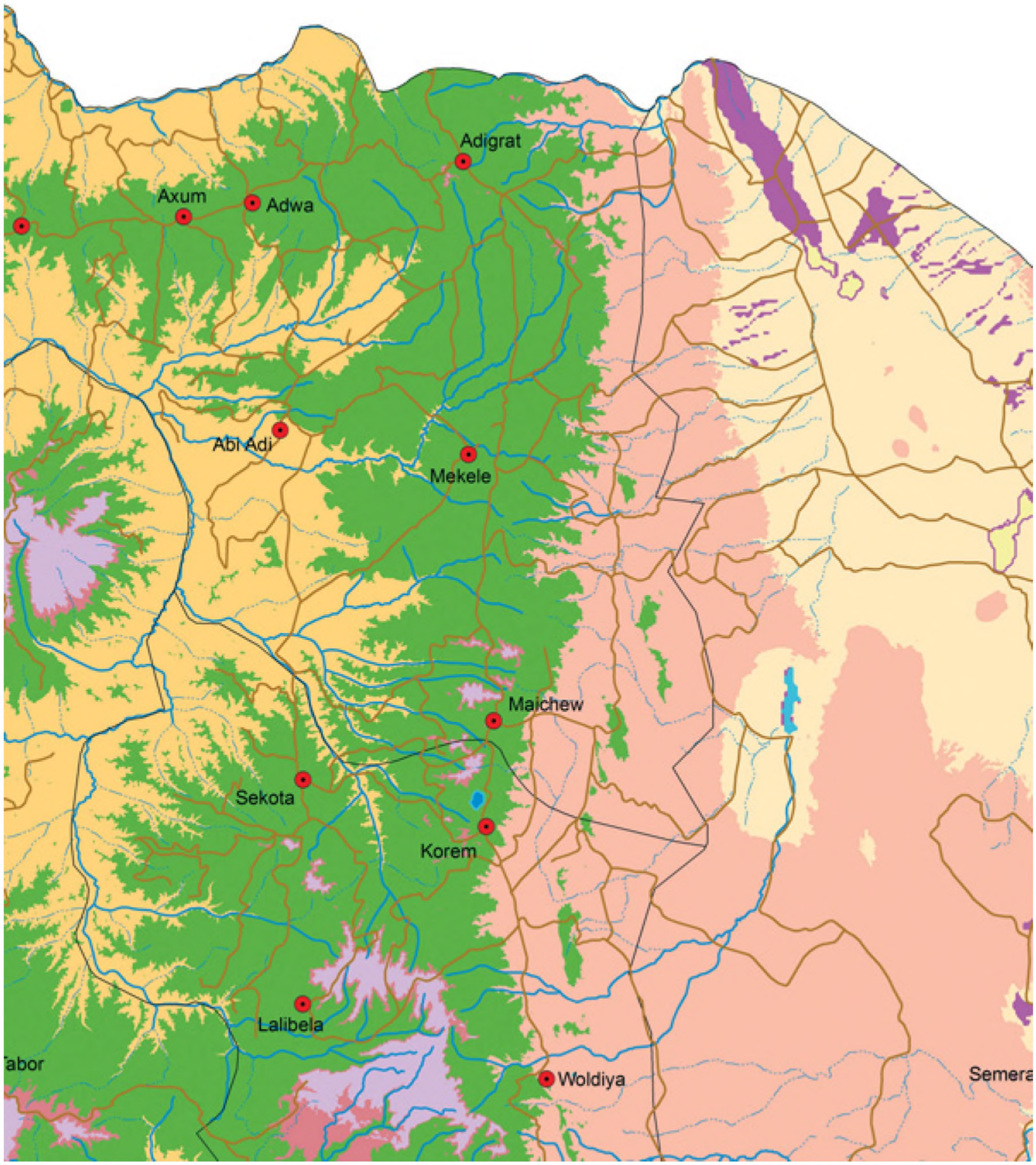

Adigrat
Axum
Adwa
Abi Adi
Mekele
Maichew
Sekota
Korem
Lalibela
Tabor
Woldiya
Semera

PLATE DI

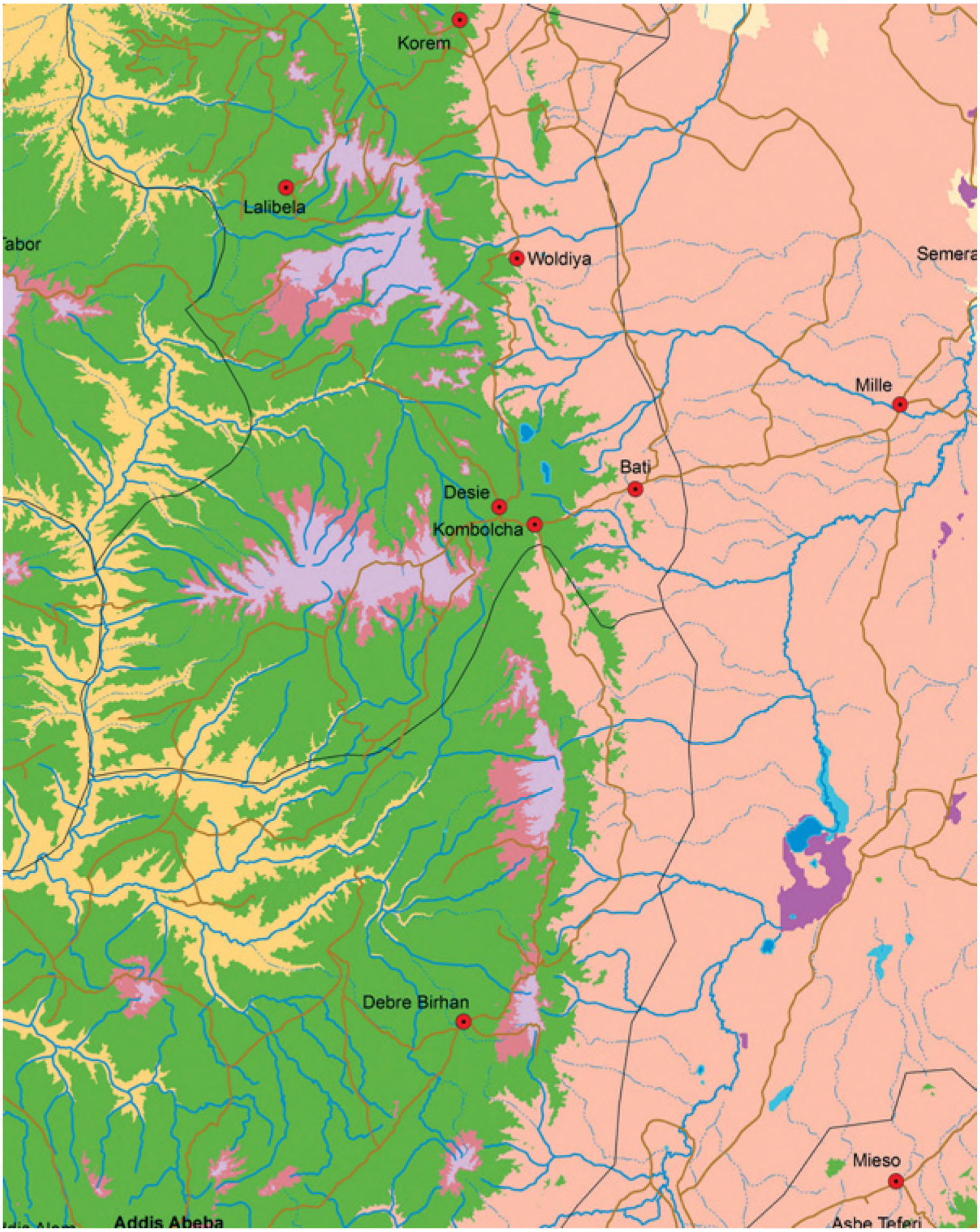

Korem
Lalibela
Woldiya
Semera
Mille
Bati
Desie
Kombolcha
Debre Birhan
Mieso
Addis Abeba

PLATE D2

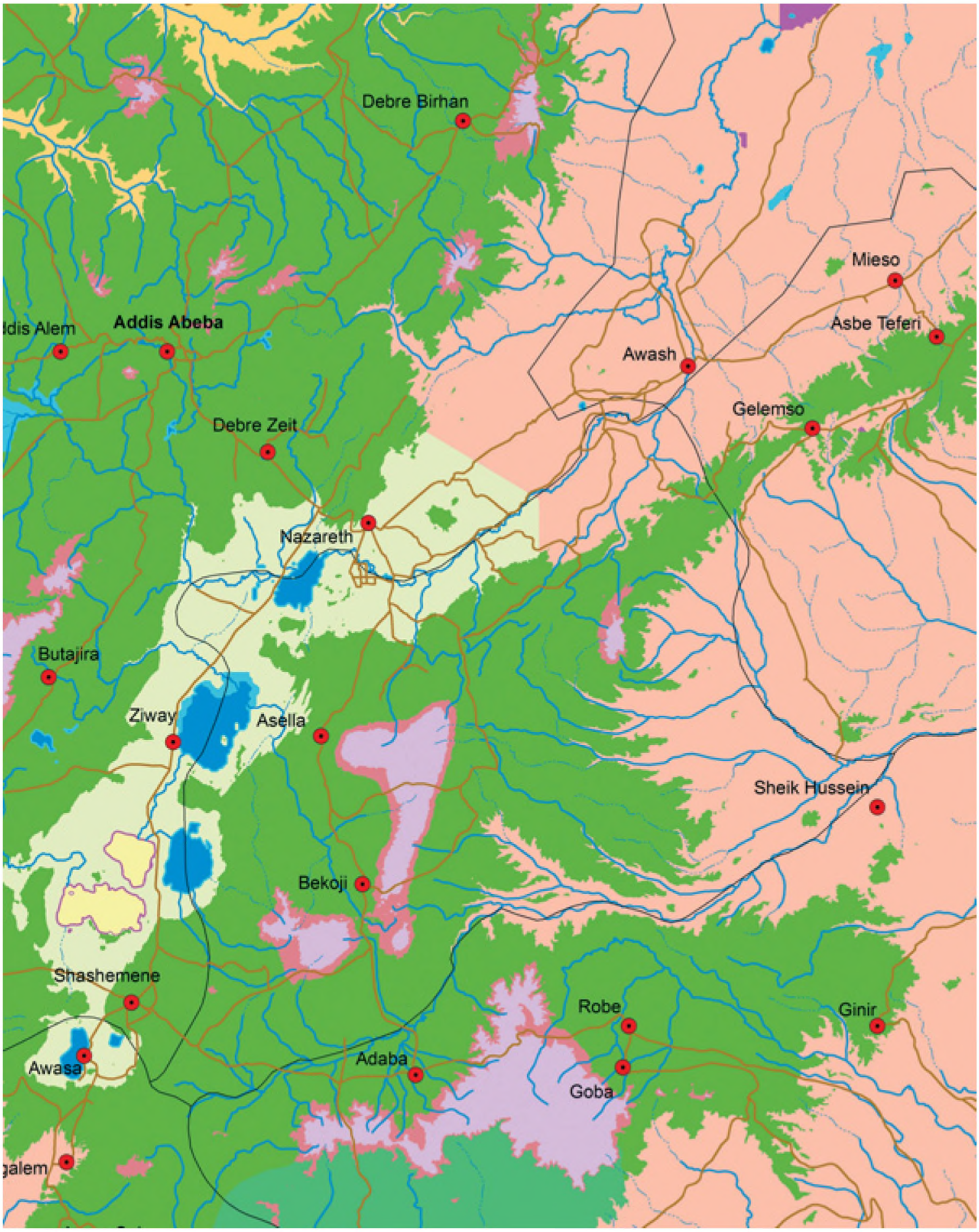

Debre Birhan
Mieso
Asbe Teferi
dis Alem
Addis Abeba
Awash
Gelemso
Debre Zeit
Nazareth
Butajira
Ziway
Asella
Sheik Hussein
Bekoji
Shashemene
Robe
Ginir
Adaba
Awasa
Goba
galem

PLATE D3

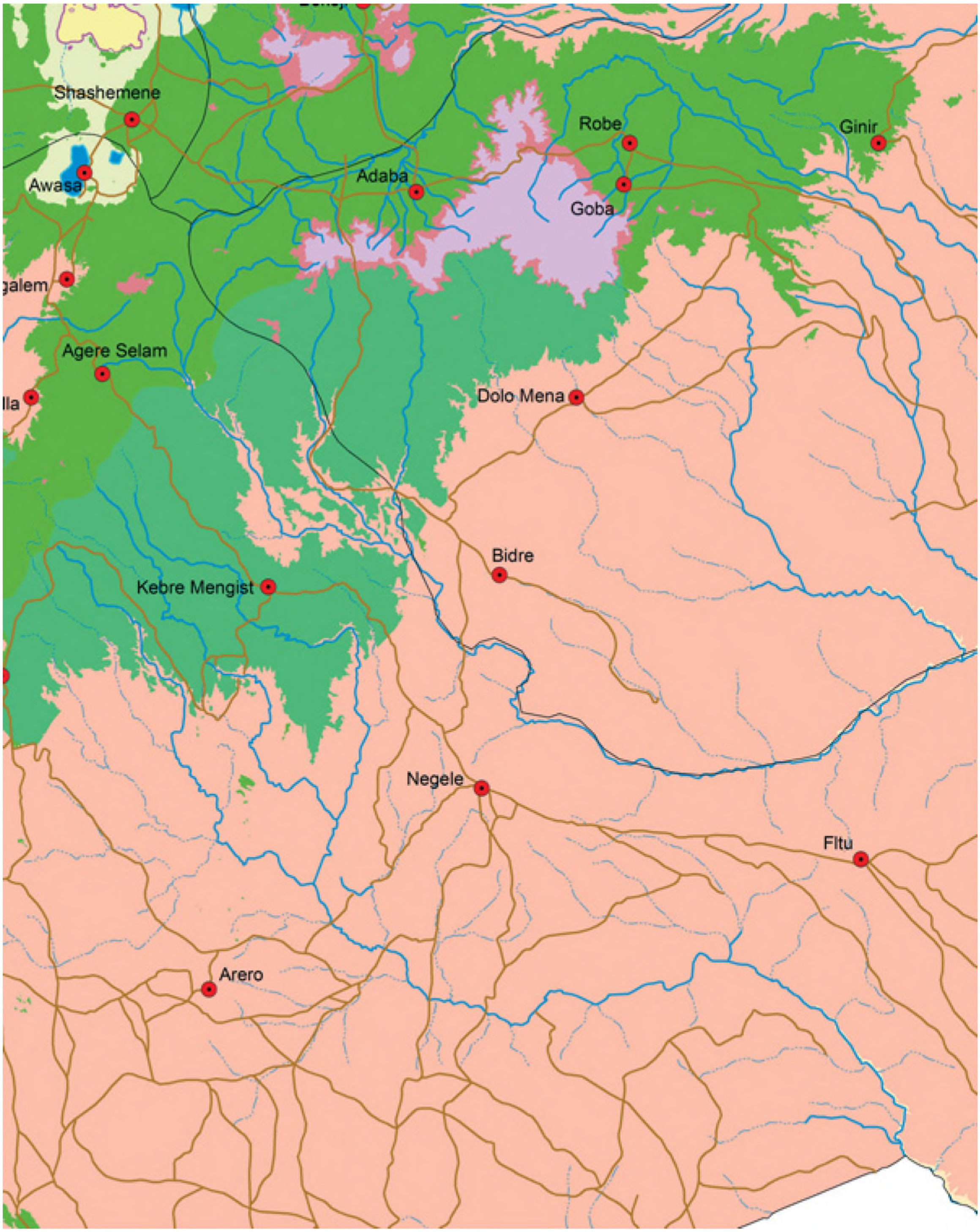

Shashemene
Awasa
Adaba
Robe
Goba
Ginir
galem
Agere Selam
lla
Dolo Mena
Bidre
Kebre Mengist
Negele
Fltu
Arero

PLATE D4

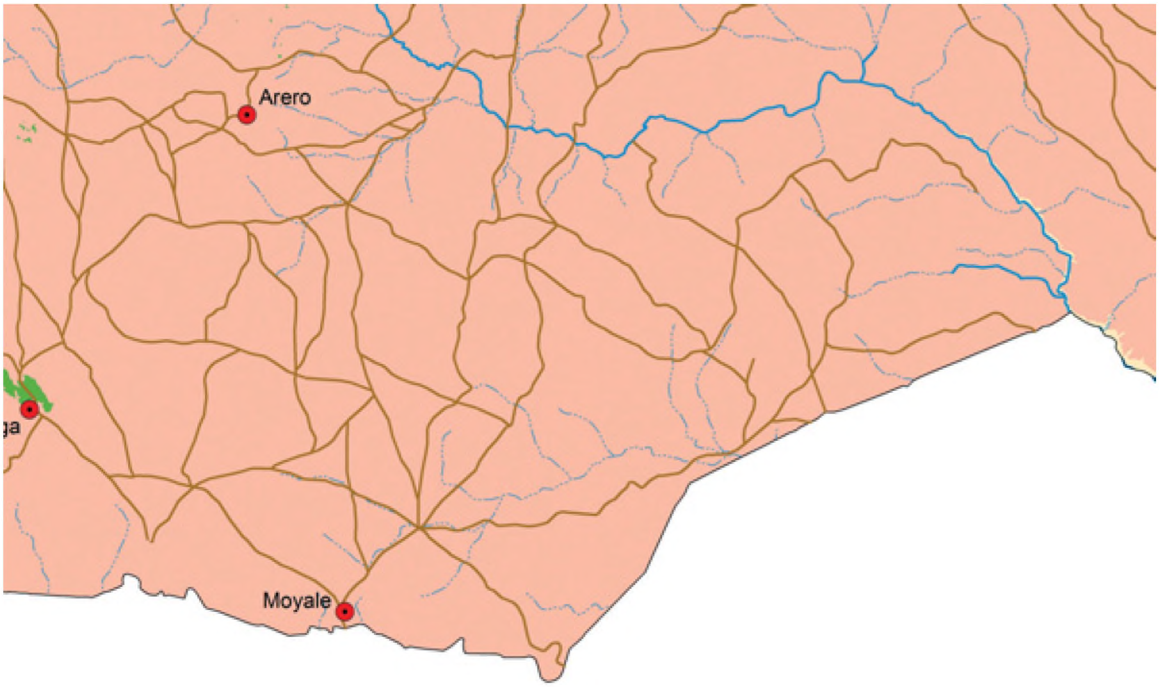


PLATE D5

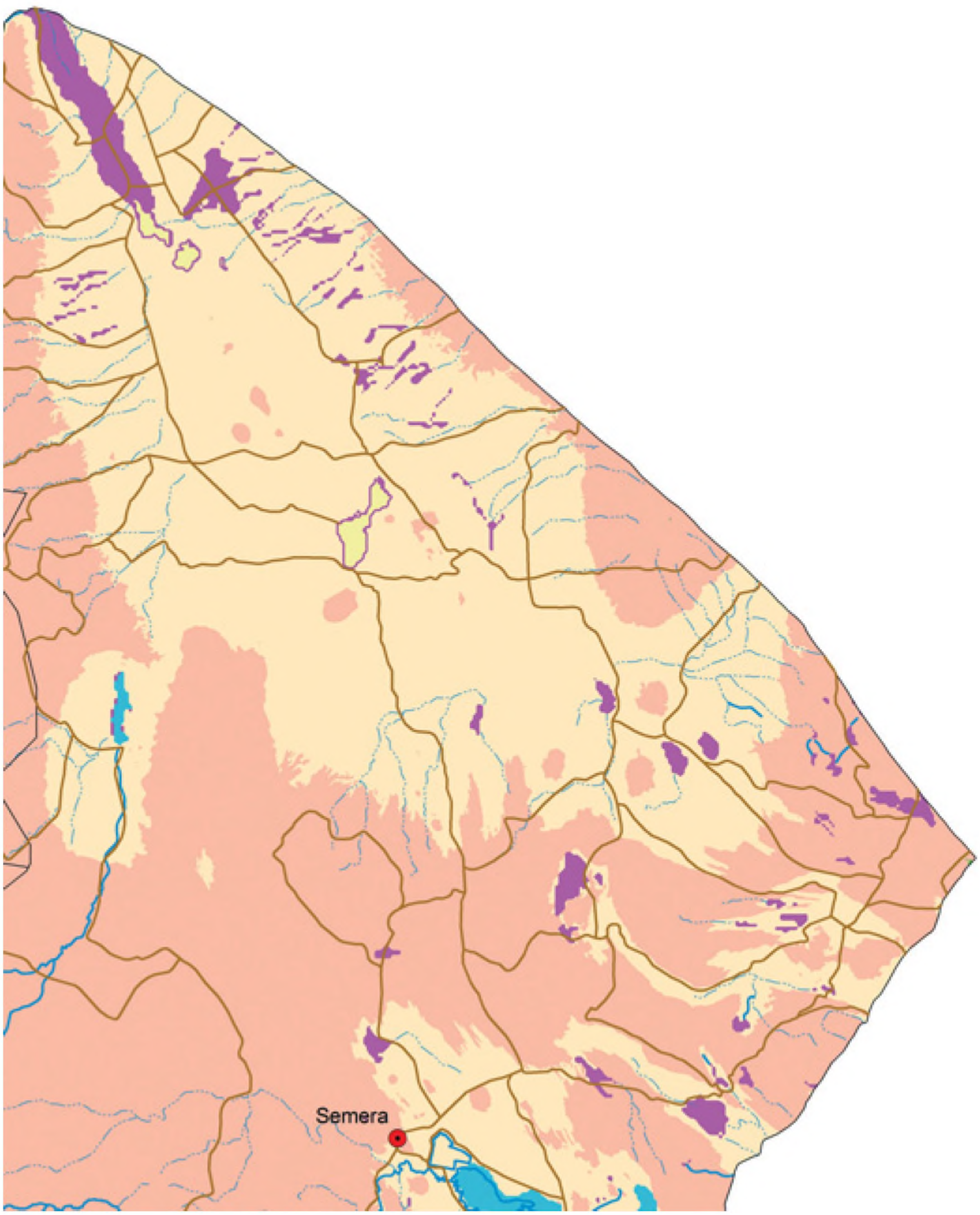


PLATE EI

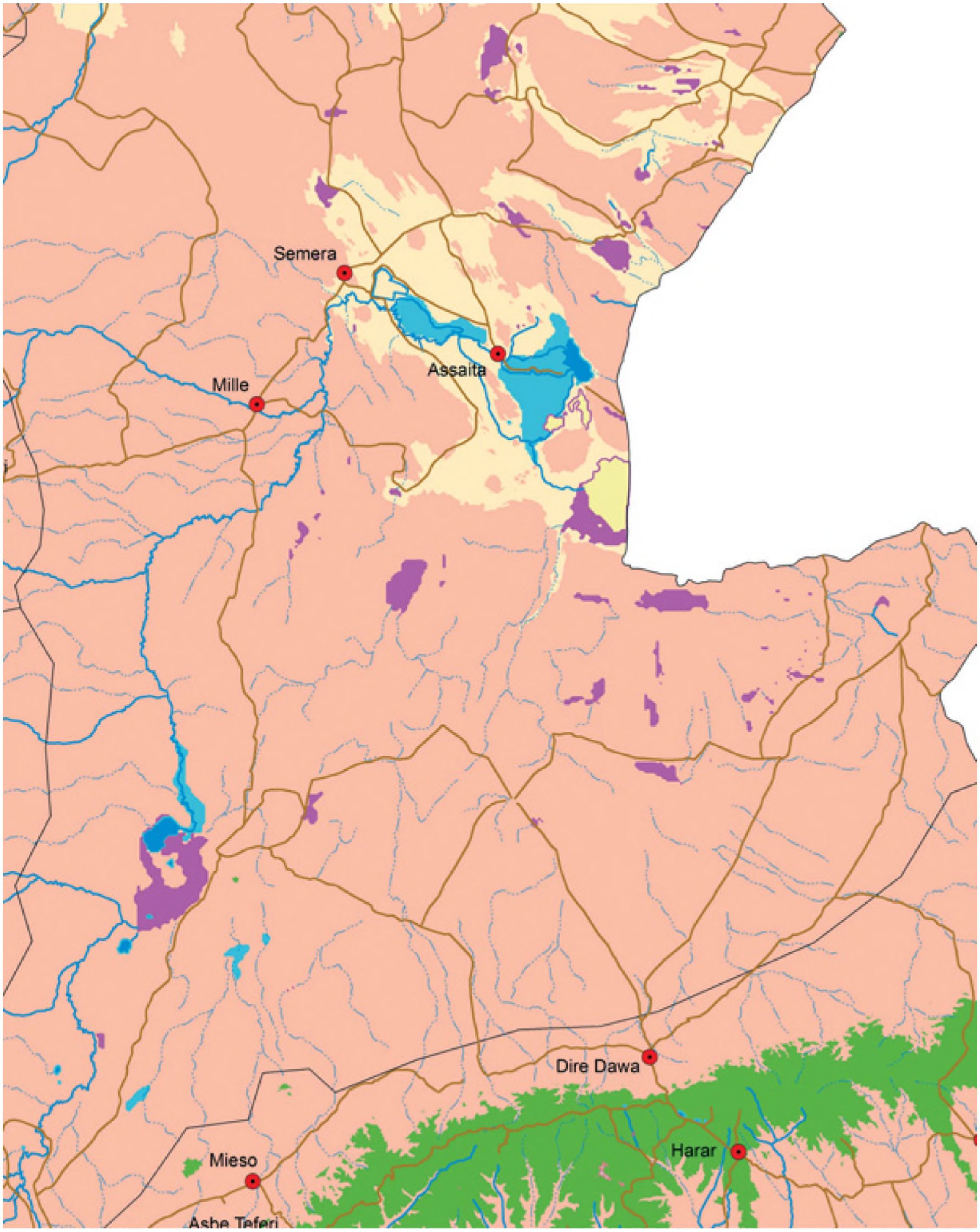


PLATE E2

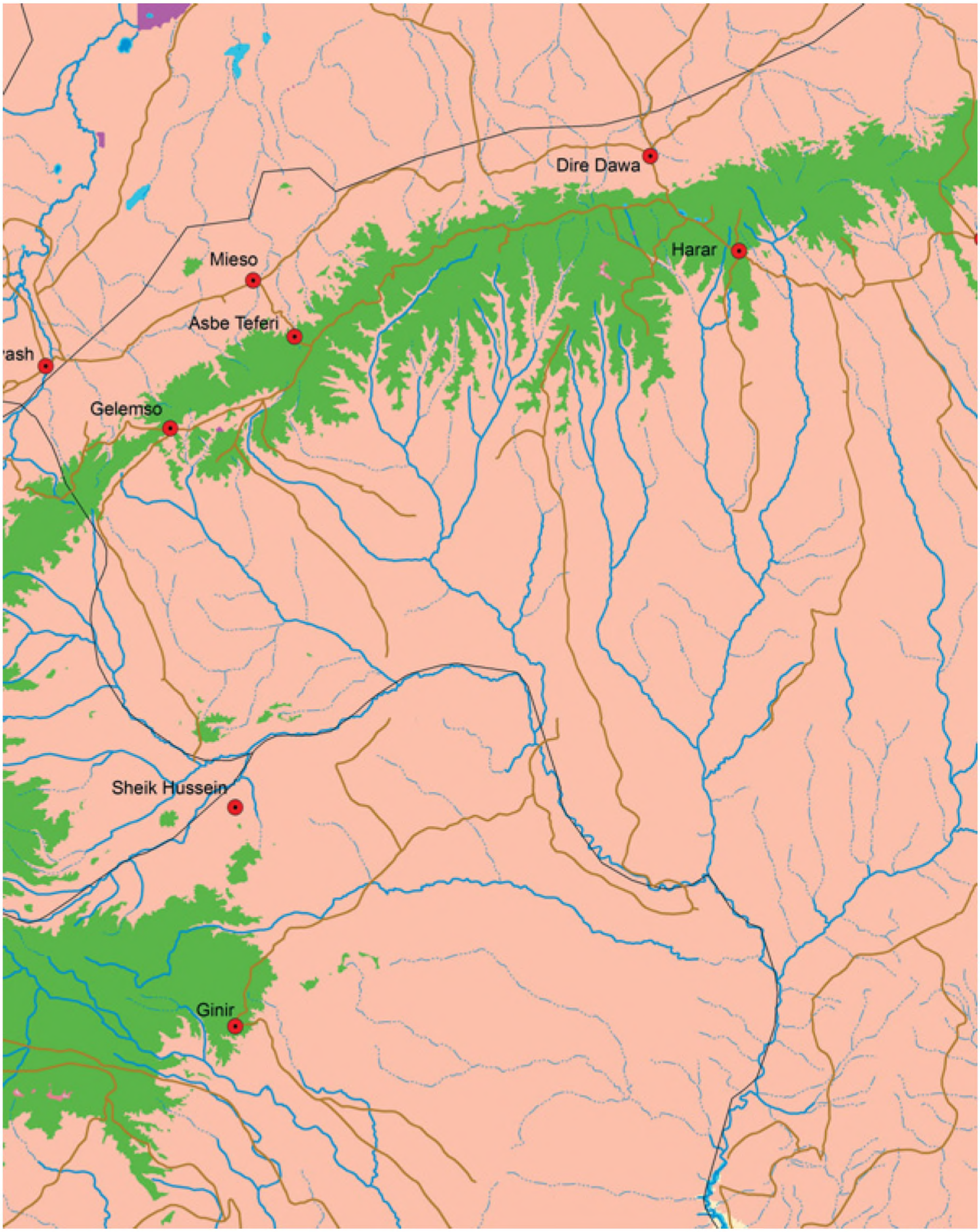

Dire Dawa
Mieso
Harar
Asbe Teferi
rash
Gelemso
Sheik Hussein
Ginir

PLATE E3

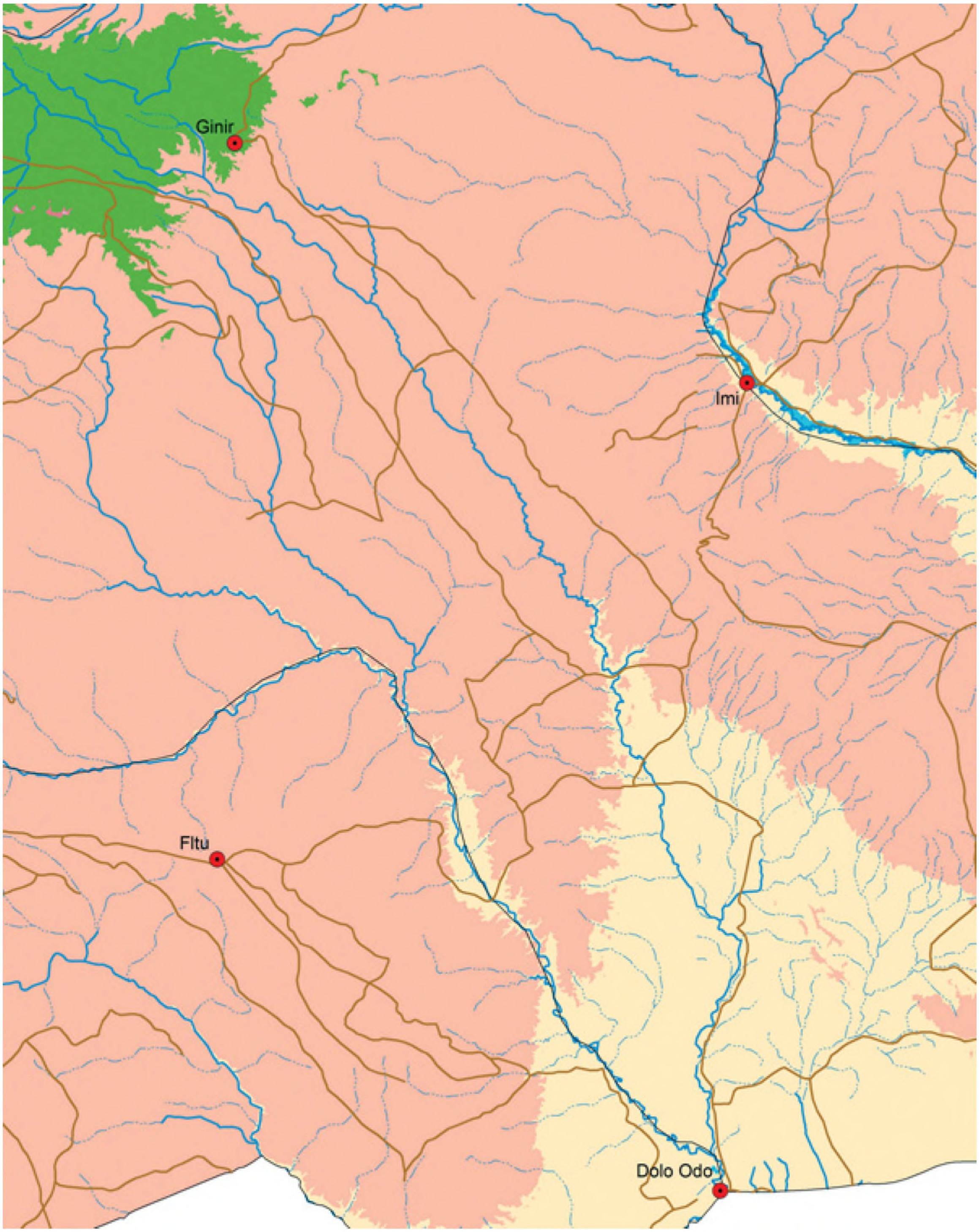


PLATE E4

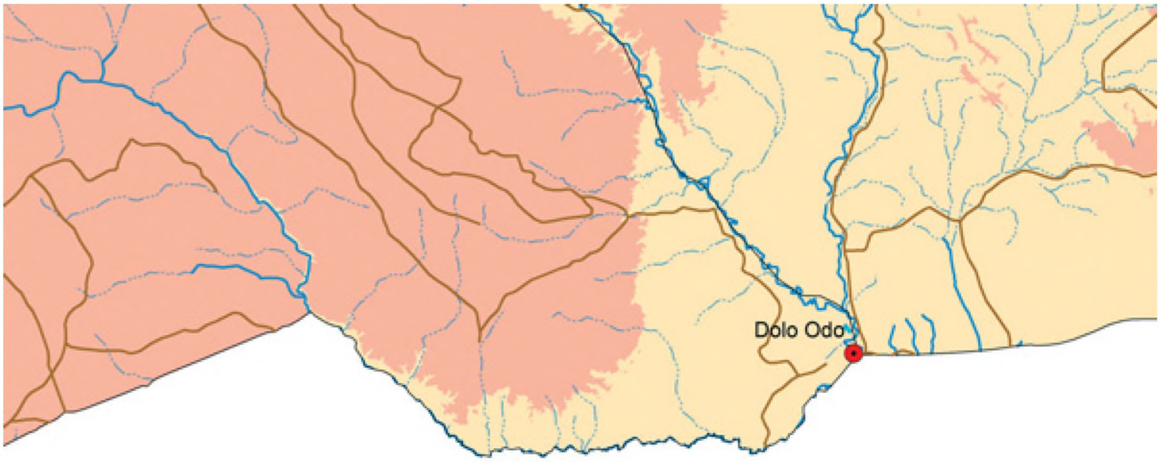


PLATE E5

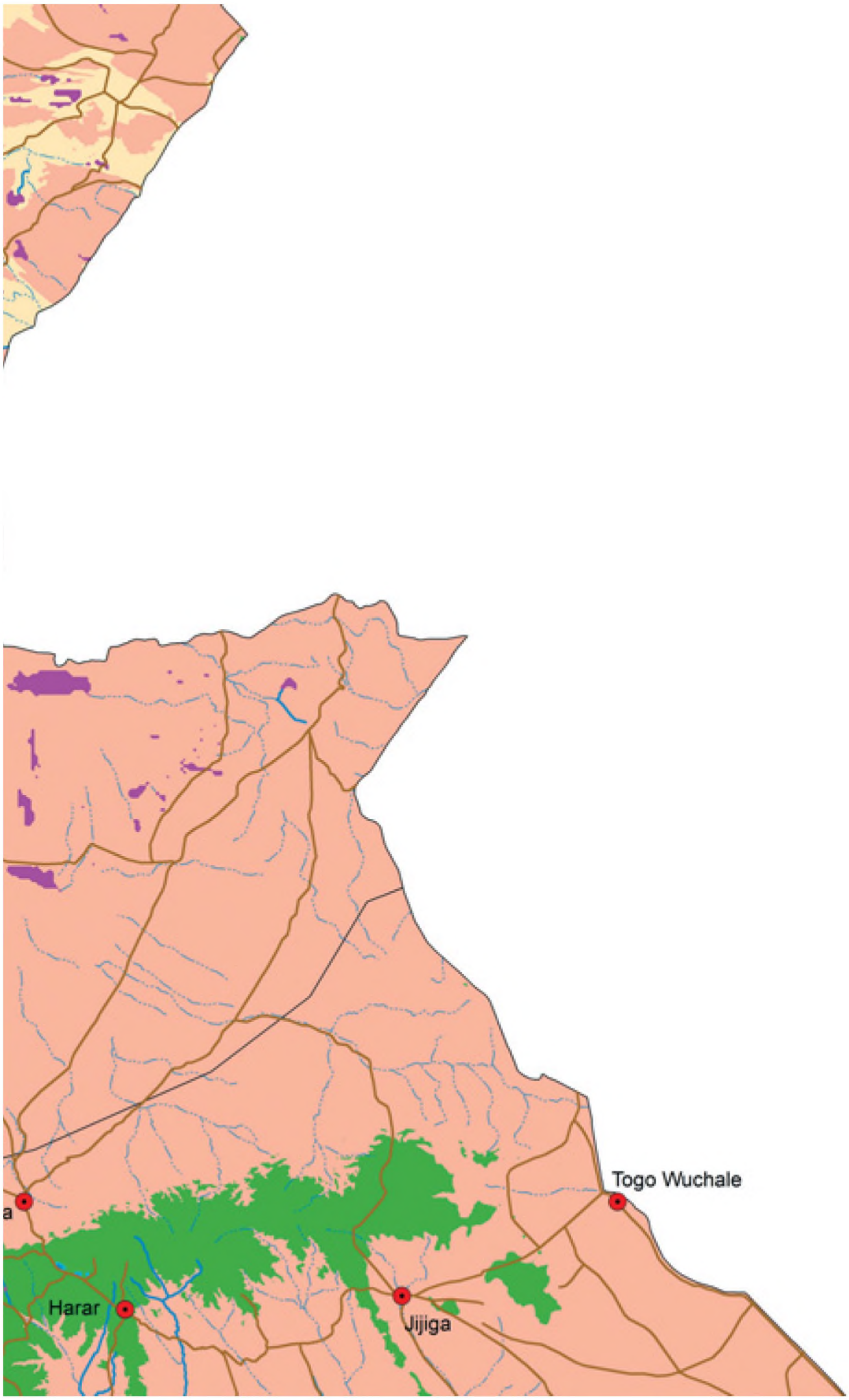


PLATE F2

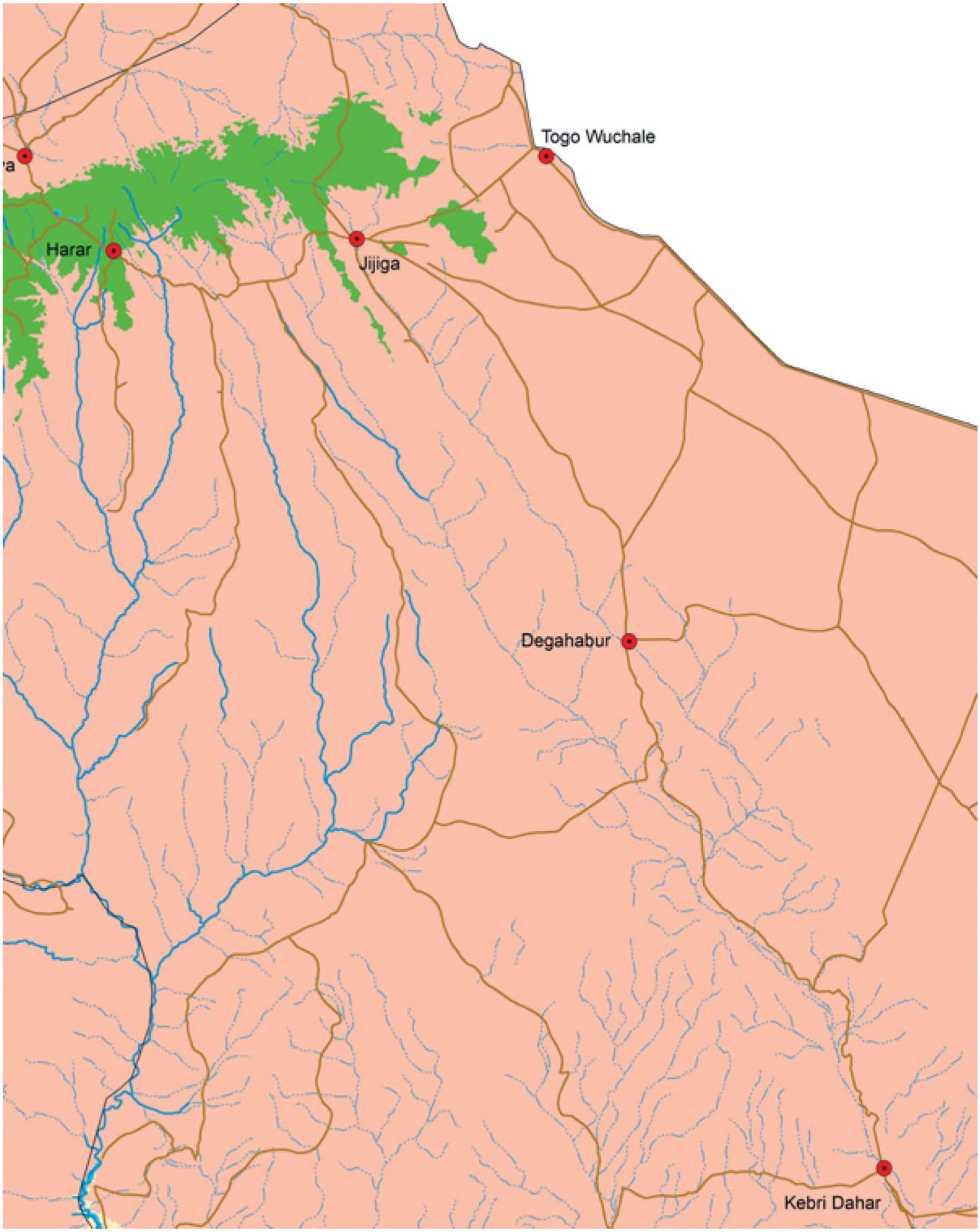


plate f3

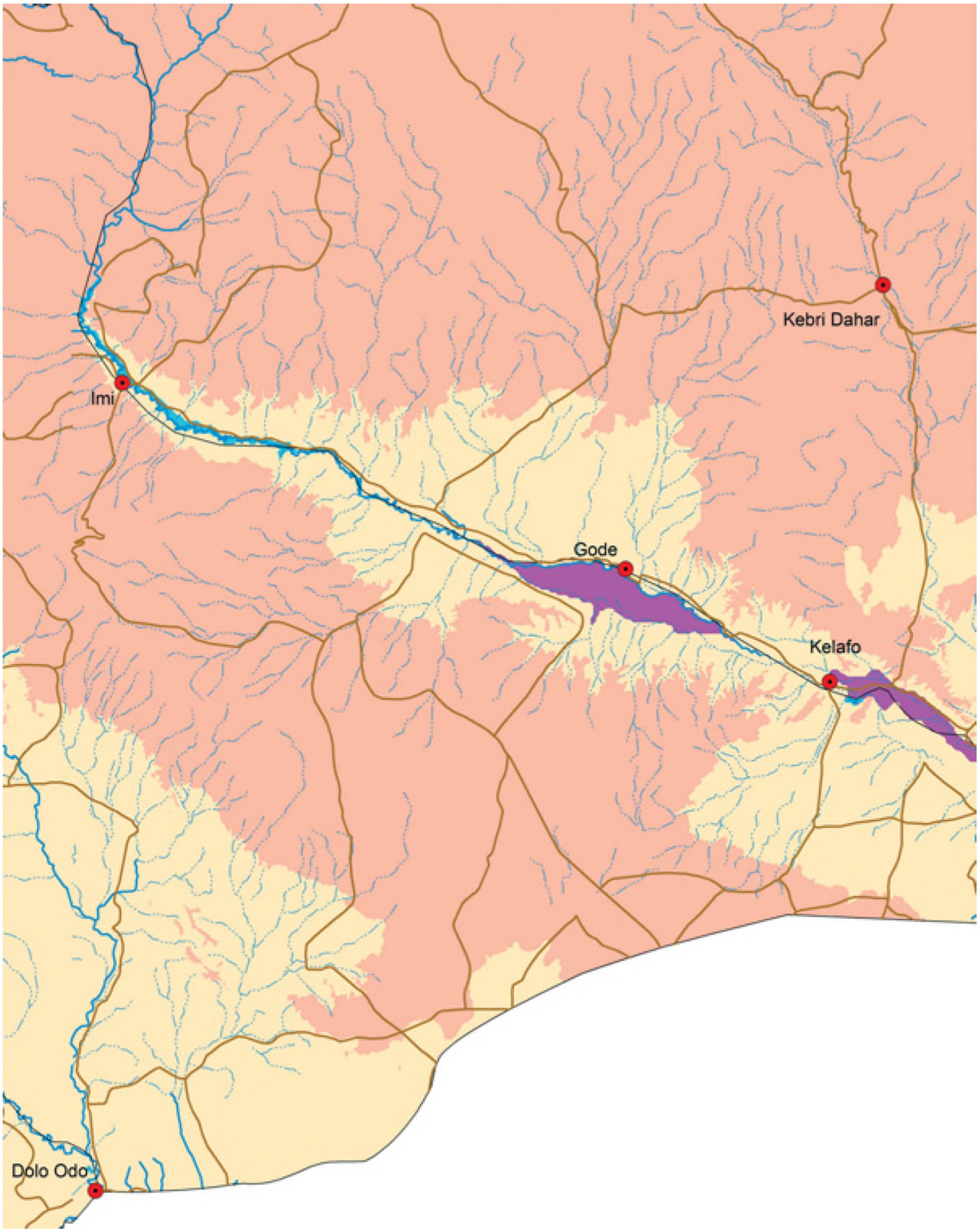


PLATE F4

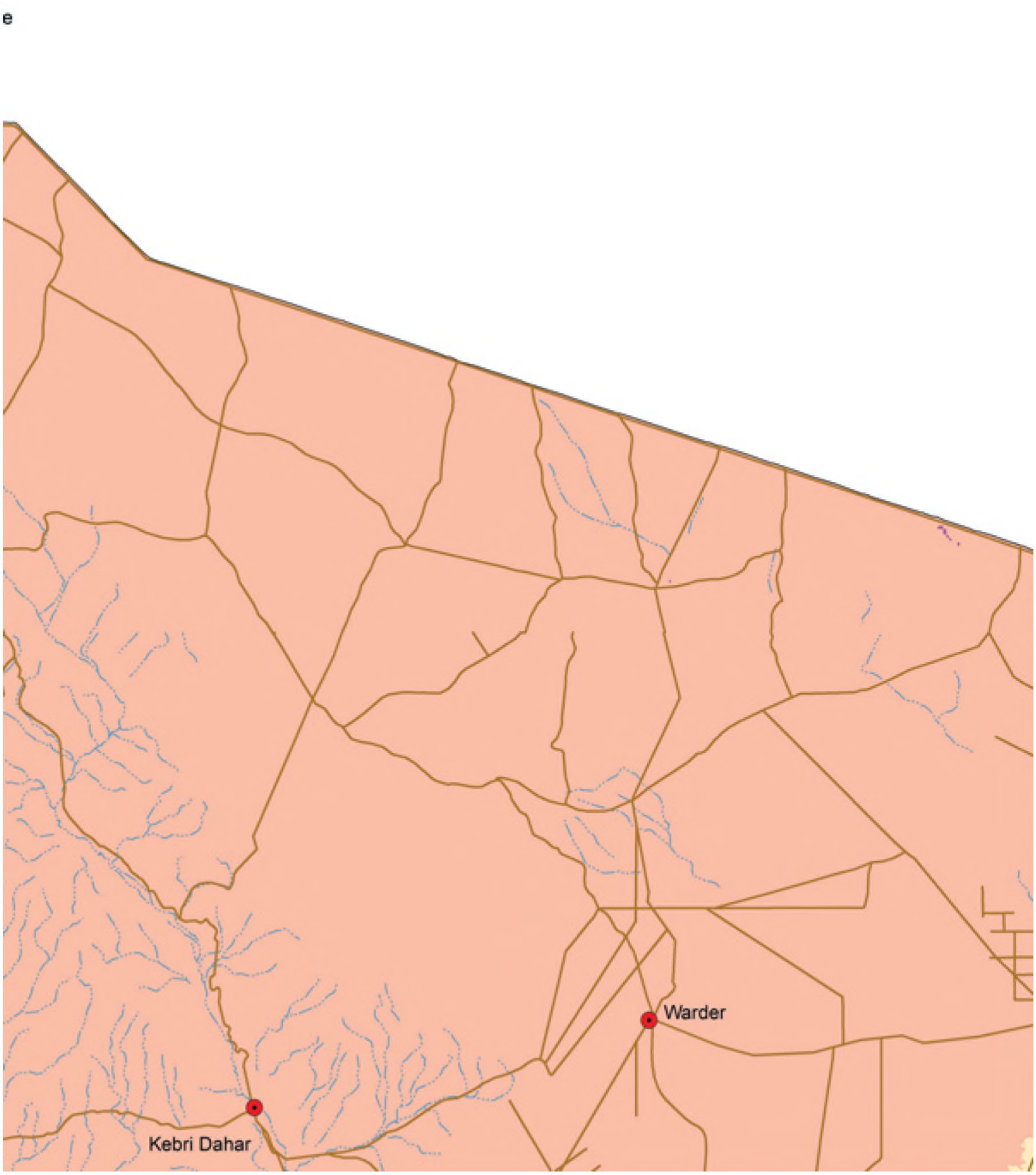


PLATE G3

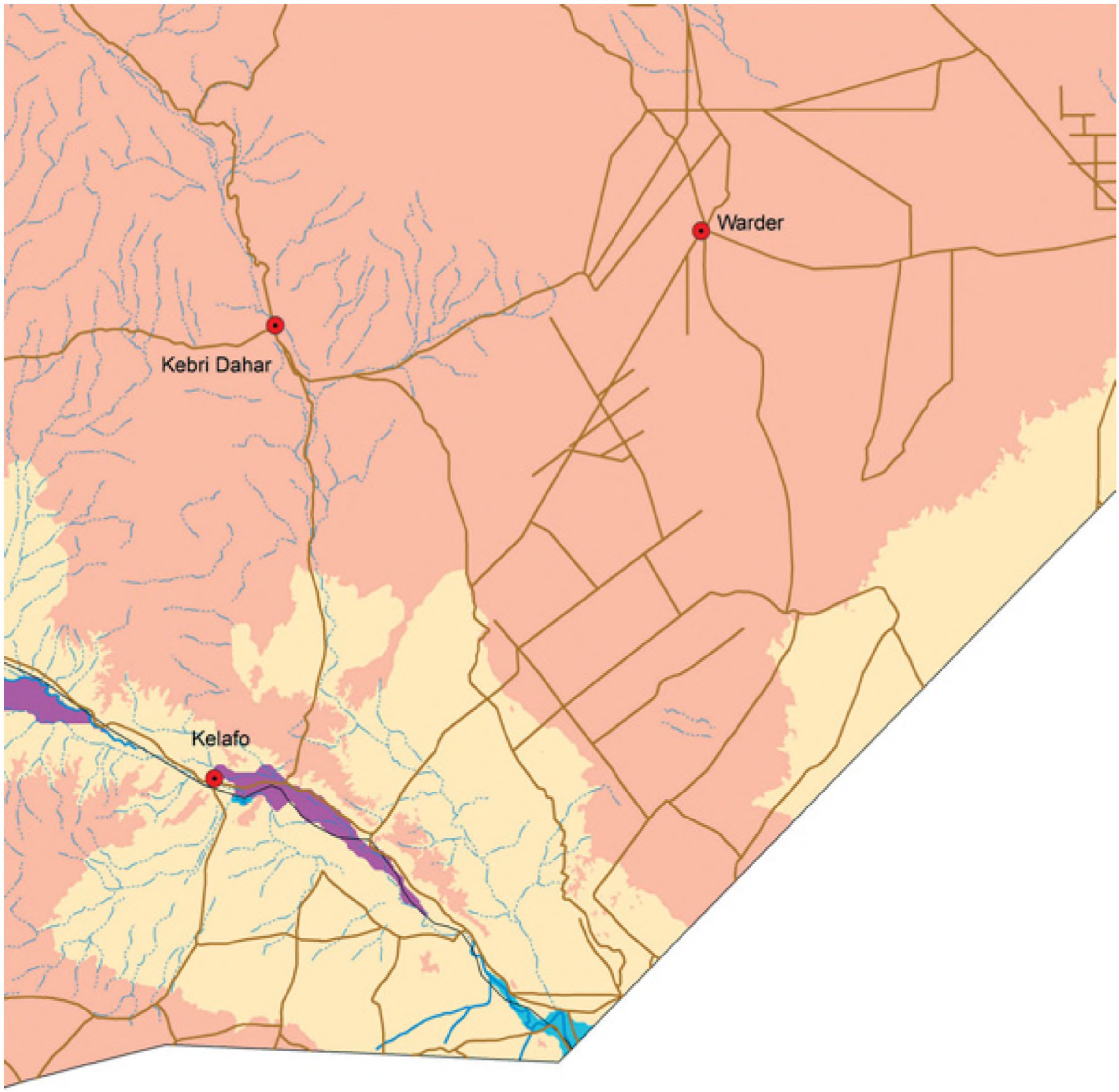


PLATE G4

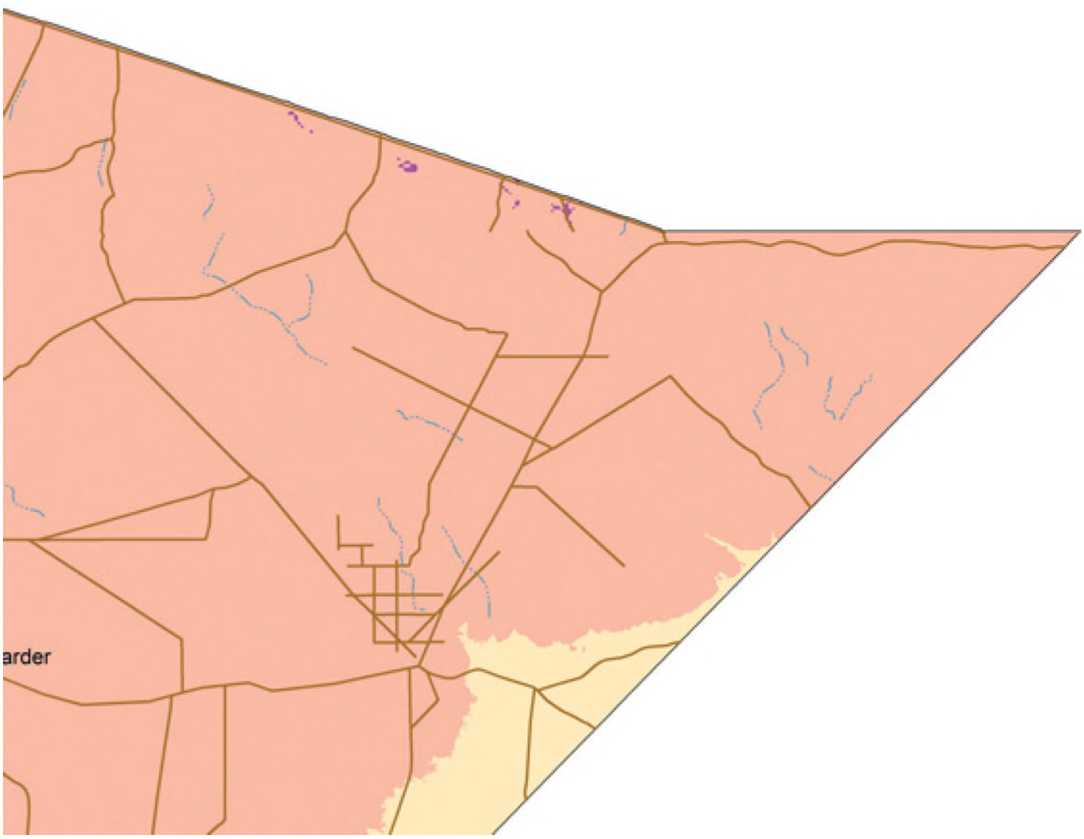


PLATE H3

Index to plant names

The index includes only plants referred to by species name, not plants referred collectively by name of genus or family. The index does not include plant names in Appendix 3 (p. 177-237), which is arranged strictly in agreement with the *Flora of Ethiopia and Eritrea*.

A

B

C

D

E

F

G

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I

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Z

Index to Ethiopian place names

The index includes references to floristic regions, except where these are mentioned in tables an in Appendix 3. References are made to alternative spellings of place names if these are quoted i the text.

A

B

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Titles should be kept as short as possible, preferring words useful for indexing and information retrieval.

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An abstract in English is required. It should be of 10-15 lines, outline main features, stress novel information and conclusions, and end with the author's name, title, and institutional and/or private postal address. – Papers in Danish must be provided with a summary in another language as agreed between author and editor.

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