Friis, I., van Breugel, P., Weber, O., Sebsebe Demissew, 2022. The *Western Woodlands of Ethiopia*

Zerihun Woldu[1]

The Western Woodlands of Ethiopia describes the woodland vegetation of western Ethiopia, which has been less studied compared to other parts of the country. The study of the flora and vegetation on the Horn of Africa has resulted in many, much-needed publications, considering the importance of the Horn as one of the significant biodiversity hot spots in the world. With this great publication, Friis and his collaborators have given the world the first detailed description of the woodlands of western Ethiopia.

The authors of the Western Woodland of Ethiopia are highly acclaimed scientists in their fields of specialization.

1. Ib Friis is a Danish professor and Emeritus of botany at the Natural History Museum of Denmark, University of Copenhagen. Friis has studied the flora and vegetation of Africa south of the Sahara, with a special emphasis on the vegetation of Ethiopia, botanical nomenclature, and the history of exploration of the plant world of the tropics.
2. Paulo van Breugel is a lecturer at the Applied Geo-information Science program of the HAS University of Applied Sciences, where he teaches spatial data analysis and biodiversity.
3. Odile Weber is a scientific assistant and research fellow at the National Museum of Natural History of Luxembourg.
4. Sebsebe Demissew is a Professor of Plant Systematics and Biodiversity at Addis Ababa University. Prof. Sebsebe Demissew served as the Leader of the Flora of Ethiopia and Eritrea between 1996 until its completion in 2009. Prof. Sebsebe Demissew has authored and co-authored books and articles in peer-reviewed journals on the vegetation and plants of Ethiopia and Africa.

Prof. Ib Friis and Prof. Sebsebe Demissew studied at the same university for their terminal degrees (Institute of Systematic Botany, Uppsala University, Uppsala, Sweden) and have worked together as early as 1980 on many occasions, developing a succinct and focused view of the flora of Ethiopia

[1] Prof., Department of Plant Biology and Biodiversity Management College of Natural Sciences, Addis Ababa University: email – zerihun.woldu@aau.edu.et

and vegetation as a result of the many years of collaborative work. An iconic output of the collaboration of the authors was a more general work by Ib Friis, Sebsebe Demissew, and Paulo van Breugel, "Atlas of the Potential Vegetation of Ethiopia. It appears that the Atlas of the Vegetation of Ethiopia has inspired and given additional impetus to the research that has led to the preparation of the present book.

The book provides descriptions of the woodlands with information on the topography, geology, pedology, and climatology of the area. It has made judicious use of previous publications, including especially Italian studies in the 1930s, Friis et al (2010), the phytogeographic syntheses of Pichi Sermolli (1957), and White (1983), all of which were accompanied by detailed maps and detailed descriptions of species in Flora volumes of Ethiopia and Eritrea (1989 - 2009) (which has detailed hand drawings of type specimens).

This book, with over 500 pages, is the first monograph dealing with the general environment of the western slopes of Ethiopia and the adjacent lowland towards the Nile, the physiognomy of the vegetation, the woody flora, its adaptation to eight environmental parameters, its phytogeography, particularly concerning other parts of Ethiopia and to "low Africa" and "high Africa", and cluster analyses of the 151 vegetation samples that have been studied during fieldwork from 2012 to 2018. The authors have worked along the whole western escarpment, from the border with Eritrea to the border with Kenya (ca. 10 degrees latitude).

Based on fieldwork and herbarium studies, the authors intended to increase our knowledge of these woodlands. The academic qualifications of the authors match the rigor required to treat the sections of the book.

The work is the result of a long-standing collaboration between scientists in Luxembourg, Ethiopia, Denmark, and the Netherlands and fieldwork in western Ethiopia since 2012, supported by the Danish Carlsberg Foundation.

The western woodland of Ethiopia was viewed by previous authors, including Friis et al. (2010) and Pichi Sermolli (1957), as a continuous zone from south to north, spanning ca. 10° latitude and dominated by species of Combretum and Terminalia. The current study has changed this view and shown that three weakly defined clusters—the northern woodlands just south of the Abay, the woodlands south of the Abay; and the woodlands of the upper Tekezze and

Abay Rivers can be recognized in the Western Woodlands. The clusters relate to variables such as latitude, altitude, climate, and soil types, while slope, fire frequency, and other parameters are found to be less important.

The book is divided into 11 sections. These are:

1. Introduction
2. The western lowlands of Ethiopia
3. Previous studies of the western lowlands of Ethiopia
4. The project backgrounds: research questions; methods and terminology, and what has been done since Friis et al. (2010).
5. Description of the profile
6. The woody plants in the sample; their distribution, ecological range, and floristic element
7. Phytogeography and distribution
8. Environment, adaptations, and ecological categories
9. Modeled distribution of typical Ethiopian *Combretum terminalia* woodland species
10. Cluster analyses and ordinations
11. Conclusions: What are the answers to the scientific questions

All sections were analyzed with adequate thoroughness and scientific rigor. The volume of the book is complex but well-articulated, beginning with information on topography, geology, and climate, mostly focused on the western slopes of the Ethiopian highlands in a wider African framework.

Sections 1 to 3 deal with introducing the work and reviewing the scanty literature of previous works on the vegetation of Ethiopia, which have been less studied, and laying the groundwork for the following sections by including information on climatology and geology. Worthy of mentioning as a useful previous study is the work of Pichi Sermoli (1957), which has given a detailed physiographic description of the vegetation of the Horn of Africa, which can be considered a precursor to several ecological and floristic works in Ethiopia.

The main work on the vegetation of western woodlands begins in Section 4, which provides the research background, research questions, and methods of data collection. Here, five research questions were paused, which the authors hope to answer in Section 11. The research questions paused could be considered the objectives of the book, but it would have been ideal if the

objectives of the book were stipulated instead of pausing research questions in the project background. However, readers could easily decipher that the aim of the book could be:

1. Establish the extent and types within the *Combretum-Terminalia* woodland at a higher level with delimitation in the south and the north.
2. Compile information on the state of the environment about *Combretum-Terminalia* woodland and environmental factors which have implications for the conservation of hotspots in the wider African context;
3. Provide exemplary work on the compilation of harmonious and reproducible data based on fieldwork and secondary sources in Ethiopia and other African countries.
4. The Great Ethiopian Renaissance Dam (GERD) lies in the western woodlands of Ethiopia covering about 1,874 km^2 of the area. One good justification, but not indicated in the book is to capture the botanical information of the area before it is inundated once and for all.

Section 5 is dedicated to providing descriptions of the vegetation of 16 profiles (A - Q) from the highlands to the lowlands along the entire western escarpment of Ethiopia, from the border with Eritrea in the north to the border with Kenya in the south; and the distribution and ecological ranges of the woodland species. This section has demonstrated the taxonomic capacity and familiarity of the authors with the flora and vegetation types of Ethiopia. The excellent and vivid original photographs of carefully selected representative woodland species and accompanying captions to the photographs have added to the high quality of the work. The photographs are very useful input for botanists who may intend to engage in detailed ecological studies at local levels. A total of 169 woody species have been encountered in 151 relevés (observation sites) in the whole study area. The 99 photographs in the book, which appear to have been chosen among the many in the custody of the authors show the variations in the vegetation in response to the environmental factors considered. However, the objective of providing the photographs is not indicated. However, one could easily guess that some of the photographs are intended to provide impressions of the profiles while the other pictures are intended to provide close-up views of some characteristic plant species in the profiles. However, both objectives have not been fully achieved due to a lack of systematic organization of pictures depicting both the profiles and the characteristic species occurring in them. The photographs of some iconic plant species that have been mentioned in Appendix 2 are missing.

Some other species that could not have escaped the able scrutiny of the authors are not recorded or may have been dismissed as unimportant as diagnostic or indicator species.

Section 6 presents maps of the distribution and ecological ranges of some woody species observed in 151 observation sites in the field and information from herbaria where collections from Ethiopia are deposited. The information in this section is a valuable supplement for the various volumes of the Flora of Ethiopia and is an indispensable input for detailed ecological studies in the future.

The works in sections 5 and 6 have demonstrated that the Flora of Ethiopia and Eritrea is not a culmination of floral work but could be improved over time. The book has radically increased the floristic information available about the country, and this new knowledge allows an increasingly detailed floristic characterization of the vegetation of Ethiopia.

Both sections 5 and 6 conclude that neither the phytogeographical differentiation nor adaptations to the environmental factors show marked patterns. Geographical variation in the ecological adaptation of the woody species is limited, and there are no sharp discontinuities in species diversity. Also, the floristic richness shows a limited variation (but the richest flora is along the Blue Nile).

The geographical and altitudinal distribution of taxa given in Section 7 does not seem to be easily comprehensible by many users (acronyms are not clearly defined) and could have been easily assimilated in section 6. Figures 7.8 and 7.9 could have been drawn in two-dimensional plots to save space with a description of the third dimension in legends. The taxa in relation to altitude, adaptation, and ecological categories in Section 8 could have been combined with the previous two sections for ease of cross-referencing.

Particularly interesting is section 9, which is dedicated to the analyses of twelve indicator species of the western woodlands, the distributions of which are seen in both an African and an Ethiopian context, accompanied by clearly colored cartography. This section provides an attempt to model the distribution of twelve of the most characteristic species of *Combretum-Terminalia* woodland species with three mutually inclusive objectives; i.e. model the distribution of these species in relation to the distribution in the rest

of Africa with similar environmental setups; to see if the local elements in Ethiopia are likely to represent similar groups of species with the same distribution in West Africa, and to document the general position of the western Ethiopian lowlands as part of the Sudanian region. Three patterns can be recognized, east-west distribution in Africa with higher amplitude in the western lowland of Ethiopia, north-south distribution with higher amplitude distribution again in the western lowlands of Ethiopia, and a third pattern that shows low or no distribution in the rest of Africa but high amplitude in northwestern Ethiopia. This interesting finding provides useful information to researchers who would like to conduct autecology of the species of interest and design conservation strategies for those species whose center of distribution is mainly in Ethiopia.

Section 10 provides clustering and ordination analyses of binary (presence/absence) woodland vegetation data from the western lowlands of Ethiopia in order to study the continuity and discontinuity of the vegetation and the drivers of variation.

The data frame is constructed from 151 observation sites (Appendix 1), which the authors refer to as relevés. A relevé, however, is defined as a list of species observed in a quadrat together with estimates of their abundance/ dominance, or cover (Braun-Blanquet, 1932; van der Maarel, 1979). The sampling procedure in this study is highly modified, so much so that the sample plot size is undefined (varying in size from 10 to over 100 ha), following motorized access roads in most cases, and recording the presence of woody species in each sampling point in about 45 minutes. The use of the term relevé is therefore inappropriate for this study.

Ecological data collection is a very expensive and time-consuming venture. One could easily understand the constraints and unforeseen and predictable risks that may have compelled the researchers to consider fewer observation sites than one would have liked to see. The constraints include the paucity of motorable roads in Ethiopia in general and the study area in particular, which curtailed the possibility of a fair and systematic sampling procedure. Overnight destinations along the motorable roads and in the forests are not easily available and could be risky. Given that, opting for a rapid sampling procedure with some of its limitations that may have compromised the outputs of the analyses is very rational. The sampling procedure considered could impose uncertainty on the findings and the conclusion that followed.

The surface area of the western woodlands of Ethiopia could have been estimated by overlaying the vector map of the study area on the 90m DTM or, preferably, the 30m DTM that can be freely acquired from USGS. This would have given the total area covered by the western woodlands of Ethiopia instead of giving its north-south latitudinal extension only. The authors have demonstrated their capacity to use proprietary and freely available GIS software, which could have been used to estimate the surface area.

Rattray (1960) studied the grass covers of Africa and related them to the vegetation types they occurred in. He suggested that grass species in Africa may be less prominent in woodlands but are as frequent and significant as the tree species and recognized major grass associations dominated by one genus, and subdivided them according to the physiognomy of the vegetation in which they occurred.

Rattray (1960) recognized three grass genera associated with the woodland vegetation of western Ethiopia. There are:

1. CE3 - the genus *Cenchrus* associated with savanna in Omo valley in southern and the southern rift valley in Ethiopia.
2. H30 - the genus *Hypparhenia* associated with savanna in western Ethiopia bordering South Sudan and Sudan.
3. S3 - the genus *Setaria* associated with woodland in the Abay Watershed east of H30.

Neglecting herbaceous species, including grasses, may have led to a loss of information that may have compromised the clear differentiation of the clusters of associations.

The resemblance index chosen for the cluster analysis is Simpson's Similarity Index. This index is like the Jaccard Similarity Index and the Sørensen Similarity Index, which do the same job on binary data frames but with slightly different logic as shown in equations 1, 2, and 3.

$S_{si} = a/(a+\min(b,c)$ …… Equation 1
$J_{Si} = a/(a + b + c)$ …….. Equation 2
$S_{Si} = 2a/(2a + b + c)$ ……. Equation 3

Where

a = number of species common to (shared by) quadrats,
b = number of species unique to the first quadrat, and
c = number of species unique to the second quadrat

S_{si} is recommended in situations where there are large differences in species richness between the samples, and eventually, it turns out that this index produces nestedness. Nestedness happens when one of the two samples being compared contains the same species as the other one plus some more. The sample that contains a lesser number of species is perfectly nested within the one that contains a higher number of species, and the value of Simpson's Similarity Index is equal to one.

The cluster analysis has shown that the western woodlands are variable and that a high number of small and narrowly defined units might be identified (Figure 10.4). A significant number of trees are widespread from north to south, but some are restricted to the north, a few to the center and south, and many just enter the woodlands with the main distribution elsewhere. However, most of the small clusters of the western Ethiopia escarpment can be agglomerated into three distinct plant associations at a higher level.

The choice of S_{SI} is appropriate for the current study in that minor discontinuities are restrained and only major differences are allowed to show up. The use of the other two indices would have produced more splinter groups, which could have made the interpretation of the classification more uncertain.

Figure 10.4 would have been more informative had the similarity (dissimilarity) or the height of the dendrogram been shown along the y-axis and the leaves of the branches and the labels of the sampling points in each cluster along the x-axis been identified by different colors for the sake of better presentation and visualization.

The ordination part of the data analysis was elegantly conducted and has shown that many of the environmental factors considered explained parts of the variations in the clusters, the most important being latitude, altitude, climate, and soil types, while slope, fire frequency, and other parameters seem to be less important.

The concluding chapter attempts to answer the central research questions paused in the background of the book. Here it is verified that three associations can be recognized in the gradual transition of the Western Woodlands of Ethiopia along the latitudinal gradient and identified indicator species for each association or cluster which have been identified. The woodland species in the western woodlands of Ethiopia showed distinct patterns of distribution in Africa, with north-south, west-east, and central dispersion. Important drivers of the variation in vegetation have been recognized. The general theme behind the work has been fully achieved by showing how the information generated has improved knowledge of the western woodlands of Ethiopia and providing solid information about the current status of vegetation. This could facilitate informed decisions for conservation of the environment, including creating buffer zones surrounding the GERD and creating a biosphere reserve to compensate for the area, which will eventually be inundated by the biggest human-made lake in Africa.

The authors of Atlas of the Potential Vegetation of Ethiopia (Friis et al. 2010) have recognized, although belated that the word potential is a misleading term or misnomer in that it ignores the fact that vegetation is dynamic and should be described with reference to space and time. The static concept of vegetation implied by the term potential underestimates the possibility of multiple stable states in the rehabilitation of vegetation after degradation. The consideration that potential should, therefore, be replaced by a more inclusive title of the atlas as **Potential Natural Vegetation of Ethiopia** is a welcome decision by all botanists who were uncomfortable with the earlier title.

The front and back covers of the book, the excellent level of editing, the clear and elegant layout, and the general production of all texts, maps, and photographic work are very admirable.

Although the book had some limitations in data collection due to some insurmountable constraints, it can be epitomized as a landmark in the knowledge of the vegetation of the western part of Ethiopia, which until now has been so little studied and so scarcely documented in the literature. Any study of the vegetation of Ethiopia or an advanced course in systematic and ecological botany will be incomplete without a close inspection and a comprehensive use of the information in the book, in addition to the use of the various volumes of the Flora of Ethiopia and Eritrea.

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