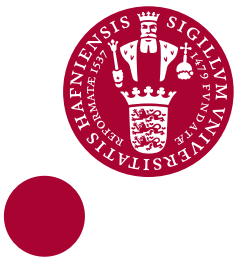

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Publication date:
2011

Document Version
Publisher's PDF, also known as Version of record

FOREST & LANDSCAPE

THE ROCKEFELLER FOUNDATION

World Agroforestry Centre
TRANSFORMING LIVES AND LANDSCAPES

FOREST & LANDSCAPE WORKING PAPERS 63 / 2011

Potential Natural Vegetation of Eastern Africa (Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda and Zambia)

VOLUME 3

Description and Tree Species Composition for Woodland and Wooded Grassland Potential Natural Vegetation Types

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Collaborating Partner
World Agroforestry Centre

Publisher
Forest & Landscape Denmark
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Series - title and no.
Forest & Landscape Working Paper 63-2011

ISBN
ISBN 978-87-7903-552-2

DTP
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Citation
Kindt, R., van Breugel, P., Lillesø, J.-P.B., Bingham, M., Sebsebe Demissew, Dudley, C., Friis, I., Gachathi, F., Kalema, J., Mbago, F., Minani, V., Moshi, H.N., Mulumba, J., Namaganda, M., Ndangalasi, H.J., Ruffo, C.K., Jamnadass, R. and Graudal, L. 2011. Potential natural vegetation of eastern Africa. Volume 3: Description and tree species composition for woodland and wooded grassland types. Forest & Landscape Working Paper 63-2011

The report is available electronically from
www.sl.life.ku.dk

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Introduction

This book represents **Volume 3** in a seven-volume series that documents the potential natural vegetation map that was developed by the VECEA (Vegetation and Climate change in East Africa) project. The VECEA map was developed as a collaborative effort that included partners from each of the seven VECEA countries (Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda and Zambia).

- In **Volume 1**, we present the potential natural vegetation map that we developed for seven countries in eastern Africa. In Volume 1, we also introduce the concept of potential natural vegetation and give an overview of different application domains of the VECEA map.
- **Volumes 2** to **5** describe potential natural vegetation types, also including lists of the "useful tree species" that are expected to naturally occur in each vegetation type – and therefore also expected to be adapted to the environmental conditions where the vegetation types are depicted to occur on the map. **Volume 2** focuses on forest and scrub forest vegetation types. **Volume 3** focuses on woodland and wooded grassland vegetation types. **Volume 4** focuses on bushland and thicket vegetation types. In **Volume 5**, information is given for vegetation types that did not feature in Volumes 2 to 4.
- **Volume 6** gives details about the process that we followed in making the VECEA map.
- **Volume 7** shows the results of modelling the distribution of potential natural vegetation types for six potential future climates.

Acknowledgements

We are extremely grateful to the Rockefeller Foundation for having funded most of the work that has led to the development and publication of the VECEA map and its accompanying documentation.

We also greatly appreciate the comments and suggestions that were made by Paul Smith and Jonathan Timberlake (both of Royal Botanic Gardens Kew) when they reviewed early drafts of volumes 2, 3, 4 & 5.

Thanks to anybody in our institutions who contributed directly or indirectly to the completion of the VECEA vegetation map and its associated documentation. We especially appreciate the assistance by Nelly Mutio (as for organizing logistics for the regional workshop that we organized in 2009 and for assisting in administrative issues), Melita Jørgensen (for desktop publishing), and of Jeanette van der Steeg for helping with the final preparation of the maps for Volume 1.

Thanks to Ann Verdoodt and Eric Van Ranst (both from the University of Ghent) for compiling and sharing thematic soil maps that were derived from the soil of Rwanda (Birasa, E.C., Bizimana, I., Bouckaert, W., Gallez, A., Maesschalck, G., and Vercruysse, J. (1992). Carte Pédologique du Rwanda. Echelle: 1/250.000. Réalisée dans le cadre du projet "Carte Pédologique du Rwanda" (AGCD, CTB). AGCD (Belgique) et MINAGRI, Kigali).

Thanks to Eugene Kayijamahe, Center for Geographic Information System and Remote Sensing at National University of Rwanda for sharing the digital map "Vegetation of Volcanoes National Park" that allowed us to classify in greater detail this part of the VECEA map.

Thanks to UNEP-GEF for funding the Carbon Benefits Project (CBP) through which information was compiled on indicator and characteristic species for The Vegetation Map of Africa (White 1983). (This work led to the publication in 2011 of an Africa-wide tree species selection tool that is available from: *http://www.worldagroforestrycentre.org/our_products/databases/ useful-tree-species-africa)* Thanks to BMZ for funding the ReACCT project in Tanzania through which funding was made available for field verification of the VECEA map around Morogoro (this was essential in preparing the VECEA map as the base map for Tanzania was essentially a physiognomic map.

Abbreviations

Abbreviation	Full
A	Afroalpine vegetation
B	Afromontane bamboo
Bd	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket
Be	Evergreen and semi-evergreen bushland and thicket
bi (no capital)	Itigi thicket (edaphic vegetation type)
br (no capital)	Riverine thicket (edaphic vegetation type, mapped together with riverine forest and woodland)
C	In species composition tables: we have information that this species is a characteristic (typical) species in a national manifestation of the vegetation type
D	Desert
DBH	diameter at breast height (1.3 m)
E	Montane *Ericaceous* belt (easily identifiable type)
f (no capital)	In species composition tables: since this species is present in the focal country and since it was documented to occur in the same vegetation type in some other VECEA countries, this species potentially occurs in the national manifestation of the vegetation type
Fa	Afromontane rain forest
Fb	Afromontane undifferentiated forest (Fbu) mapped together with Afromontane single-dominant *Juniperus procera* forest (Fbj)
Fc	Afromontane single-dominant *Widdringtonia whytei* forest
fc (no capital)	Zanzibar-Inhambane scrub forest on coral rag (edaphic forest type)
Fd	Afromontane single-dominant *Hagenia abyssinica* forest
Fe	Afromontane moist transitional forest
fe (no capital)	Lake Victoria *Euphorbia dawei* scrub forest (edaphic forest type mapped together with evergreen and semi-evergreen bushland and thicket)
FeE	distinct subtype of Afromontane moist transitional forest in Ethiopia
FeK	distinct subtype of Afromontane moist transitional forest in Kenya
Ff	Lake Victoria transitional rain forest
Fg	Zanzibar-Inhambane transitional rain forest
Fh	Afromontane dry transitional forest
Fi	Lake Victoria drier peripheral semi-evergreen Guineo-Congolian rain forest
FLD	Forest & Landscape (URL *http://sl.life.ku.dk/English.aspx)*
Fm	Zambezian dry evergreen forest
Fn	Zambezian dry deciduous forest and scrub forest
Fo	Zanzibar-Inhambane lowland rain forest
Fp	Zanzibar-Inhambane undifferentiated forest
Fq	Zanzibar-Inhambane scrub forest
fr (no capital)	Riverine forests (edaphic forest type mapped together with riverine woodland and thicket)
Fs	Somalia-Masai scrub forest (mapped together with evergreen and semi-evergreen bushland and thicket)
fs (no capital)	Swamp forest (edaphic forest type)
G	Grassland (excluding semi-desert grassland and edaphic grassland
g (no capital)	Edaphic grassland on drainage-impeded or seasonally flooded soils (edaphic vegetation type)
gv	Edaphic grassland on volcanic soils (edaphic subtype)
ICRAF	World Agroforestry Centre (URL *http://www.worldagroforestry.org/*)
L	Lowland bamboo
M	Mangrove
P	Palm wooded grassland (physiognomically easily recognized type)
PROTA	Plant Resources of Tropical Africa (URL *http://www.prota.org/*)
S	Somalia-Masai semi-desert grassland and shrubland
s (no capital)	Vegetation of sands (edaphic type)

T	*Termitaria* vegetation (easily identifiable and edaphic type, including bush groups around *termitaria* within grassy drainage zones)
UNEP	United Nations Environment Programme (URL *http://www.unep.org/*)
VECEA	Vegetation and Climate Change in Eastern Africa project (funded by the Rockefeller Foundation)
Wb	*Vitellaria* wooded grassland
Wc	Combretum wooded grassland
Wcd	dry *Combretum* wooded grassland subtype
Wcm	moist *Combretum* wooded grassland subtype
WCMC	World Conservation Monitoring Centre (URL *http://www.unep-wcmc.org/*)
wd (no capital)	Edaphic wooded grassland on drainage-impeded or seasonally flooded soils (edaphic vegetation type)
We	Biotic *Acacia* wooded grassland
Wk	Kalahari woodland
Wm	Miombo woodland
Wmd	Drier miombo woodland subtype
Wmr	Miombo on hills and rocky outcrops subtype
Wmw	Wetter miombo woodland subtype
Wn	north Zambezian undifferentiated woodland and wooded grassland (abbreviation: undifferentiated woodland)
Wo	Mopane woodland and scrub woodland
wr (no capital)	Riverine woodland (edaphic vegetation type, mapped together with riverine forest and thicket)
Wt	*Terminalia sericea* woodland
Wvs	*Vitex - Phyllanthus - Shikariopsis (Sapium) - Terminalia* woodland (not described regionally)
Wvt	*Terminalia glaucescens* woodland (not described regionally)
Wy	Chipya woodland and wooded grassland
X	Fresh-water swamp
x (no capital)	In species composition tables: we have information that this species is present in a national manifestation of the vegetation type
Z	Halophytic vegetation
ZI	Zanzibar-Inhambane coastal mosaic (Kenya and Tanzania coast)

Contents

List of Tables

1. Definition of woodlands and wooded grasslands

Woodlands are open stands of trees of at least 8 m tall with a canopy cover of 40 percent or more[1], but never with interlocking crowns and usually with a field layer of heliophilouis ('sun-loving') grasses. Woodlands have similar height as **forests** (continuous stands of trees at least 10 m tall with interlocking crowns), but woodlands never have densely interlocking crowns (although the crowns can be in contact)[2]. **Wooded grasslands** are lands covered with grasses and other herbs with woody plants (trees [≥ 7 m tall], bushes [3 - 7 m], dwarf trees, palm trees or shrubs [≤ 2 m]) covering between 10 and 40 percent of the ground. Woody plants nearly always occur scattered (White 1983 pp. 46, 47 and 52).

White (1983 p. 46) distinguishes **scrub woodlands** as a physiognomic formation of local extend. Scrub woodlands are intermediate in structure between woodland and bushland, being stunted variants (< 8 m) of main woodland vegetation types (*i.e.* containing the same dominant tree species). In the Zambezian floristic region, each of the main woodland types occur as scrub woodland (sometimes no more than 3 m high) under limiting conditions. For example, scrub miombo woodland is found towards the upper altitudinal limits of miombo woodland (Wm; White 1983 p. 54).

Transition woodland includes woodland vegetation that under certain circumstances[3] (such as the exclusion of fire) reverts back to forest (White 1983 p. 54).

1: The criterion of 40 percent has not been uniformly applied in all physiognomic classification systems for eastern Africa. For example, Pratt *et al.* (1966) used a criterion of 20 percent, whereas Gillman (1949) used a criterion of 50 percent. As a consequence, a vegetation type that was classified as woodland in one classification system will be classified in some alternative classification systems as wooded grassland.

2: Whereas forests are defined physiognomically to have 100% canopy cover, in reality vegetation types with canopy cover above 80% (not 100%) are likely to be classified as forest. A critical factor here is not just the physiognomy, but the species composition that indicates that the vegetation type is degraded forest (and hence the potential natural vegetation type is forest). As forest vegetation types have quite a different suite of species from woodland vegetation types, floristic information (i.e. information on species composition) allows classifying most vegetation types with canopy cover above 80% as forest potential natural vegetation types (J. Timberlake, pers. comm.).

3: This may be difficult to verify (J. Timberlake, personal communication)

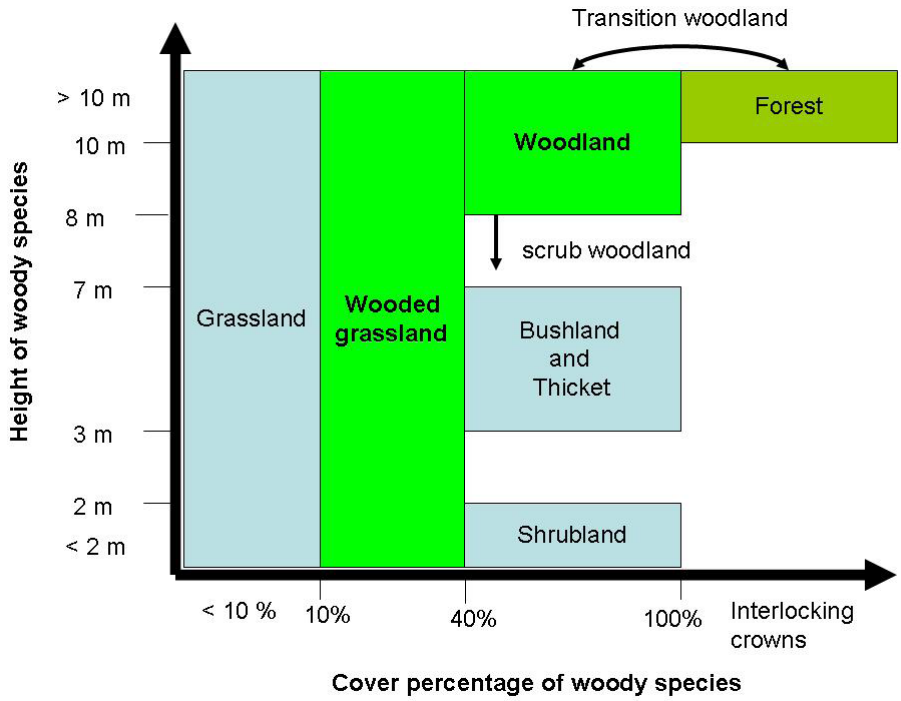


Figure 1. Height and cover percentage limits for major physiognomic types. Transition woodland is woodland that reverts to forest under certain conditions. Scrub woodland is a stunted variant of typical woodland formations such as "scrub miombo woodland".

2. Methodology

2.1. Main description of a woodland or wooded grassland type

In these sections, we relied heavily on The Vegetation of Africa (White 1983) - especially since this reference built on the extensive expertise that Frank White and his collaborators obtained from literature (including 2400 references) and field work (including the experience from many reviewers [White 1983 p. 13]). By comparing species composition described at national (or subnational levels) with species composition described at a continental level, we were seeking to identify potential natural vegetation types of continental relevance that included the various national "manifestations" of these continental vegetation types. Moreover, we now expect to have set the stage for a potential further expansion of the VECEA map in other countries in Africa. **Within the structure of this volume, the first section ("description") within the description of a particular woodland (or wooded grassland) type refers to the "regional information" that was mainly obtained from "The Vegetation of Africa" (White 1983).**

2.2. Information for the VECEA region

Other than key reference on The Vegetation of Africa, we mainly consulted the references that were directly associated with the base maps that we used: Ethiopia, Kenya (two different maps, see volume 6), Rwanda (Bloesch *et al.* [2009] contains an updated version of the vegetation map prepared by Prioul [1981]; the latter is the vegetation map that we digitized (see volume 6), Uganda and Zambia. For two countries, information was limited and we therefore reverted to various other references: Malawi and Tanzania. **Within the structure of this volume, the second section ("VECEA region") within the description of a particular woodland type refers to information that was obtained from one of the national descriptions of the seven VECEA countries.**

The second section also explains the correspondence between the mapping units of the regional map (the VECEA map) and the national maps. For more details how the regional map was obtained from the national maps, see volume 6.

2.3. Information on species assemblages for a particular woodland or wooded grassland type

For each of the woodland types, we obtained information on species assemblages (those tree species expected to occur in a particular vegetation type) based on information that was provided in the national references. For each of the countries where we had information on the national "manifestation" of a woodland type (for example, miombo woodland as it was described for

Zambia by Fanshawe 1971), we created a separate column within which we gave an indication that a particular tree species was expected to occur within that woodland type within that country.

Where species were not listed in the national reference for a focal country, we checked with information on national lists of all the tree species that occur in the focal country ([4] whether the species could **potentially** occur in the focal woodland (or wooded grassland) type and focal country **because the species was documented to occur in the same forest type in other countries**. For example, the species *Brachystegia allenii* was documented to occur in miombo woodland in Malawi and Zambia. From the Flora of Tropical East African and the UNEP-WCMC species database, there was information that this species also occurs in Tanzania. This led us to indicate that there was information that the species potentially occurred in miombo woodland in Tanzania (we used the coding of "f" in the species assemblage table to indicate this). **Note that it is possible that species indicated with "f" for a particular country and woodland (or wooded grassland) type do NOT occur in that particular country and forest type in reality (meaning that, in reality, differences exist between species assemblages of the same woodland [or wooded grassland] type between countries – or possibly indicating errors in the obtained species assemblage for a particular country).**

We used a consistent naming system for all the species that were listed in this volume. Information on synonyms (see Appendix 2) was mainly obtained from the African Plants Database *(http://www.ville-ge.ch/musinfo/bd/cjb/africa*), whereas we generally attempted to use the same botanical names as adopted in the Plant Resources of Tropical Africa (PROTA) database *(http://www.prota4u.org/)*. Generally we did not differentiate below the species level. Even though the type species of the *Acacia* genus has recently been modified to be an Australian species (previously the type species was *Acacia nilotica*), we will continue to use the name of *Acacia* (in its widest sense, i.e. combining *Senegalia* and *Vachellia*) in Africa.

After compiling information on species assemblages, we selected a subset of tree species to feature in species composition tables. These were mainly "useful tree species", which are tree, shrub or liana species that are expected to be useful to farming or pastoral communities in the VECEA countries (see Appendix 1).

The regional information (*i.e.* mainly White 1983) was used to collate information on the "regional status" of a species. The regional status included in regional information on "indicators", "characteristic species" and "species that are not characteristic". We defined these categories as:

- Indicator: A species that was **only listed for the focal woodland** type among all the woodland types described for the same floristic region of the focal forest type. For example, *Acacia robusta* is a positive indicator for north Zambezian undifferentiated woodland ("Undifferentiated woodland [Wn]") since this species was only listed for Undifferentiated woodland (White 1983 p. 95 listed *Aca-*

4: These floristic references included the UNEP-WCMC species database, the Flora of Tropical East Africa (for Kenya, Tanzania and Uganda), the Flora Zambesiaca (for Malawi and Zambia), and some of the national references (Friis *et al.* 2010 for Ethiopia; Beentje 1994 for Kenya; Bloesch *et al.* 2009 for Rwanda; the Uganda Forest Department Biodiversity Database (Howard & Davenport [1996], Viskanic [1999]) for Uganda; and Burgess and Clarke 2000 for the coastal areas of Kenya and Tanzania)

cia robusta ssp. *clavigera*) among all the woodlands described for the Zambezian floristic region.

- Characteristic species: A species that was listed for more than one of the woodland types that were described for the same floristic region, including the focal woodland type. For example, *Acacia erioloba* is not a characteristic species for Undifferentiated woodland (Wn) since it is listed for Undifferentiated woodland (White 1983 p. 95), but is also listed for Kalahari woodland (White 1983 p. 97).
- Species that is not characteristic: A species that was listed among all the woodland types described for the same floristic region as the focal woodland type, but that was **not listed** for the focal woodland type. For example, *Brachystegia bussei* is a negative indicator for Undifferentiated woodland (Wn) since this species was only listed for miombo woodland (White 1983 p. 92) among all the woodlands described for the Zambezian floristic region (and thus not listed as a species for Undifferentiated woodland).

Information on indicators was used to identify the VECEA woodland type during the compilation of the VECEA map[5]. For each of the national woodland types, the selected VECEA woodland type was the woodland type with the highest number of indicators (for this analysis, the complete species assemblages were investigated [i.e. not only the subset of species shown in the species composition tables in the 'sections 3']).

2.4. Information on the distribution of altitude, rainfall and temperature for each woodland or wooded grassland type

We obtained information on annual rainfall and annual mean temperature from Worldclim (Hijmans *et al.* 2005; resolution of 30 arc seconds [~ 925 m]). Information on altitude was obtained from CGIAR-CSI (2008; resolution of 3 arc seconds [~ 90 m]). We created a layer of sample points at a density of approximately one point per 5 km^2 and with a minimum distance of 900 m. In a next step, we sampled the environmental data layers at the sample point locations. All steps were carried out in the GRASS GIS software (GRASS Development Team 2010).

For histograms, we excluded sample points from vegetation mosaics (*i.e.* polygons that contained more than one vegetation type). In each histogram, we compare the distribution of altitude, temperature and rainfall of the focal woodland (or wooded grassland) type with the distributions for all vegetation types and for all woodland (and wooded grassland) types combined. The information for the combined vegetation types was also based on exclusion of sample points from vegetation mosaics.

5: Two exceptions where no regional VECEA type could be assigned to national vegetation types (based on indicator species) were woodland vegetation types that were originally mapped in Uganda as *Vitex doniana - Margaritaria discoidea - Sapium ellipticum - Terminalia glaucescens* woodland (original mapping unit H1) and *Terminalia glaucescens* woodland (originally mapped as H2). Unfortunately, Langdale-Brown *et al.* 1964 did not provide information on species composition in their appendix. Since the extent of these two (mainly adjacent) vegetation types is limited and since information on species composition was also scarce (besides the species that were mentioned earlier, only the riverine species of *Hallea stipulosa* and *Khaya senegalensis* are known to occur), we did not include these two woodland vegetation types with the other regional woodland types described in this volume.

3. *Vitellaria* wooded grassland (Wb)

3.1. Description

Vitellaria paradoxa (synonym *Butyrospermum paradoxum*) is a species that is endemic to the Sudanian floristic region. It occurs both in the Sudanian woodlands of the drier northern parts and Sudanian woodlands of the wetter southern parts of the Sudanian region (White 1983 p. 105). *Vitellaria paradoxa* often replaces *Isoberlinia doka* in secondary grasslands where *Isoberlinia doka* dies out because of frequent cultivation (White 1983 p. 108).

Since most of the Sudanian region has a gradually changing climate (a result from relatively low altitudes and without pronounced relief) and since most species have wide environmental tolerances, it is not possible to distinguish distinct vegetation types and zones - except by dividing Sudanian woodlands in wetter woodlands in the south (which are often dominated by *Isoberlinia doka*) and drier woodlands in the north (which lack *Isoberlinia doka* except on rocky hills; White 1983 pp. 105- 106).

Trapnell and Langdale-Brown (1972 p. 133) mention that *Combretum* is replaced as a dominant species from *Combretum* wooded grassland (Wc) by ***Vitellaria paradoxa*** in wooded grasslands similar to west African wooded grasslands. They mention that *Combretum* species and *Terminalia mollis* still occur as associated species. Lind and Morrison (1974 p. 93) mention that ***Vitellaria paradoxa*** is dominant in parts of Uganda and often accompanied by *Combretum* and associated species - ***Vitellaria paradoxa*** can be distinguished by its latex-loaded twigs.

Figure 3.1 *Vitellaria* (synonym: *Butyrospermum*) wooded grassland about 15 km north-west of Kitgum (Uganda). Photograph by J. Kalema (August 2011).

Figure 3.2 *Vitellaria* wooded grassland in Karamoja District (Uganda). Photograph by F. Gachathi, 2006.

3.2. VECEA region

Within the VECEA region, *Vitellaria* wooded grassland only occurs in Uganda (Figure 3.3, also see Volume 6).

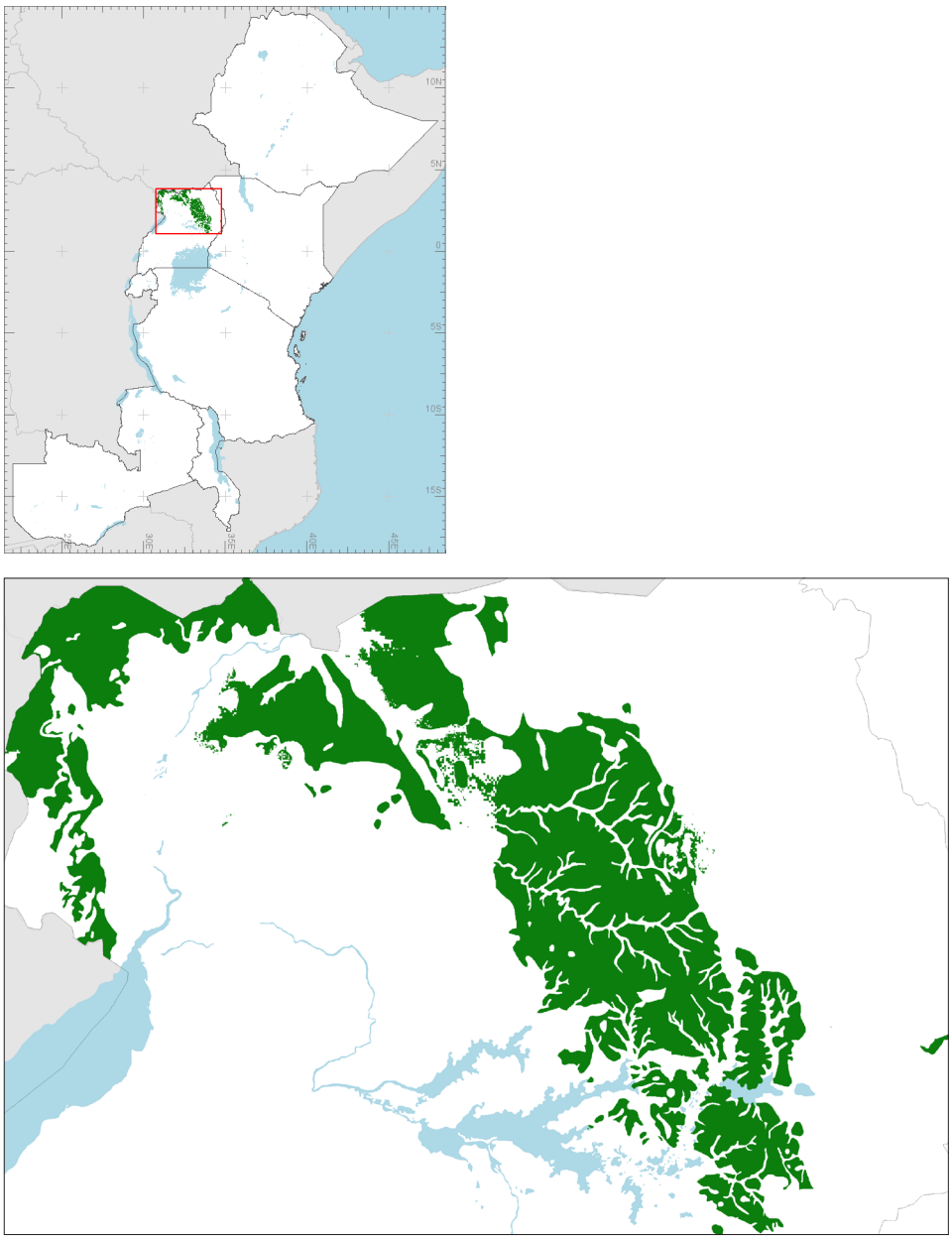
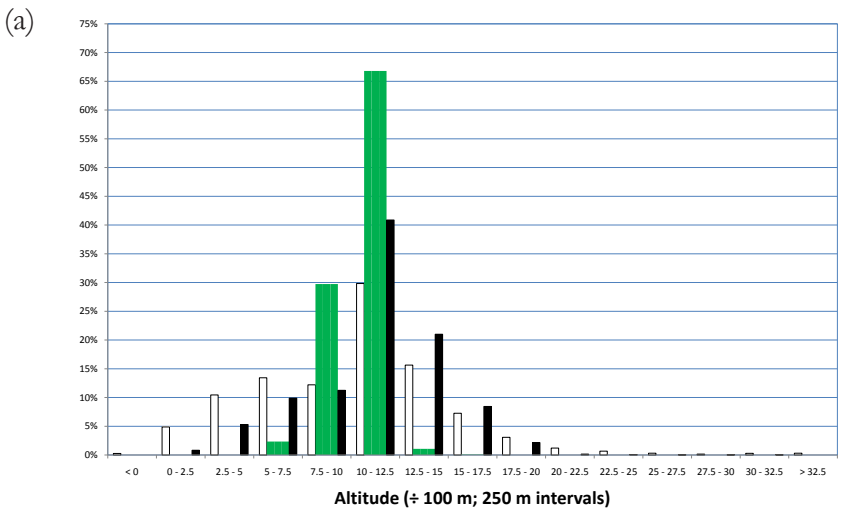
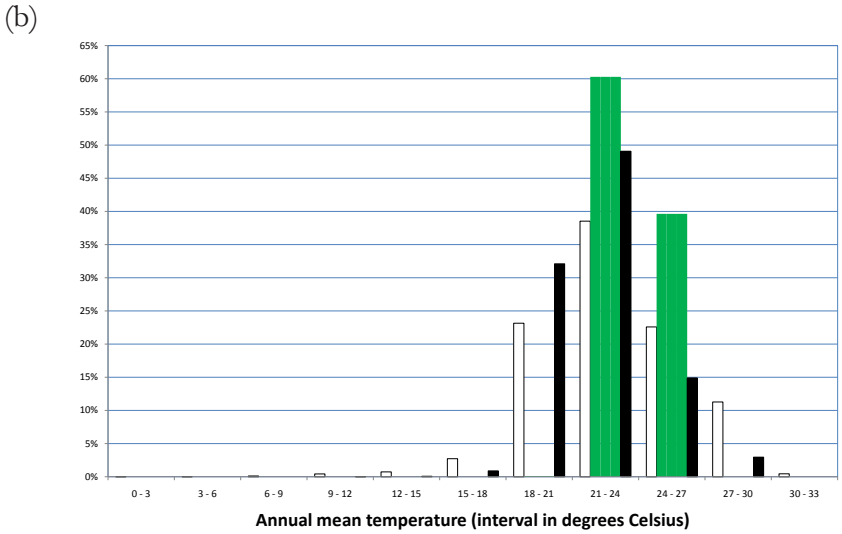


Figure 3.3. Mapped distribution of *Vitellaria* wooded grassland in the VECEA region (Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda and Zambia). Areas where we mapped this vegetation type are depicted by green polygons.

Vitellaria wooded grassland was originally mapped in Uganda as *Butyrospermum* savanna (subtypes of L1, L2 and L3). Langdale-Brown *et al.* (1964, p. 58) treat the three subtypes as relicts, regressional or post-cultivation successional vegetation types of a *Isoberberlinia-Daniellia* woodland climax (especially subtype L1 [*Vitellaria - Daniellia - Hyparrhenia/Hyperthelia*]) or a *Vitellaria* woodland or wooded grassland climax (subtype L2 was described as a fire climax that is closely related to the natural climax). Subtype L2 (*Vitellaria - Hyparrhenia rufa*) has some characteristics in common with moist *Combretum* wooded grassland (such as the dominance of the perennial grass species *Hyparrhenia rufa* [also dominant in wetter *Borassus* palm wooded grassland] and the occurrence of an *Imperata cylindrica* stage in post-cultivation communities), but is different in the occurrence of "west African" species such as *Lophira lanceolata* and ***Vitellaria paradoxa.*** Subtype L3 (*Vitellaria - Hyperthelia dissoluta*) is a drier plant community where, similar as in drier *Combretum* and *Borassus* wooded grasslands, the grass layer is dominated by *Hyperthelia dissoluta* [synonym: *Hyparrhenia dissoluta*].

Investigation of environmental distribution of *Vitellaria* wooded grassland in the VECEA region (Figure 3.4) shows that more than 95% of the samples occur in an interval from 750 – 1250 m. The altitude interval where most of samples occur is the same for this vegetation type (1000 – 1250 m; 66.8% of samples) as for all woodlands and wooded grasslands combined (40.9%). *Vitellaria* wooded grassland receives between 1000 and 1400 mm annual rainfall (> 95% of samples). The rainfall interval of 1200 – 1400 mm contains the highest number of samples (63.1%) for this vegetation type. Among all other woodlands and wooded grasslands, only *Terminalia glaucescens* woodland (Wvt) has a higher rainfall interval where the most samples occur (1400 – 1600 mm, 80.5%).





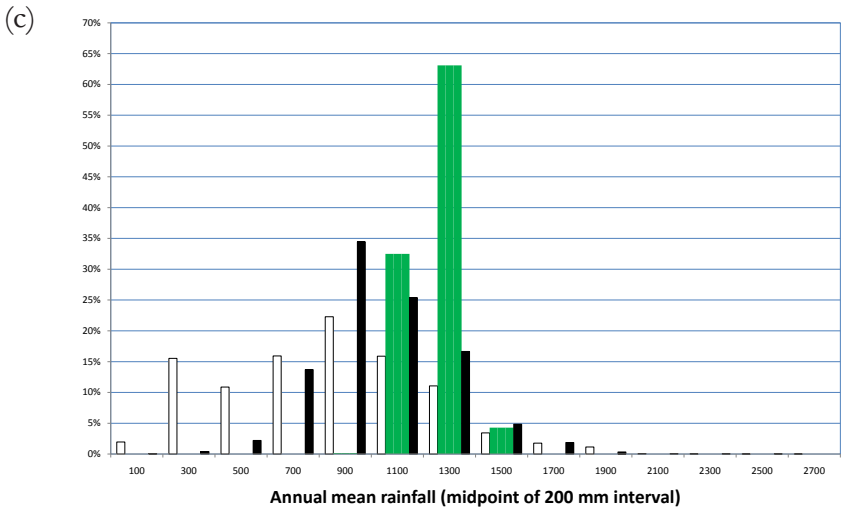


Figure 3.4. Histograms of the distribution of altitude (a), mean annual temperature (b) and mean annual rainfall (c). Bars at the centre of each interval show the percentage of samples within *Vitellaria* (synonym: *Butyrospermum*) wooded grassland (Wb, *n* = 6,287). Bars on left (open) show the overall percentage of samples (*n* = 740,047). Bars on the right (black) show the percentages of samples within woodland or wooded grassland (*n* = 354,078).

3.3. Species composition

Species assemblages were obtained from the following references:

- *Vitellaria - Daniellia - Hyparrhenia* wooded grassland (column "Wb1U"): Langdale-Brown *et al.* (1964). All species that were listed to occur in "*Butyrospermum - Daniellia - Hyparrhenia* savanna" (L1) in the appendix were coded "x" (unless they were characteristic species).
- *Vitellaria - Hyparrhenia rufa* wooded grassland (column "Wb2U"): Langdale-Brown *et al.* (1964). All species that were listed to occur in "*Butyrospermum - Hyparrhenia rufa*" (L2) in the appendix were coded "x" (unless they were characteristic species).
- *Vitellaria - Hyperthelia dissoluta* wooded grassland (column "Wb3U"): Langdale-Brown *et al.* (1964). All species that were listed to occur in "*Butyrospermum - Hyparrhenia dissoluta* savanna" (L3) in the appendix were coded "x" (unless they were characteristic species).

Characteristic species were determined as:

- Uganda. Species that were mentioned in the main text where the vegetation type was described were coded "C". ***Vitellaria paradoxa*** was coded as the dominant species ("D").

Since the vegetation type of *Vitellaria* wooded grassland was not documented regionally (White 1983), we used the proxy of "Sudanian woodland" (White 1983 pp. 105 - 106) when compiling the regional status of a species.

Table 3. Species composition of *Vitellaria* (synonym: *Butyrospermum)* wooded grassland (Wb)

Species	Regional status (see section 2.3)	Wb1U (Uganda)	Wb2U (Uganda)	Wb3U (Uganda)
Vitellaria paradoxa	characteristic	D	D	D
Acacia gerrardii				x
Acacia hockii	indicator for (Sudanian woodland)	x		x
Acacia polyacantha	indicator for (Sudanian woodland)		x	
Albizia amara				x
Albizia coriaria			x	
Albizia zygia			x	
Annona senegalensis	characteristic		x	C
Boscia salicifolia	indicator for (Sudanian woodland)			x
Bridelia scleroneura			x	x
Burkea africana	characteristic			x
Combretum adenogonium				C
Combretum collinum	characteristic		x	x
Combretum molle	indicator for (Sudanian woodland)	x	x	x
Commiphora africana	indicator for (Sudanian woodland)			x
Daniellia oliveri	characteristic	C		
Dombeya rotundifolia			x	
Erythrina abyssinica			x	
Kigelia africana			x	
Lannea barteri		x	x	
Lannea humilis				x
Lannea schimperi	indicator for (Sudanian woodland)			C
Lophira alata		f	f	f
Lophira lanceolata	characteristic	x	x	x
Pappea capensis				x
Philenoptera laxiflora	indicator for (Sudanian woodland)			x
Piliostigma thonningii	characteristic	x	x	x
Sclerocarya birrea	indicator for (Sudanian woodland)			x
Strychnos innocua	not characteristic (indicator for Guineo-Congolian secondary wooded grassland)		x	
Tamarindus indica	indicator for (Sudanian woodland)	x	x	
Terminalia glaucescens	Characteristic	x	x	
Terminalia mollis		x	x	x

4. *Combretum* wooded grassland (Wc)

4.1. Description

Trapnell and Langdale-Brown (1972 p. 133) describing *Combretum* wooded grasslands of Kenya, Tanzania and Uganda mention that various broad-leaved *Combretum* species (the most general species being ***Combretum adenogonium*** [synonym: *Combretum ghasalense*], ***Combretum collinum*** [synonym: *Combretum binderianum*], ***Combretum molle*** and ***Combretum zeyheri***) are associated with larger-leaved species of *Terminalia* (another species of the Combretaceae botanical family [6]) in wetter areas - especially ***Terminalia glaucescens*** and ***Terminalia mollis***. In drier areas, *Combretum* species are associated with smaller-leaved *Terminalia* species: ***Terminalia brownii*** in Kenya and Uganda and ***Terminalia sericea*** in the "monsoon sector" of Tanzania (*i.e.* areas with a one-season summer rainy season typically occupied by miombo woodland [Wm]). These authors further mentioned that *Combretum* wooded grasslands is the major East African wooded grassland vegetation type.

White (1983) does not refer to *Combretum* or *Combretum-Terminalia* vegetation in the main descriptions of the Zambezian, Somalia-Masai, Sudanian, Afromontane, Lake Victoria or Zanzibar-Inhambane regional centres of endemism[7]. However, in the description of the greater Serengeti region, White (1983) describes *Combretum-Terminalia* secondary wooded grassland as a vegetation type with an open overstorey that is dominated by ***Combretum molle*** (10 - 13 m) and ***Terminalia mollis*** (15 -17 m). This vegetation type is a fire climax community that has replaced dry evergreen forest on ridges tops and upper slopes in the northern part of the Serengeti national park (White 1983 p. 121). ***Combretum molle*** woodland is probably a fire-induced vegetation type that has replaced evergreen bushland (Be) or scrub forest on wetter upland areas of Marsabit district (White 1983 p. 121). "Ethiopian undifferentiated woodland" as described by White (1983 p. 107) is virtually equivalent to *Combretum-Terminalia* woodland and wooded grassland described in the atlas of potential natural vegetation types of Ethiopia (Friis *et al.* 2010 p. 170).

6: Lind and Morrison (1974 p. 90) use the name of "Combretaceous wooded grassland and woodland" because the common occurrence of *Combretum* and *Terminalia*. *Terminalia* is similar in appearance to *Combretum*, but *Terminalia* can be recognized from its two-winged woody fruits whereas *Combretum* is characterized by four-winged woody fruits. These authors (p. 81) make the distinction between woodland and wooded grassland vegetation types with predominantly compound-leaved trees (miombo woodland and *Acacia* woodland) and vegetation with predominantly simple-leaved trees (Combretaceous woodland and wooded grassland, *Vitellaria* woodland and wooded grassland and *Borassus* palm grassland).

7: This is probably because in many cases, these vegetation types are transitional or secondary (J. Timberlake, pers. comm.)

Figure 4.1 This type of *Combretum* wooded grassland vegetation was originally described as "tall *Hyparrhenia* – *Combretum* wooded grassland". Note that *Hyparrhenia* is a genus of grass species. Pratt *et al.* (1966, Fig 5a). Image obtained from URL: http://www.jstor.org/stable/2401259.

Figure 4.2 *Combretum – Terminalia* woodland and wooded grassland on stony soil derived from the basement complex at the foothills of the western escarpment near Bumbadi (Ethiopia). The palm species *Hyphaene thebaica* can be seen in the foreground. Altitude approximately 750 m. Photograph by I. Friis and Sebsebe Demissew (October 2008). Reproduced from Biologiske Skrifter of the Royal Danish Academy of Sciences and letters, Vol. 58, Fig 18A. 2010.

Figure 4.3 *Combretum – Terminalia* woodland and wooded grassland with tall underground of grasses (mainly *Hyparrhenia* species) on rocky outcrops east of Kurmuk (Ethiopia). Altitude approximately 1100 m. Photograph by I. Friis and Sebsebe Demissew (October 1998). Reproduced from Biologiske Skrifter of the Royal Danish Academy of Sciences and letters, Vol. 58, Fig 18B. 2010.

4.2. VECEA region

Within the VECEA region (Ethiopia, Kenya, Malawi, Rwanda, Tanzania[8], Uganda and Zambia), *Combretum* wooded grassland was mapped in Ethiopia, Kenya and Uganda (Figure 4.4, see Volume 6).

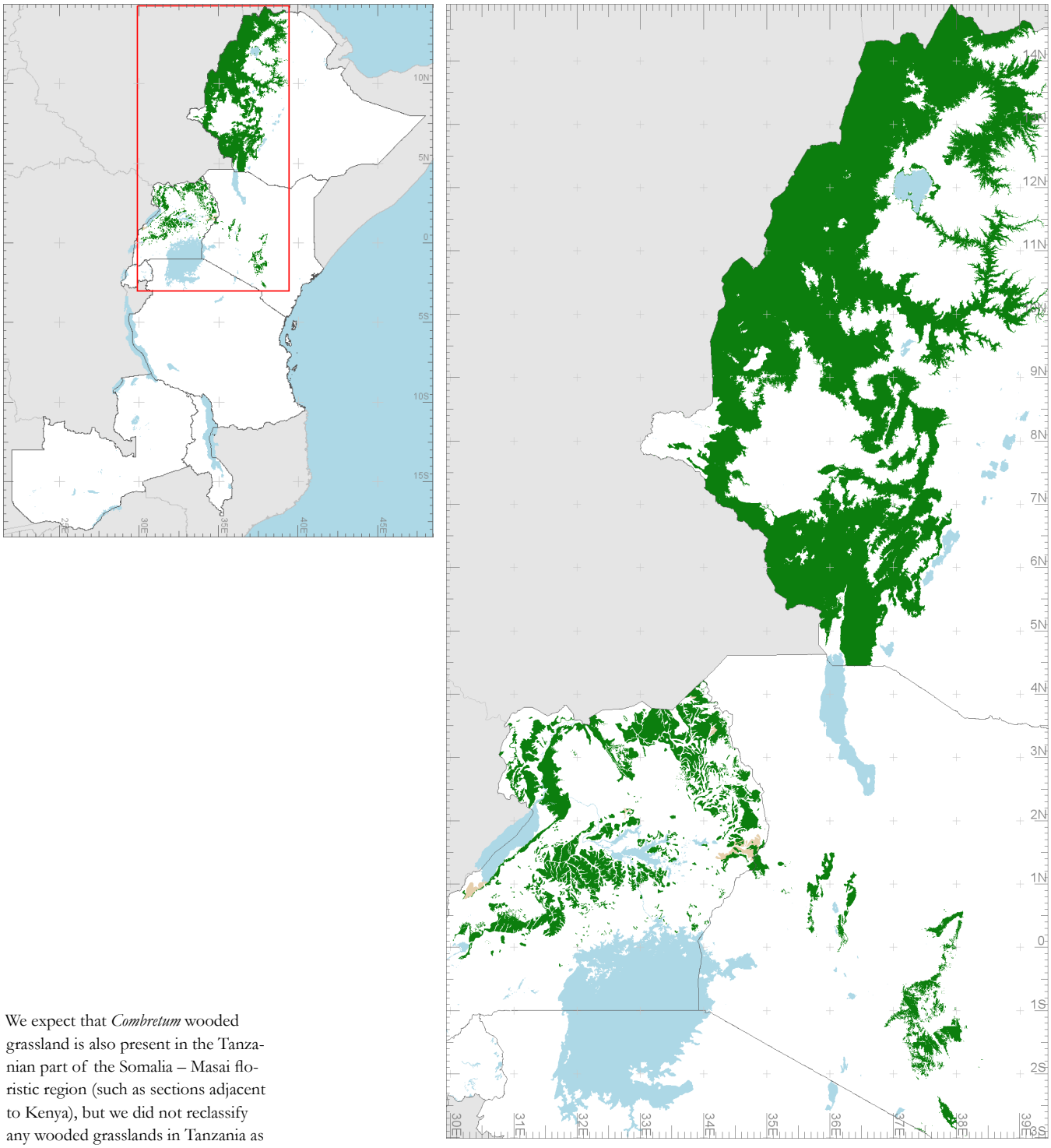


Figure 4.4. Mapped distribution of dry *Combretum* wooded grassland in the VECEA region (Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda and Zambia). Where this vegetation subtype does not occur in mosaic, it is depicted by green polygons. In Uganda, it is also mapped as part of different vegetation mosaics (shown in greyish-brown). Wooded grasslands that are similar to *Combretum* wooded grassland were all classified as Undifferentiated woodland (Wn) in areas of the VECEA map that belong to the Zambezian region.

8: We expect that *Combretum* wooded grassland is also present in the Tanzanian part of the Somalia – Masai floristic region (such as sections adjacent to Kenya), but we did not reclassify any wooded grasslands in Tanzania as *Combretum* wooded grassland. The main reason for this decision was that the base map that we used for Tanzania was a physiognomic map (see Volume 6). As a consequence, some of the area mapped in VECEA as Acacia-Commiphora deciduous wooded grassland (Wd) could be *Combretum* wooded grassland in reality.

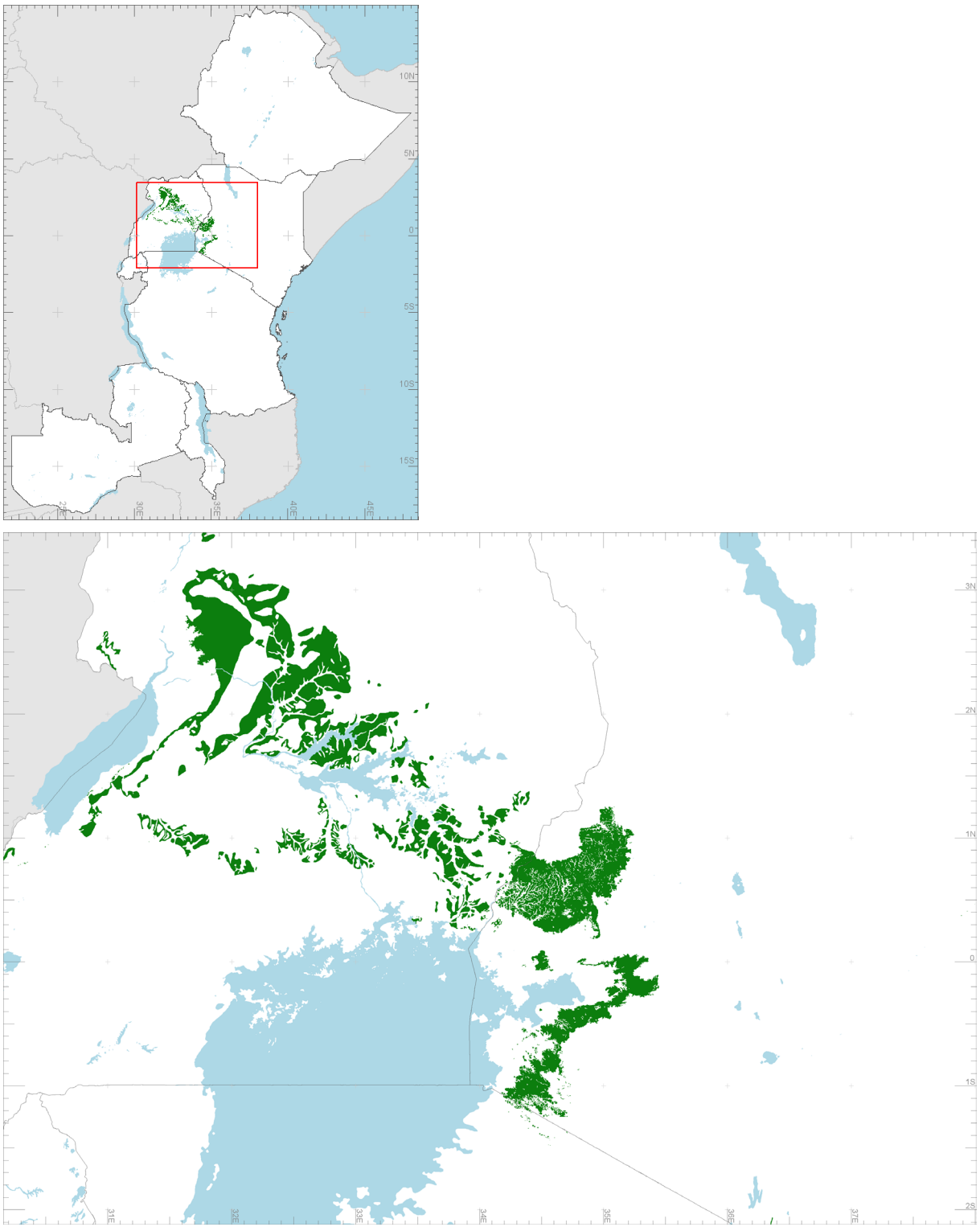


Figure 4.5. Distribution of moist *Combretum* wooded grassland in the VECEA region (Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda and Zambia). The distribution of this vegetation sub-type is depicted by green polygons. Various areas that are mapped as moist *Combretum* wooded grassland are possibly fire climax areas that are secondary to forest.

Because *Combretum* wooded grasslands vegetation types that occur in catenary sequences with miombo woodland (Wm) correspond better to the description in VECEA of Undifferentiated woodland (Wn, see section 9), we excluded mapping unit Wc from the Zambezian region (see Volume 6). We did this for cartographic reasons (since *Combretum* wooded grassland was not mapped separately from *Acacia* wooded grassland in various situations in the Zambezian region) and for floristic reasons (since we expected that many species would not cross the floristic boundary between the Zambezian, Somalia-Masai and Sudanian centres of endemism).

In Ethiopia, *Combretum* wooded grassland was originally described and mapped as *Combretum - Terminalia* woodland and wooded grassland (CTW).

In Kenya, *Combretum* wooded grassland was originally described and mapped by Trapnell *et al.* (1966, 1969, 1976, 1986) as the subtypes of "Moist *Combretum* and allied vegetation", "Dry *Combretum* and allied vegetation", "Eastern *Combretum* and allied vegetation" or other "*Combretum* and allied broad-leaved savanna types". We classified the "Eastern *Combretum* and allied vegetation" as dry *Combretum* wooded grassland since it was adjacent to deciduous bushland (Bd) and since it was not qualified later (i.e. by Trapnell and Brunt 1987) as probably secondary to forest. We classified "*Faurea* and *Parinari - Combretum* types" (original mapping unit 40g), "Parinari and Parinari - *Combretum* mixtures" (40h), "*Piliostigma* and *Combretum - Piliostigma* (40j) and "Burnt-out savanna - grassland areas" (40k) as moist *Combretum* wooded grassland since all other vegetation mapping units coded as mapping unit 40 were mapped as moist *Combretum* wooded grassland by Trapnell *et al.* (1966, 1969, 1976, 1986).

The Range Management Handbook of Kenya (RMHK; Schwartz *et al.* 1991; Shaabani *et al.* 1992abc; Herlocker *et al.* 1993, Herlocker *et al.* 1994abcd) did not clearly separate *Combretum* vegetation types from other vegetation types of similar physiognomy. Based on names of vegetation types, we reclassified the following mapping units as dry *Combretum* wooded grassland: "*Combretum - Euphorbia (candelabrum)* evergreen and semi-deciduous woodland" (original mapping unit 4.3; West Pokot district; Combretaceae species included *Combretum collinum* and *Combretum molle*), "forbs - *Combretum - Ziziphus* semi-deciduous wooded grassland" (6.2; Baringo district; Combretaceae species only included unidentified *Combretum* species), "*Combretum - Terminalia - Albizia* deciduous and semi-deciduous bushland" (13.3; Baringo, Elgeyo-Marakwet and Turkana districts; Combretaceae species included unidentified *Combretum* species and *Terminalia brownii*), "*Terminalia* deciduous and semi-deciduous bushland" (13.4; Baringo district; Combretaceae species included *Combretum apiculatum*, *Terminalia brownii* and *Terminalia spinosa*) and "*Combretum* deciduous and semi-deciduous bushland" (13.5, West Pokot district, Combretaceae species that were listed included unidentified *Combretum* species and *Terminalia brownii*).

In Uganda, *Combretum* wooded grassland was originally described and mapped as the subtypes of "moist *Combretum* savanna", "dry *Combretum* savanna" and "*Albizia - Combretum* woodland". We classified "*Albizia* -

Combretum woodland" (original mapping unit H4 in Uganda) together with *Combretum* wooded grassland since two of the four characteristic species were *Combretum* species (***Combretum collinum*** [synonym: *Combretum binderianum*] and ***Combretum molle***) and the two other characteristic species (***Albizia zygia*** and ***Lannea barteri*** [synonym: *Lannea kerstingii*]) were also characteristic in some *Combretum* wooded grassland (sub)types in Uganda. Moreover, Langdale-Brown *et al.* (1964 p. 57) mentioned that in some situations, moist *Combretum* wooded grassland appears to have been derived from *Albizia - Combretum* woodland, therefore further suggesting that *Albizia - Combretum* woodland could be mapped together with other *Combretum* wooded grassland vegetation types in a potential natural vegetation map.

Besides the suggestions by White (1983) that various *Combretum* wooded grassland types have replaced forests or evergreen bushland after fire (as mentioned in the previous section), Langdale-Brown *et al.* (1964 p. 57) propose that moist *Combretum* wooded grassland is derived from forest, evergreen bushland (Be), *Vitex - Phyllanthus - Shikariopsis (Sapium) - Terminalia* woodland (Wv) or *Albizia - Combretum* woodland (original mapping unit H4). Langdale-Brown *et al.* (1964) further mention that moist *Combretum* wooded grassland vegetation types are intermediate between forests and drier wooded grassland types. They also point out that there are similarities between forest - wooded grassland mosaics (original mapping units F1 and F2) in height and species composition of the grasses, including the dominance by the *Imperata cylindrica* in one stage of post-cultivation succession. Trapnell and Brunt (1987 p. 7) mention that a later modification of their maps involved the addition of "probably secondary" for the moist *Combretum* wooded grassland of western Kenya since most of it may have originated from former forest (except an area near the Uganda border that may have originated from former semi-evergreen thicket [Be]).

Investigation of environmental distribution of *Combretum* wooded grassland in the VECEA region (Figure 4.6.; limits are for areas of the VECEA map where this vegetation type is not mapped as mosaic) shows that both dry and moist *Combretum* wooded grassland occur at average elevations. With more than 90% of the samples occurring in an interval from 500 – 1750 m, dry *Combretum* wooded grassland occurs at slightly lower altitudes than moist *Combretum* wooded grassland (where almost all samples occur between 750 and 2000 m). There is also considerable overlap in the annual rainfall that these two vegetation types receive: more than 95% of samples receive between 600 and 1800 mm in dry *Combretum* wooded grassland, whereas over 95% receive between 1000 and 1800 mm in moist *Combretum* wooded grassland. Most samples occur in the 1000 – 1200 mm interval for dry *Combretum* wooded grassland (22.1%), whereas most samples occur in the 1200 – 1400 mm interval for moist *Combretum* wooded grassland (60.5%). These intervals with the highest number of samples are above the overall average (of all woodlands and wooded grasslands combined, 34.3% occur in the 800 – 1000 mm interval).

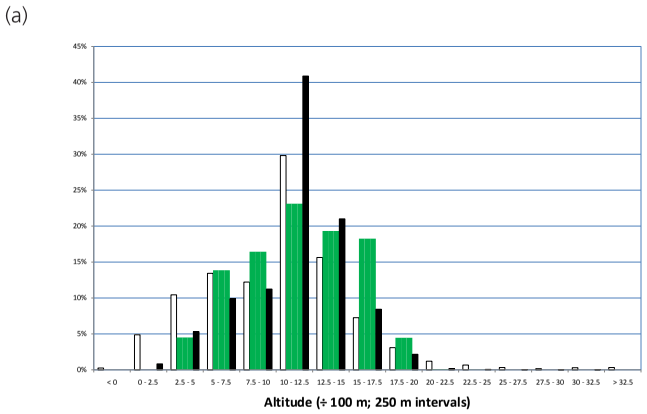


Figure 4.6.1. Histograms of the distribution of altitude for dry *Combretum* wooded grassland (a, *n* = 74,173) and moist *Combretum* wooded grassland (b, *n* = 6,403). Bars at the centre of each interval show the percentage of samples within dry or moist *Combretum* wooded grassland. Bars on left (open) show the overall percentage of samples (*n* = 740,047). Bars on the right (black) show the percentages of samples within woodland or wooded grassland (n =354,078).

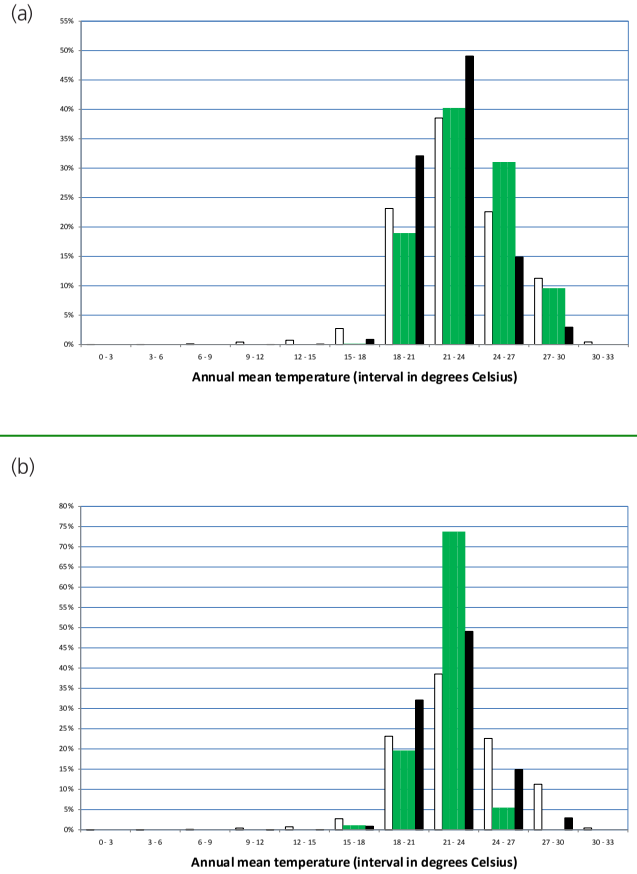


Figure 4.6.2. Histograms of the distribution of mean annual temperature for dry *Combretum* wooded grassland (a, *n* = 74,173) and moist *Combretum* wooded grassland (b, *n* = 6,403). Bars at the centre of each interval show the percentage of samples within dry or moist *Combretum* wooded grassland. Bars on left (open) show the overall percentage of samples (*n* = 740,047). Bars on the right (black) show the percentages of samples within woodland or wooded grassland (n =354,078).

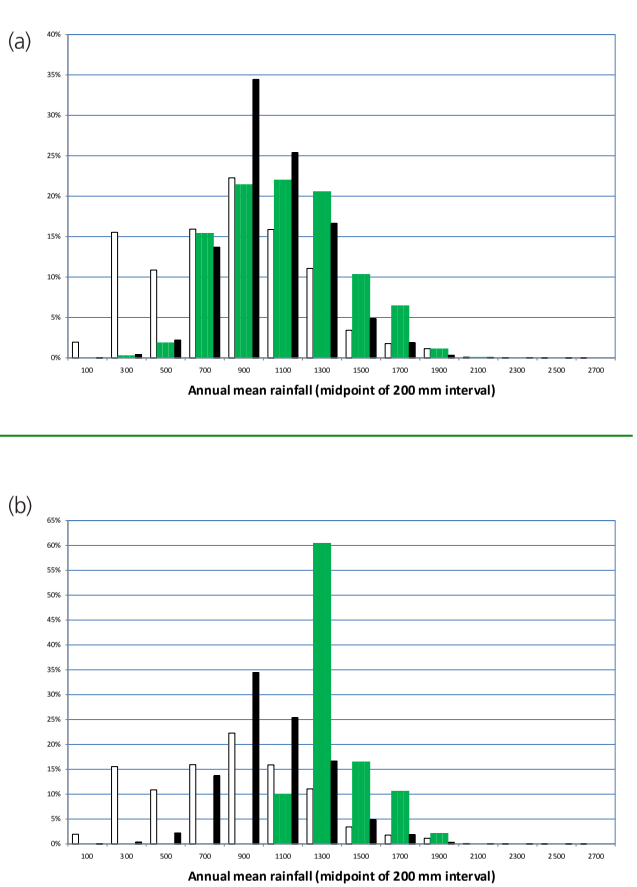


Figure 4.6..3. Histograms of the distribution of mean annual rainfall for dry *Combretum* wooded grassland (a, *n* = 74,173) and moist *Combretum* wooded grassland (b, *n* = 6,403). Bars at the centre of each interval show the percentage of samples within dry or moist *Combretum* wooded grassland. Bars on left (open) show the overall percentage of samples (n = 740,047). Bars on the right (black) show the percentages of samples within woodland or wooded grassland (*n* =354,078).

4.3. Species composition

Species assemblages were obtained from the following references:

- Ethiopia: Friis *et al.* 2010. Species mentioned in Appendix 3 for "*Combretum-Terminalia* woodland and wooded grassland" [CTW] were coded "x" (unless they were characteristic species).
- Kenya (columns "WcdK" and "WcmK"): Species that were expected to occur in the forest type based on information from Beentje (1994), the Flora of Tropical East Africa and field experience from our Kenyan co-author (F. Gachathi) were coded "x". Species expected to occur in drier *Combretum* wooded grassland were listed in column "WcdK" and species expected to occur in moister *Combretum* wooded grassland were listed in column "WcmK").
- Uganda (columns "WcdU", "WcmU" and "WacU"): Langdale-Brown *et al.* (1964). All species that were listed to occur in "Moist *Combretum* savanna" (original mapping unit K) in the Appendix were coded "x" (unless they were characteristic species) in column "WcmU". Species listed to occur in forest - wooded grassland mixtures in the appendix were coded "s1" in case they were listed for original mapping unit F1 or "s2" in case they were listed for original mapping unit F2, but no new species were committed to the species assemblages. Species listed to occur in moist *Acacia* wooded grassland areas [9] in the appendix were coded "j1" in case they were listed for original mapping unit J1 or "j2" in case they were listed for original mapping unit J2, but no new species were committed to the species assemblages. In a separate column ("WacU"), all species that were listed in the Appendix to occur in "*Albizia-Combretum* woodland" (original mapping unit H4) in the Appendix were coded "x" (unless they were characteristic species). In a third separate column ("WcdU"), all species that were listed to occur in one of the dry *Combretum* subtypes were coded "c". However, we excluded species that only occurred in subtypes N4 or N8.

Characteristic species were determined as:

- Ethiopia: Those species that were mentioned in the description of the vegetation type in the main text were coded as "C".
- Kenya: *Combretum* and *Terminalia* species were coded "C". Species mentioned for one of the mapping types of the Trapnell *et al.* (1966, 1969, 1976, 1986) map were also coded "C".
- Uganda: Species expected to be characteristic based on being mentioned in the main text where the vegetation type was described or based on the field experience from our Ugandan co-authors were coded "C". Numbers indicated whether the species was characteristic for subtypes 1 - 9, and "a", "b", "c" and "d" suffixes indicated subtypes 10, 11, 12 and 13 respectively. Species mentioned in the main text for moist *Acacia* wooded grassland were coded "J".

9: Langdale-Brown *et al.* (1964 p. 56) indicate that the J1 moist *Acacia* wooded grassland is the result of long continued cutting, cultivation and burning in areas that once supported forest or evergreen thicket - i.e. indicating a similar secondary nature as for moist *Combretum* wooded grassland. J2 moist *Acacia* wooded grassland is believed to be the result from long continued cutting, cultivation and burning of deciduous woodlands or wooded grasslands - i.e. including dry *Combretum* wooded grassland.

Within the information on assemblages, coding "f" indicates that there is information that the species **potentially** occurs in the vegetation type since it occurs in the focal country and in the same woodland (or wooded grassland) type in other countries (see section 2.3).

Since the vegetation type of *Combretum* wooded grassland (Wc) was not documented regionally (White 1983), we used the proxies of "Sudanian woodland" (White 1983 pp. 105 - 106) and "Ethiopian undifferentiated woodland" (White 1983 p. 107) when documenting the regional status of a species.

Table 4. Species composition of *Combretum* wooded grassland (Wc)

Species	**Regional status (see section 2.3)**	**(Ethiopia)**	WcdK **(Kenya subtype)**	WcdU **(Uganda subtype)**	**W**cmK **(Kenya subtype)**	WcmU **(Uganda subtype)**	WacU **(Uganda subtype)**
Combretum aculeatum		f	x	f			
Combretum adenogonium	characteristic	C	x	C3d	C	f	
Combretum collinum	characteristic	C	C	C23 J2	C	x	C
Combretum hartmannianum	indicator for (Ethiopian undifferentiated woodland)	C					
Combretum molle	characteristic	C	C	C123abd J2	C	C	C
Combretum schumannii			x				
Combretum zeyheri			C		x		
Terminalia brownii	indicator for (Ethiopian undifferentiated woodland)	C	C	Cc	x	f	
Terminalia glaucescens	characteristic	f		C1 j2		C	x
Terminalia laxiflora	characteristic)	C		f			
Terminalia mollis			x	x j2	C	f	
Terminalia prunioides		f	x				
Terminalia spinosa		f	x	Cc			
Abutilon angulatum		x		f			
Acacia abyssinica					x	f	
Acacia brevispica		f	x	f	x	f	
Acacia bussei		f	x				
Acacia drepanolobium		x	x	f	x	f	
Acacia elatior			x	f			
Acacia gerrardii	not characteristic (listed for biotic *Acacia* wooded grassland)	x	x	x	x	f	
Acacia hockii	characteristic	C	x	Cabc j2	x	f	x
Acacia lahai					x	f	
Acacia mellifera		f	x	f			
Acacia nilotica	characteristic	f	x	x			
Acacia oerfota		f	x	f			
Acacia polyacantha	characteristic	x	x	x J2	x	x s2 J1	x
Acacia senegal	characteristic	x	x	x			
Acacia seyal	characteristic	x	x	Cb	x	f	
Acacia sieberiana	characteristic	x	f	x j2	x	J1	x
Acacia tortilis		x	x	f			
Acacia xanthophloea			x				
Acokanthera oppositifolia			x		x		

Species	**Regional status (see section 2.3)**	**(Ethiopia)**	WcdK **(Kenya subtype)**	WcdU **(Uganda subtype)**	**W**cmK **(Kenya subtype)**	WcmU **(Uganda subtype)**	WacU **(Uganda subtype)**
Acokanthera schimperi		f	x	f	x	f	
Adansonia digitata		C	x				
Adenium obesum		f	x				
Albizia amara					x	f	
Albizia anthelmintica		x	x	C			
Albizia coriaria		x	f	C J2	x	x s12 J1	x
Albizia gummifera					x	s1 j1	
Albizia malacophylla		x		x			
Albizia zygia			f	C23 J2	x	C s2	C
Allophylus africanus		x	f	f	x	f	
Allophylus rubifolius		x	x	f	x		
Annona senegalensis	characteristic	x	x	C	C	x	x
Anogeissus leiocarpa	characteristic for Ethiopian undifferentiated woodland and Sudanain woodland	C					
Antiaris toxicaria					x	s2	
Antidesma venosum		f	x	f	x	f	
Apodytes dimidiata		f	x	f	x	f	
Balanites aegyptiaca	characteristic for Ethiopian undifferentiated woodland and Sudanain woodland	C	x	C	x	f	
Balanites glabra		f	x				
Balanites rotundifolia		f	f	x			
Beilschmiedia ugandensis					x	f	
Berchemia discolor		f	x	f			
Borassus aethiopum	(palm species)	x	f	f	x	f	
Boscia angustifolia		f	x	f			
Boscia coriacea		f	x	f			
Boscia salicifolia	characteristic	f	x	x			
Boswellia papyrifera	indicator for Ethiopian undifferentiated woodland	C	f	Ca j2			
Breonadia salicina		f	x	f			
Bridelia micrantha		f	x	f	x	f	
Bridelia scleroneura		x	x	C j2	x	x	x
Buddleja polystachya					x	f	
Caesalpinia decapetala					x	f	

Species	**Regional status (see section 2.3)**	**(Ethiopia)**	WcdK **(Kenya subtype)**	WcdU **(Uganda subtype)**	**W**cmK **(Kenya subtype)**	WcmU **(Uganda subtype)**	WacU **(Uganda subtype)**
Calotropis procera		f	x	f	x	f	
Capparis tomentosa		f	x	f	x	f	
Carissa spinarum		f	x	f	x	f	
Cassia abbreviata			x				
Catha edulis		f	x	f	x	f	
Chrysophyllum albidum					x	f	
Clausena anisata		f	x	f	x	f	
Clerodendrum myricoides		x	x	f	x	f	
Commiphora africana	characteristic for Ethiopian undifferentiated woodland and Sudanian woodland	f	x	C			
Commiphora habessinica		f	x	x			
Cordia africana		x	x	f			
Cordia monoica		f	x	f	x	f	
Cordia sinensis		f	x	f			
Crossopteryx febrifuga	characteristic	x	f	f			
Crotalaria agatiflora					x	f	
Croton macrostachyus		x	x	x	x	s1	
Cussonia arborea	characteristic	x	x	x	x	f	
Cussonia holstii		f	x	f	x	f	
Cussonia spicata			x	f		s1	
Dalbergia melanoxylon	characteristic for Ethiopian undifferentiated woodland and Sudanian woodland	C	x	C			
Dichrostachys cinerea	characteristic	x	x	f	x	f	
Diospyros mespiliformis	characteristic	x	x	f			
Dobera glabra		f	x	f			
Dodonaea viscosa		f	x	f	x	f	
Dombeya buettneri		x					
Dombeya rotundifolia		f	x	C8	x	f	
Dovyalis abyssinica					x	f	
Dovyalis macrocalyx					x	f	
Ehretia cymosa					x	f	
Ekebergia benguelensis			x				
Ekebergia capensis	characteristic	f	f	x		s1	

Species	**Regional status (see section 2.3)**	**(Ethiopia)**	WcdK **(Kenya subtype)**	WcdU **(Uganda subtype)**	**W**cmK **(Kenya subtype)**	WcmU **(Uganda subtype)**	WacU **(Uganda subtype)**
Elaeodendron buchananii		f	x	f	x	f	
Entada abyssinica		x	f	x	x	f	
Entandrophragma angolense					x	f	
Erythrina abyssinica	indicator for Ethiopian undifferentiated woodland	x	x	x j2	x	x s12 j1	x
Erythrina burttii			x				
Erythrina excelsa					x	f	
Erythrina melanacantha		f	x				
Erythroxylum fischeri					x	f	
Euclea divinorum		f	x	f	x	s1	
Euclea racemosa		f	x	x	C	f	
Eugenia capensis					x	f	
Euphorbia candelabrum		x	x	f	x	f	
Euphorbia tirucalli		f	x	f	x	f	
Faurea rochetiana		x	f	f	C	f	
Faurea saligna	characteristic		C	f	x	s1	
Ficus glumosa	characteristic	x	x	f	x	f	
Ficus natalensis			x	f	x	f	
Ficus ovata					x	f	
Ficus platyphylla		f		x			
Ficus sycomorus	characteristic	f	x	f	x	f	
Ficus thonningii					x	f	
Ficus vallis-choudae					x	f	
Flacourtia indica		f	x	f	x	f	
Flueggea virosa		x	x	f	x	f	
Garcinia buchananii					x	s1	
Gardenia ternifolia	characteristic	x	x	x	x	f	
Gardenia volkensii		x	x	f	x	f	
Grewia bicolor		x	x	f	x	f	
Grewia mollis		x	x	f	x	f	
Grewia similis		f	x	f	x	f	
Grewia tembensis		f	x		x		
Grewia villosa		f	x	f	x	f	
Harrisonia abyssinica		x	x	C	x	f	

Species	**Regional status (see section 2.3)**	**(Ethiopia)**	WcdK **(Kenya subtype)**	WcdU **(Uganda subtype)**	**W**cmK **(Kenya subtype)**	WcmU **(Uganda subtype)**	WacU **(Uganda subtype)**
Harungana madagascariensis					x	f	
Hyphaene thebaica	(palm species)	x					
Indigofera swaziensis			x	f	x	f	
Jatropha curcas			x	f	x	f	
Kedrostis gijef			x				
Kigelia africana		f	x	x j2	x	f	
Kigelia moosa					x	f	
Lannea alata			x				
Lannea barteri		C		x			C
Lannea fulva					x	f	
Lannea humilis	characteristic	f	f	C			
Lannea rivae		f	x				
Lannea schimperi	characteristic for Ethiopian undifferentiated woodland and Sudanian woodland	x	x	C	x	f	
Lannea schweinfurthii		x	x	f	x	f	
Lannea triphylla		f	x	C			
Lecaniodiscus fraxinifolius		f	x	f	x	f	
Lippia kituiensis			x		x		
Maerua decumbens		f	x	f	x	f	
Maesopsis eminii					x	s2	
Mangifera indica	(introduced species)					x s2	
Manilkara mochisia			x				
Markhamia lutea					x	x s12	
Markhamia obtusifolia					x		
Maytenus arbutifolia		f	x	f	x	f	
Maytenus senegalensis	not characteristic (indicator for Guineo-Congolian secondary wooded grassland)	x	x	C j2	C	f	
Maytenus undata		f	x	f	x	f	
Melia volkensii		f	x				
Meyna tetraphylla		x	x	f			
Milicia excelsa		f	x	f	x	x s2	
Millettia dura			x	f			
Morus mesozygia					x	f	

Species	Regional status (see section 2.3)	(Ethiopia)	WcdK (Kenya subtype)	WcdU (Uganda subtype)	WcmK (Kenya subtype)	WcmU (Uganda subtype)	WacU (Uganda subtype)
Mussaenda arcuata					x	f	
Newtonia buchananii					x	s2	
Newtonia hildebrandtii			x				
Oncoba spinosa		x	x	f	x	f	
Opilia campestris		f	x				
Oreobambos buchwaldii	(bamboo species indigenous to Africa)				x	f	
Ormocarpum kirkii			x				
Ormocarpum trichocarpum		f	x	x	x	f	
Oxytenanthera abyssinica	(lowland bamboo species)	C		C4			
Ozoroa insignis		x	x	Cac	x	x	
Pappea capensis		x	x	x	x	f	
Parinari curatellifolia	characteristic		x	f	C	f	
Pavetta crassipes		x	x	x	x	f	
Pavetta oliveriana		x	f	f	x	f	
*Phileno*ptera laxiflora	characteristic for Ethiopian undifferentiated woodland and Sudanian woodland	C		Cd			
Phytolacca dodecandra		f	x	f	x	f	
Piliostigma thonningii	characteristic	C	x	C j2	C	x	
Pittosporum viridiflorum		f	x	f	x	f	
Plectranthus barbatus		f	x	f	x	f	
Pouteria altissima					x	f	
Premna resinosa		f	x	f	x	f	
Pseudocedrela kotschyi	characteristic	x		C			
Pseudospondias microcarpa					x	s2	
Psydrax parviflora		x	f	f			
Psydrax schimperiana		x	x	f	x	f	
Pterolobium stellatum		f	x	f	x	f	
Rauvolfia caffra			x	f	x	f	
Rhamnus staddo		f	x	f	x	f	
Rhoicissus revoilii		x	x	f	x	f	
Rhoicissus tridentata		x	x	f	x	f	
Rhus longipes		x	x	f	x	f	
Rhus natalensis		x	x	C	x	f	

Species	**Regional status (see section 2.3)**	**(Ethiopia)**	WcdK **(Kenya subtype)**	WcdU **(Uganda subtype)**	**W**cmK **(Kenya subtype)**	WcmU **(Uganda subtype)**	WacU **(Uganda subtype)**
Rhus tenuinervis		x	x				
Rhus vulgaris		x	x	f	x	f	
Rothmannia urcelliformis					x	f	
Rubus volkensii		f	x	f	x	f	
Saba comorensis		x	f				
Salvadora persica		f	x	f	x	f	
Sarcocephalus latifolius	not characteristic (indicator for Guineo-Congolian secondary wooded grassland)	x	f	f	x	f	
Sclerocarya birrea	characteristic	C	x	C			
Scutia myrtina		f	x	f	x	f	
Securidaca longipedunculata	not characteristic (indicator for Guineo-Congolian secondary wooded grassland)	x	x	x	x	f	
Senna didymobotrya		f	x	f	x	s1	
Senna septemtrionalis			x	f	x	f	
Senna singueana		f	x	x	x	f	
Sesbania sesban		x	f	f			
Solanecio cydoniifolius			x	f			
Solanecio mannii					x	f	
Solanum aculeastrum					x		
Spathodea campanulata					f	x s12	
Spirostachys venenifera			x				
Steganotaenia araliacea	characteristic	x	x	x	x	f	
Sterculia africana		x	x				
Stereospermum kunthianum	characteristic	C	x	C j2	x	x	
Strychnos henningsii		x	x	f	x	f	
Strychnos innocua	not characteristic (indicator for Guineo-Congolian secondary wooded grassland)	x	f	C			x
Strychnos spinosa	not characteristic (indicator for Guineo-Congolian secondary wooded grassland)	x	x	f	x	f	
Synsepalum brevipes					x	f	
Syzygium guineense	characteristic	x	f	x	x	s1	
Tamarindus indica	characteristic	f	x	x j2	x	x	
Tamarix nilotica		f	x				
Tarenna graveolens		f	x	f	x	f	

Species	**Regional status (see section 2.3)**	**(Ethiopia)**	WcdK **(Kenya subtype)**	WcdU **(Uganda subtype)**	**W**cmK **(Kenya subtype)**	WcmU **(Uganda subtype)**	WacU **(Uganda subtype)**
Tephrosia vogelii			x	f	x	f	
Tetradenia riparia		f	x		x		
Thespesia garckeana			x				
Trichilia emetica	characteristic	f	x	f	x	f	
Uvaria scheffleri			x	f			
Vangueria apiculata		f	x	f	x	f	
Vangueria infausta			x	f	x	f	
Vangueria madagascariensis		f	x	f	x	f	
Vepris nobilis		f	x	f	x	j1	
Vernonia amygdalina					x	s1	
Vernonia auriculifera					x	f	
Vernonia myriantha					x	f	
Vitellaria paradoxa	characteristic (dominant species of *Vitellaria* wooded grassland [Wb])	x		x			
Vitex doniana	characteristic	C	f	f	C	f	
Vitex payos			x				
Warburgia ugandensis		f	x	f	x	f	
Ximenia americana		x	x	x	x	f	
Xymalos monospora					x	f	
Zanthoxylum chalybeum		f	x	f	x	f	
Zanthoxylum usambarense		f	x		x		
Ziziphus abyssinica	characteristic	x	x	C	x	f	
Ziziphus mauritiana	characteristic	f	x	f			
Ziziphus mucronata	characteristic	x	x	f	x	f	
Ziziphus pubescens		f	x	f	x	f	

5. *Acacia-Commiphora* deciduous wooded grassland (synonym: deciduous wooded grassland, Wd)

5.1. Description

Throughout volumes 2 to 5, we use "deciduous wooded grassland (Wd)" as a synonym of "*Acacia-Commiphora* deciduous wooded grassland (Wd)".

Although grasses are inconspicuous in typical Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket (Bd), *Acacia-Commiphora* deciduous wooded grassland communities exist such as the wooded grasslands from the greater Serengeti region (Tanzania). The wooded grasslands from the greater Serengeti region are different from typical deciduous bushland communities (Bd) by the insignificance of bushy plants other than *Acacia* and *Commiphora* and by the relative abundance of grasses (especially perennial grass species). The extent to which these features might be a result from prevalent grass fires or a large ungulate population is uncertain, but rainfall is too high in most places of the greater Serengeti region for typical deciduous bushland to occur (except along the drier eastern fringe; White 1983 pp. 125 and 128).

Somalia-Masai deciduous wooded grassland is the most extensive woody vegetation type (88 percent) in the Serengeti National Park. It consists of a single open stratum of *Acacia* or *Commiphora* thorn trees mostly 3 to 7 m high, but 9 to 20 m in a few species. This vegetation is wooded grassland since canopy cover is less than 40 percent in most places. The grass stratum is 0.5 to 1.5 m high and is dominated by *Digitaria macroblephara*, *Eustachys paspaloides*, *Pennisetum mezianum* (on poorly drained soils) and *Themeda triandra*. The wooded grasslands of the greater Serengeti region can be mapped by one mapping unit that is dominated by ***Commiphora schimperi*** and 38 mapping units that contain one or several of 11 *Acacia* species (including ***Acacia drepanolobium, Acacia gerrardii, Acacia hockii, Acacia nilotica, Acacia robusta, Acacia senegal, Acacia seyal, Acacia sieberiana, Acacia tortilis, Acacia polyacantha*** and ***Acacia xanthophloea***; White 1983 p. 126). Several of these species are also characteristic of biotic *Acacia* wooded grassland [We; especially *Acacia gerrardii* and *Acacia hockii*], Somalia-Masai edaphic grassland [we; especially *Acacia drepanolobium* and *Acacia xanthophloea*]), riparian communities (wr; especially *Acacia xanthophloea*) or Undifferentiated woodland (Wn; especially *Acacia polyacantha* and *Acacia sieberiana*; within the greater Serengeti region these species occur as riparian species).Rather than attempting to subdivide these wooded grasslands, we classified all woody grasslands within the Somalia-Masai region and Tanzania as "*Acacia-Commiphora* deciduous wooded grassland (Wd)" except where vegetation modelling suggested that evergreen bushland (Be) could occur (we mapped these specific areas as biotic *Acacia* wooded grassland [We]; see Volume 6). **We thus think that it is probable that the areas of biotic**

***Acacia* wooded grassland (We) and Somalia-Masai edaphic grassland (we) are underestimated in Tanzania.** It is also likely that vegetation types similar to Undifferentiated Woodland (Wn) and that can possibly be classified as *Combretum* wooded grassland (Wc) cross the floristic boundary between the Zambezian and Somalia-Masai regions; this seems especially a possible scenario in the southern part of the area that we mapped as *Acacia-Commiphora* deciduous wooded grassland (Wd).

Figure 5.1 *Acacia tortilis* woodland in Isiolo District (Kenya) was classified in VECEA as subtype WdK. Since this vegetation type does not occur near (seasonal) rivers, it was not classified as riverine vegetation. Photograph by F. Gachathi (2008).

5.2. VECEA region

Within the VECEA region, *Acacia-Commiphora* deciduous wooded grassland occurs in Kenya and Tanzania (Figure 5.2, see also Volume 6).

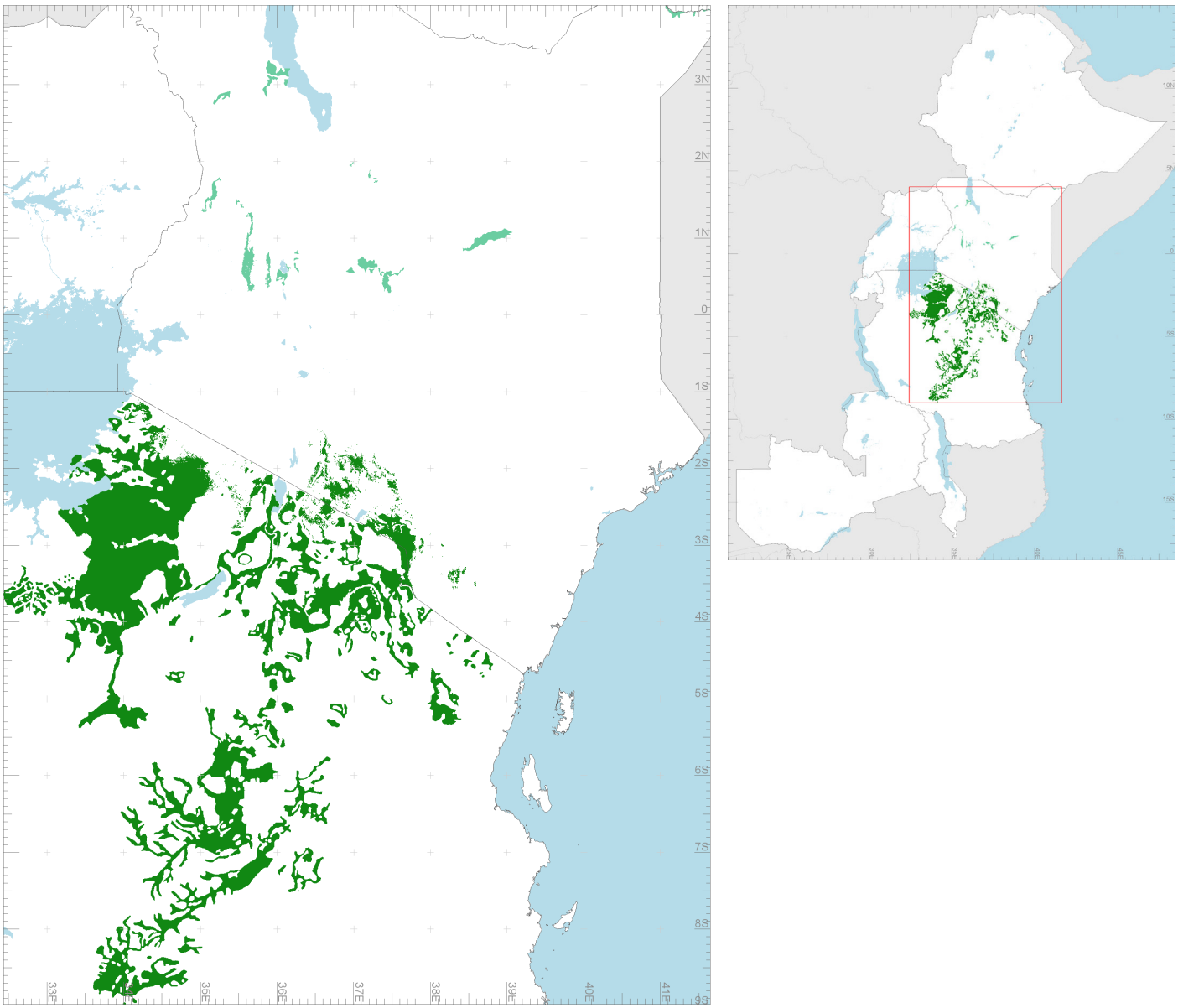


Figure 5.2. Mapped distribution of *Acacia-Commiphora* deciduous wooded grassland in the VECEA region (Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda and Zambia). Areas in light green (south of the equator) depict where we mapped this vegetation type after excluding the WdK subtype. Areas in olive green (north of the equator) show the WdK subtype where it was mapped in northern Kenya. We expect that some of the mapped areas in Tanzania could be Combretum wooded grassland (Wc), biotic *Acacia* wooded grassland (We) or edaphic wooded grassland on drainage-impeded or seasonally flooded soils (wd) in reality.

The Tanzanian manifestation of *Acacia-Commiphora* deciduous wooded grassland corresponds with the description given in the previous section for the Serengeti National Park (i.e. based on White *et al.* 1983). We mapped this vegetation type by reclassifying some areas that were originally mapped as wooded grassland in Tanzania (see volume 6). We expect that some of these areas may be *Combretum* wooded grassland (Wc) or biotic *Acacia* wooded grassland (We) in reality (see volume 6).

The Range Management Handbook of Kenya (RMHK; Schwartz *et al.* 1991; Shaabani *et al.* 1992abc; Herlocker *et al.* 1993, Herlocker *et al.* 1994abcd) did not classify deciduous wooded grassland (WdK) separately from riverine woodland (wr; but see the discussion for this vegetation type) or *Combretum* wooded grassland (Wc). Based on information from species descriptions and landscape positions, we classified the following original mapping units as deciduous wooded grassland (WdK):

(i) *Acacia tortilis - Balanites* evergreen and semi-deciduous woodland [10] (original mapping unit 4.1; Baringo, Elgeyo-Marakwet, Isiolo and West Pokot districts);
(ii) *Acacia tortilis* semi-deciduous woodland (5.1; Baringo district);
(iii) Forbs - *Acacia tortilis - Terminalia* semi-deciduous wooded grassland (6.1; Baringo district)
(iv) *Acacia tortilis* deciduous woodland (7.1; Isiolo district);
(v) *Acacia tortilis - Cadaba* deciduous woodland (7.2; Isiolo district);
(vi) *Sporobolus - Duosperma - Acacia tortilis* deciduous wooded grassland (8.2; Isiolo district);
(vii) *Chloris - Aristida - Acacia tortilis* deciduous wooded annual grassland (9.1; Mandera district); and
(viii) *Aristida - Indigofera - Acacia tortilis* deciduous wooded annual grassland (9.2; Turkana district).

As apparent from the names of these vegetation types, *Acacia tortilis* is the characteristic *Acacia* species. Since *Acacia tortilis* also occurs in biotic *Acacia* wooded grassland (We), it is possible that some of these vegetation types should have been mapped as biotic *Acacia* wooded grassland instead (we did not reclassify as species composition corresponded better with Somalia-Masai *Acacia -Commiphora* deciduous bushland). In Baringo district where the Trapnell *et al.* (1966, 1969, 1976, 1986) map and the Range Management Handbook of Kenya (RMHK; Schwartz *et al.* 1991; Shaabani *et al.* 1992abc; Herlocker *et al.* 1993, Herlocker *et al.* 1994abcd) maps overlapped partially, the original mapping type 4.1 of the RMHK clearly corresponded with the Trapnell *et al.* (1966, 1969, 1976, 1986) "*Acacia-Commiphora* low(land) woodland, thicket and bushland" subtype of "*Acacia tortilis* woodland on alluvium" (original mapping unit 21b).

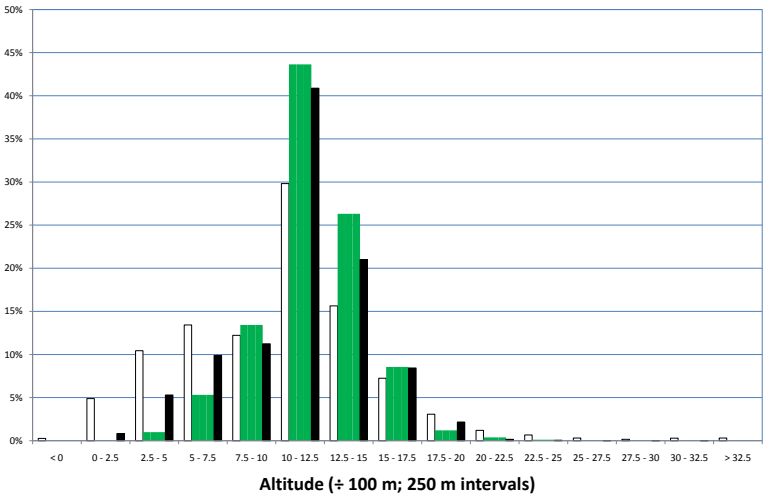
Although we documented Tanzanian and northern Kenyan subtypes of *Acacia-Commiphora* deciduous wooded grassland, we suspect (on grounds of floristic and environmental differences between these subtypes) that these subtypes are NOT manifestations of the same potential natural vegetation type. We expect that the northern Kenyan subtype is more similar to Somalia-Masai *Acacia-Commiphora* de-

10: In the RMHK, "woodland" is defined as vegetation of trees with canopy cover over 20%, whereas "wooded grassland" is defined as vegetation of trees with canopy cover between 2 and 20%. However, the cover percentages given for mapping units classified as "woodland" in the descriptions of these vegetation types were often below 20%. Note also that the regional definition of wooded grasslands specifies cover percentages of 10% and 40% (see section 1).

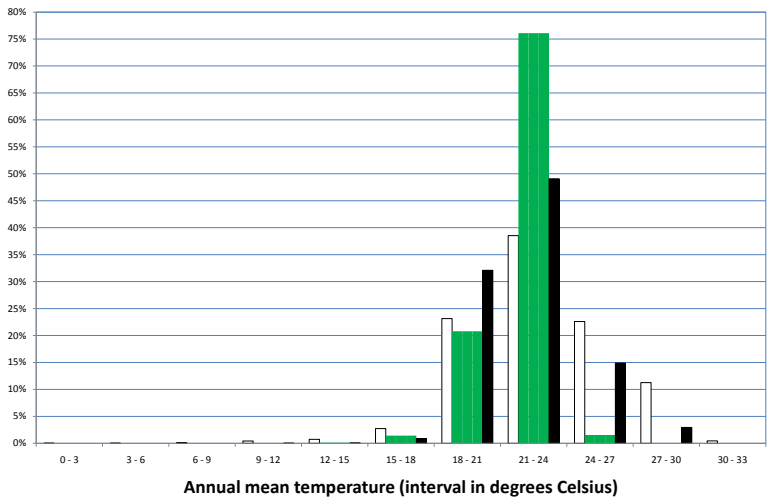
ciduous bushland and thicket (Bd). For these reasons, environmental analysis for *Acacia-Commiphora* deciduous wooded grassland was restricted to the Tanzanian subtype. Similarly, we explicitly used the name of the Kenyan subtype (i.e. WdK) on the VECEA map.

Investigation of environmental distribution of *Acacia-Commiphora* deciduous wooded grassland in the VECEA region (Figure 5.3; limits are for areas of the VECEA map where this vegetation type is not mapped as mosaic; the northern Kenyan subtype was excluded) shows that more than 95% of the samples occur in an interval from 500 – 1750 m. The altitude interval where most of samples occur is the same for this vegetation type (1000 – 1250 m; 43.6% of samples) as for all woodlands and wooded grasslands combined (40.9%). *Acacia-Commiphora* deciduous wooded grassland mainly receives between 400 and 1000 mm annual rainfall (> 90% of samples), making it among the woodland and wooded grassland types that occur in areas with the lowest rainfall. Among all woodlands and wooded grasslands, this vegetation type has the highest percentage of samples in the 400 – 600 mm interval (21.4%). Note, however, that riverine woodland occurs in even drier conditions with 38.9% of its samples in the 200 – 400 mm interval.

(a)



(b)



(c)

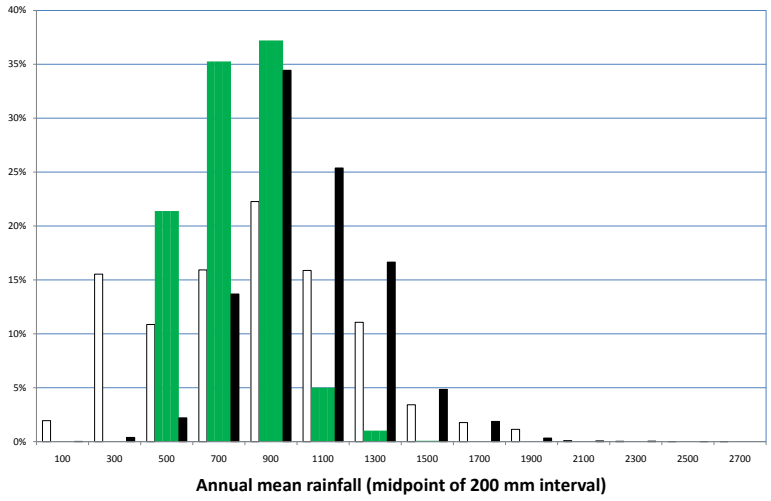


Figure 5.3. Histograms of the distribution of altitude (a), mean annual temperature (b) and mean annual rainfall (c). Bars at the centre of each interval show the percentage of samples within *Acacia-Commiphora* deciduous wooded grassland (Wd, *n* = 23,286). Samples within the northern Kenyan subtype (WdK) were excluded. Bars on left (open) show the overall percentage of samples (*n* = 740,047). Bars on the right (black) show the percentages of samples within woodland or wooded grassland (*n* =354,078).

5.3. Species composition

Species assemblages were obtained from the following references:

- Kenya: Range Management Handbook of Kenya (RMHK, Schwartz *et al.* 1991; Shaabani *et al.* 1992abc; Herlocker *et al.* 1993, Herlocker *et al.* 1994abcd). Species listed in mapping units that we classified as deciduous wooded grassland were coded "C". The suffix referred to the original physiognomic coding of the RMHK.
- Tanzania: White (1983 p. 128). Species that were listed for *Acacia-Commiphora* deciduous wooded grassland (and related types) in the Serengeti ecosystem were coded "x" (unless these were characteristic species).

Characteristic species were determined as:

- Kenya: all species were assumed to be characteristic
- Tanzania: Species for which the names were listed in the names of Herlocker's mapping units (as listed by White 1983 p. 128) were coded as "C".

Within the information on assemblages, coding "f" indicates that there is information that the species potentially occurs in the vegetation type since it occurs in the focal country and in the same woodland (or wooded grassland) type in other countries (see section 2.3).

Table 5. Species composition of *Acacia-Commiphora* deciduous wooded grassland (Wd)

Species	Regional status (see section 2.3)	(Kenya)	(Tanzania)
Acacia drepanolobium	not characteristic (characteristic for biotic *Acacia* wooded grassland and Somalia-Masai edaphic grassland)	f	C
Acacia gerrardii	not characteristic (characteristic for biotic *Acacia* wooded grassland)	f	C
Acacia hockii	not characteristic (characteristic for biotic *Acacia* wooded grassland)	f	C
Acacia mellifera	indicator (main canopy)	C45	f
Acacia nilotica	indicator (main canopy)	C46	C
Acacia oerfota		C4	f
Acacia polyacantha	riparian species in the Serengeti ecosystem	f	C
Acacia reficiens	indicator (main canopy)	C45	
Acacia senegal	not characteristic (indicator for biotic *Acacia* wooded grassland)	C9	C
Acacia seyal	not characteristic (indicator for biotic *Acacia* wooded grassland)	f	C
Acacia sieberiana	riparian species in the Serengeti ecosystem	f	C
Acacia tortilis	indicator (one of few species with well-defined trunk)	C456789	C
Acacia xanthophloea	riparian species	f	C
Albizia amara	not characteristic (characteristic for Somalia-Masai edaphic grassland)	C4	f
Balanites aegyptiaca		C46	f
Commiphora schimperi	indicator (main canopy)	f	C
Cordia monoica	indicator (main canopy)	f	x
Croton dichogamus	not characteristic (characteristic for East African evergreen and semi-evergreen bushland and thicket)	C4	f
Grewia fallax	indicator (smaller bush or shrub)	f	x
Salvadora persica	indicator (main canopy, evergreen)	C79	f
Terminalia brownii		C6	f

6. Biotic *Acacia* wooded grassland (We)

6.1. Description

Where domestic animals [11] are numerous, East African evergreen bushland (Be, see Volume 4) has been severely degraded and invaded by *Acacia* species. It is therefore typical to find ***Acacia drepanolobium*** (a species that also occurs in Somalia-Masai edaphic grassland [we]), ***Acacia hockii, Acacia kirkii*** and ***Acacia seyal*** (a species that also occurs in Somalia-Masai edaphic grassland [we])) occurring together with evergreen species such as *Carissa edulis*, *Dodonaea viscosa*, *Euclea divinorum*, *Euclea racemosa* and *Tarchonanthus camphoratus* (White 1983 p. 115). In the greater Serengeti region, ***Acacia gerrardii*** dominates secondary wooded grassland that replaces evergreen bushland, but it also occupies large areas of poorly drained clay soils (White 1983 p. 128).

Evergreen bushland (Be) communities of the Lake Victoria region have been extensively destroyed and replaced by a lightly wooded *Acacia* grassland dominated by ***Acacia hockii, Acacia gerrardii, Acacia kirkii, Acacia senegal*** (the latter also a characteristic species of deciduous bushland [Bd][12]) and *Euphorbia candelabrum* (also an emergent of evergreen bushland [Be]). White (1983 p. 182) cites references from Lebrun (1947, 1955) and Liben (1961) that suggest the pathways how evergreen thicket can regenerate within biotic *Acacia* wooded grassland. In one pathway, liana species germinate in the shade of the Acacias. These lianas eventually smother the crowns of the Acacias, which then creates suitable conditions for the establishment of shrubs and bushes. The shade from these shrubs and bushes finally completely suppresses the heliophilous ('sun-loving') Acacias that are no longer able to regenerate. In the alternative pathway, the shade from *Euphorbia candelabrum* causes a diminution in the vigour of the grass layer which then allows the invasion of woody plants (White 1983 p. 182).

We suggest that biotic *Acacia* wooded grassland is an **alternative steady state** of potential natural vegetation (corresponding to disturbance by animals) to the steady state of evergreen bushland (Be, corresponding to limited disturbance by animals). The degree of grazing pressure therefore determines the proportions of biotic *Acacia* wooded grassland compared to evergreen bushland (Be).

11: The same situation arises with wild animals

12: The variety of *Acacia senegal* var. *senegal* is a typical variety of biotic *Acacia* wooded grassland, whereas the variety of *Acacia senegal* var. *kerensis* is a typical variety of deciduous bushland (Bd; F. Gachathi, pers. comm.).

Figure 6.1 Vegetation that was originally classified as "*Acacia* wooded grassland of the Rift Valley" (ACB-RV) was reclassified by VECEA as biotic *Acacia* wooded grassland. Early dry season aspect with discontinuous ground cover. Awash National Park near the Fantale volcano (Ethiopia). Photograph by I. Friis and Sebsebe Demissew (October 2006). Reproduced from Biologiske Skrifter of the Royal Danish Academy of Sciences and letters, Vol. 58, Fig 16A. 2010.

Figure 6.2 *Acacia senegal* var. *senegal* in Kajiado District (Kenya). The variety of *Acacia senegal* var. *senegal* is a typical variety of biotic *Acacia* wooded grassland, whereas the variety of *Acacia senegal* var. *kerensis* is a typical variety of deciduous bushland (Bd). Photograph by F. Gachathi (2008).

Figure 6.3 Vegetation that was originally classified as "*Acacia – Cymbopogon / Themeda* dry *Acacia* savanna" (original mapping unit P1; *Cymbopogon* and *Themeda* are grass genera) was reclassified as biotic *Acacia* wooded grassland by VECEA. The picture shows an area close to drier *Combretum* wooded grassland (Wcd) near Maddu (Uganda). Photograph by J. Kalema (November 2010).

Figure 6.4. Biotic *Acacia* wooded grassland in Akagera National Park (Rwanda). Photograph by C.K. Ruffo (October 2009).

Figure 6.5 *Acacia gerrardii – Acacia seyal* wooded grassland with Themeda grass understorey. Height of vegetation in meter. Pratt *et al.* (1966, Fig 3b). Image obtained from URL: *http://www.jstor.org/stable/2401259*

6.2. VECEA region

Within the VECEA region, biotic *Acacia* wooded grassland was mapped in Ethiopia, Kenya, Rwanda, Tanzania and Uganda (Figure 6.6, see also Volume 6).

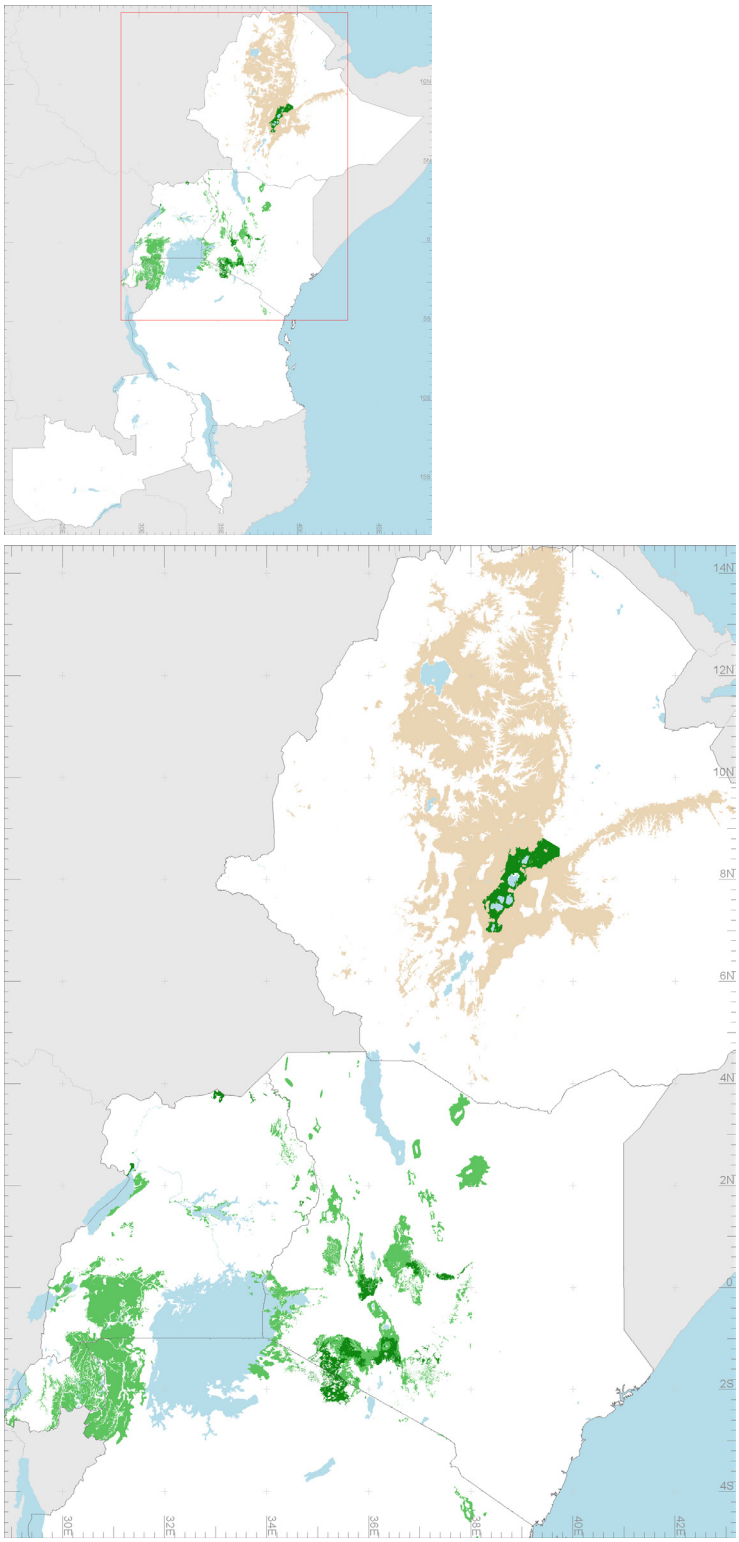


Figure 6.6. Mapped distribution of biotic *Acacia* wooded grassland in the VECEA region (Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda and Zambia). Dark-green polygons depict where we mapped this vegetation type (including Ethiopia). This vegetation type is an alternative steady state from evergreen bushland (Be; this vegetation is mapped in light-green where it was not mapped as mosaics, and greyish-brown where it was mapped as part of vegetation mosaics)

The Ethiopian original vegetation type of "*Acacia* wooded grassland of the Rift Valley" (original mapping unit ACB-RV) was treated by the authors of the Ethiopian potential natural vegetation map as a subtype of "*Acacia-Commiphora* woodland and bushland (sensu Friis *et al.* 2010)" 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" (Friis *et al.* 2010 p. 47). Within the VECEA map, the "other subtype" (*Acacia-Commiphora* woodland and bushland proper) is classified and mapped as deciduous bushland (Bd). Within the VECEA system, we included "*Acacia* wooded grassland of the Rift Valley" with biotic *Acacia* wooded grassland because (i) floristic similarity with vegetation types classified as biotic *Acacia* wooded grassland in other countries (see section 6.3); (ii) similarity in environmental conditions with vegetation types classified as biotic *Acacia* wooded grassland or Evergreen bushland (Be) in other countries; (iii) the almost complete absence of the *Commiphora* genus (Friis *et al.* 2010 p. 55); (iv) the treatment and mapping as a distinct subtype; (v) the prominence of grasses (see Friis *et al.* 2010 p. 55; grasses are not conspicuous in typical deciduous bushland [Bd], see discussion in Volume 4); (vi) the fact that a physiognomic boundary between typical "*Acacia* wooded grassland of the Rift Valley" and typical deciduous bushland (Bd) can be observed in the Afar region as a transition to drier and more open types (Friis *et al.* 2010 p. 58); and (vii) the limited number of cases where species were documented as typical for "*Acacia* wooded grassland of the Rift Valley" (ACB-RV) in Appendix 3 [13]. However, we do not dispute that there are floristic similarities between "*Acacia* wooded grassland of the Rift Valley" and typical deciduous bushland vegetation types (see also Friis *et al.* 2010 p. 47).

We included all areas that were mapped originally as "upland *Acacia* woodland, wooded grassland and bushland"[14] in the original Kenyan highlands maps within areas mapped as biotic *Acacia* wooded grassland by VECEA (*i.e.* not only the areas mapped explicitly by Trapnell *et al.* (1966, 1969, 1976, 1986) as "Upland *Acacia* (derived) from evergreen and semi-deciduous bushland"). However, some of these areas occur under specific edaphic conditions within an area that is climatically suitable for evergreen bushland (Be), especially the subtypes of "*Acacia drepanolobium* with evergreen elements on pedocal and impeded drainage soils" (original mapping units 61a, 61b and 61c, grouped under "Upland *Acacia* types (derived) from evergreen and semi-deciduous bushland"). These *Acacia drepanolobium* subtypes were mapped as edaphic wooded grassland on drainage-impeded or seasonally flooded soils (wd) in the VECEA map. Another exception to the rule of reclassifying "upland *Acacia* woodland, wooded grassland and bushland" from the original Kenyan highlands maps as the VECEA-type of biotic *Acacia* wooded grassland were "upland *Acacia*" vegetation subtypes that occur on recent alluvium. These vegetation types were classified as riverine woodland instead (wr).

Areas that were classified in Kenya as biotic *Acacia* wooded grassland furthermore included the wooded grasslands and grassland that were indicated to be derived from evergreen thicket on the Trump vegetation map (1972, see Volume 6).

In Rwanda, we reclassified areas that were originally mapped as 'savana

13: this may be a partial artefact since in Appendix 3, the same coding ("ACB") was used for "*Acacia-Commiphora* woodland and bushland" and the subtype of "*Acacia-Commiphora* woodland and bushland **proper**".

14: Trapnell and Langdale-Brown (1972 pp. 133 - 134) list several *Acacia* wooded grassland types: (i) higher-level *Acacia* types (*Acacia gerrardii*, *Acacia nilotica*, *Acacia senegal* and *Acacia seyal*) that are possible exceptions to the rule that most *Acacia* wooded grassland in East Africa is either secondary or associated with special soil and drainage conditions; (ii) *Acacia* wooded grasslands (*Acacia drepanolobium* and allied gall-*Acacia* species on black clays, *Acacia polyacantha* [in moist sites, chiefly in Uganda], *Acacia seyal* and *Acacia tortilis* [in hotter and drier climates]) on flood-plain and riverine alluvium, black clay plains, seasonally waterlogged soils and various soils described as 'hardpan' in Tanzania; and (iii) secondary *Acacia* vegetation (*Acacia gerrardii* [chief species in the most extensive areas that were former evergreen bushland (Be) types], *Acacia hockii* [involved in the most extensive areas that were former evergreen bushland (Be) types], *Acacia abyssinica* [Kenya], *Acacia lahai* [Kenya], *Acacia drepanolobium*, *Acacia polyacantha* [Uganda], *Acacia seyal*, *Acacia sieberiana* [Tanzania]). The considerable overlap in *Acacia* species between these various *Acacia* types shows that it is not trivial to identify whether the vegetation is a 'climax', edaphic or secondary type based on the identities of the *Acacia* species. Information from Edwards (1956) suggests that biotic *Acacia* wooded grassland could be also be characterized by the *Themeda triandra* grass species as this species dominates the tall even cover of herbage in *Acacia* – *Themeda* scattered-tree grassland and open grassland vegetation.

arborée', 'savana arbustive' or 'savana boisée' as biotic *Acacia* wooded grassland[15]. *Acacia polyacantha* is the typical species of wooded grasslands where woody vegetation consists of trees ("savana boisée"; Bloesch p. 650). Lebrun (1956) describes that besides an *Acacia* wooded grassland that is dominated by *Acacia gerrardii* (synonym: *Acacia hebecladoides*), another taller type of wooded grassland occurs on very fertile soils in the Akagera depression. Dominant species include *Acacia kirkii*, *Acacia sieberiana*, *Acacia polyacantha* ssp. *campylacantha*, *Ficus sycomorus* and *Blighia unijugata*, which Lebrun (1956) typifies as a plant formation that is similar to hygrophyl *Faidherbia albida* formations.

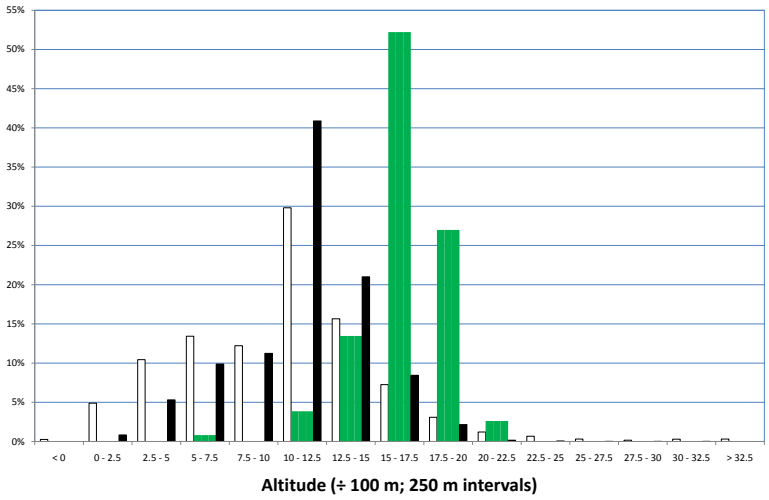
For Tanzania, we used modelling to estimate the distribution of Evergreen bushland (Be) in the northern part of the Serengeti system (in a region bordering Kenya). On the Kenyan side, most of these areas were reclassified as biotic *Acacia* wooded grasslands, an alternative stable state of Evergreen bushland (see section 6.1). Since most of the projected areas in Tanzania where mapped by Gillman (1949) as wooded grassland, we classified these areas as biotic *Acacia* wooded grassland rather then Evergreen bushland (more details are provided in Volume 6). We still expect, however, that possibly some of the areas that were mapped by the VECEA project in Tanzania as *Acacia-Commiphora* deciduous wooded grassland (Wd) are biotic *Acacia* wooded grassland (We) in reality.

From Uganda, we reclassified areas that were originally mapped as dry *Acacia* savanna subtypes of *Acacia - Cymbopogon/Themeda* dry *Acacia* savanna (original mapping unit P1) or *Acacia - Themeda - Setaria* dry *Acacia* savanna (original mapping unit P2) as biotic *Acacia* wooded grassland. This reclassification was inspired by a floristic comparison with biotic *Acacia* wooded grassland in the other countries (see also section 6.3).

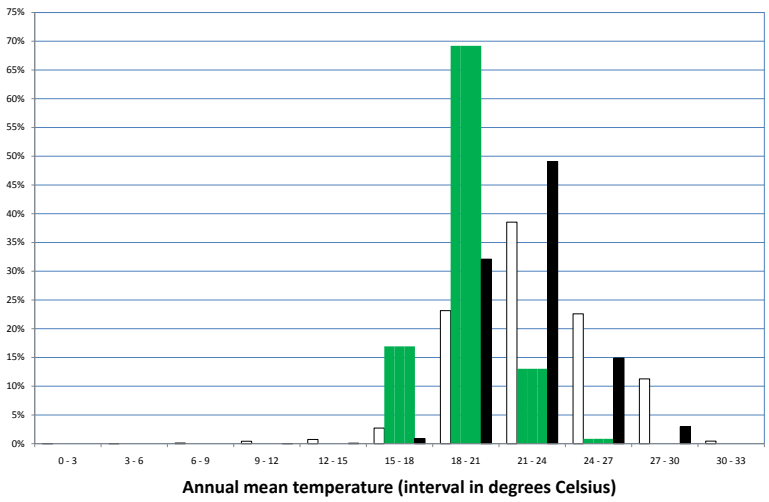
Investigation of environmental distribution of biotic *Acacia* wooded grassland in the VECEA region (Figure 6.7; limits are for areas of the VECEA map where this vegetation type is not mapped as mosaic; the northern Kenyan subtype was excluded) shows that over 95% of the samples occur above 1250 m. Among all the woodlands and wooded grasslands, this vegetation type has the highest altitude interval (1500 – 1750 m) where most samples occur (52.2%). Biotic *Acacia* wooded grassland deciduous wooded grassland receives between 600 and 1200 mm average rainfall (> 95% of samples). The rainfall interval where most of samples occur is the same for this vegetation type (800 – 1000 mm; 55.7% of samples) as for all woodlands and wooded grasslands combined (34.3%).

15: 'savana arborée', 'savana arbustive' and ' savana boisée' are all characterized by a continuous herb layer that is typically composed of grasses and are all often burned every year; they are differentiated from 'savana herbeuse' by having more than 2% woody cover. The woody species in 'savana arborée' consist of bushes and trees, those in 'savana arbustive' only consist of bushes and those in 'savana boisée' only consist of trees. Trees in 'savana boisée' are mainly *Acacia polyacantha* ssp. *campylacantha* (Bloesch et al. 2009 pp. 649 - 650).

(a)



(b)



(c)

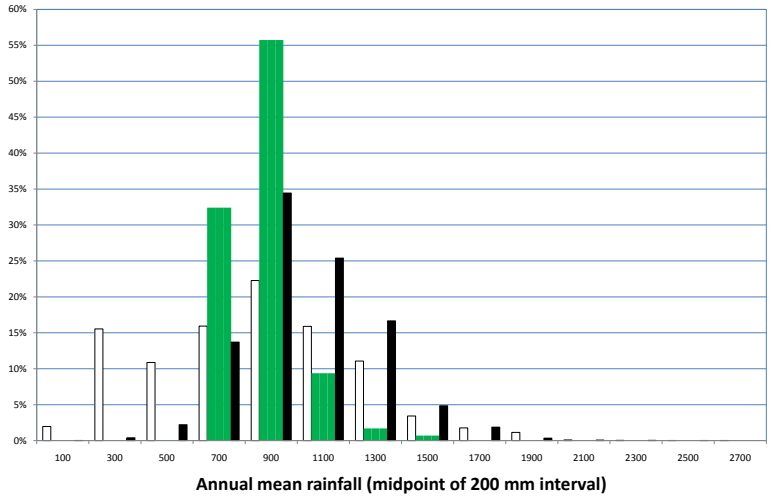


Figure 6.7 Histograms of the distribution of altitude (a), mean annual temperature (b) and mean annual rainfall (c). Bars at the centre of each interval show the percentage of samples within biotic *Acacia* wooded grassland (We, *n* = 4,769). Bars on left (open) show the overall percentage of samples (*n* = 740,047). Bars on the right (black) show the percentages of samples within woodland or wooded grassland (*n* =354,078).

6.3. Species composition

Species assemblages were obtained from the following references:

- Ethiopia: Friis *et al.* 2010. Species mentioned in Appendix 3 for "*Acacia* wooded grassland of the Rift valley" [ACB-RF] were coded "x".
- Kenya): Species that were expected to occur in the woodland type based on information from Beentje (1994), the Flora of Tropical East Africa and field experience from our Kenyan co.author (F. Gachathi) were coded "x".
- Rwanda: Bloesch *et al.* (2009). All species that were mentioned to occur in floristic regions 1C (south eastern zone with influence from the vegetation of East Africa) or 1D (depression of the Akagera river of Migongo, also with influence from the Zambezian region) and where a reference was made to 'savana arborée', 'savana arbustive' or ' savana boisée' in the description of their ecology were coded "x" (unless they were characteristic species). Species that only occurred in floristic region 1C were coded "xe". Species that only occurred in floristic region 1D were coded "xz". Species that also occurred in the habitat of 'bosquets xérophiles' or 'forêt sèche' (*i.e.* evergreen bushland [Be]) were coded "xb".
- Tanzania: only floristic similarity was investigated (see section 2.3)
- Uganda): Langdale-Brown *et al.* (1964). All species that were listed to occur in "*Acacia - Cymbogon/Themeda* dry *Acacia* savanna" (P1) in the Appendix were coded "x" in column "WecU" (unless they were characteristic species). In a separate column ("WesU"), species listed to occur in "*Acacia - Themeda - Setaria* dry *Acacia* savanna" (P2) were coded "x" (unless they were characteristic species).

Characteristic species were determined as:

- Ethiopia: Those species that were mentioned in the description of the vegetation type in the main text were coded as "C".
- Kenya: Those species that were mentioned in the names of "upland *Acacia* woodland, wooded grassland and bushland were coded "C". A suffix of "a" indicates a mention of recent alluvium. A suffix of "c" indicates a subclassification as "transitional *Acacia* mixtures"[16]. A suffix of "e" indicates a mention that the vegetation is secondary to evergreen bushland (Be). A suffix of "u" indicates a mention that this was a "proper" upland *Acacia* vegetation type.
- Rwanda: Species mentioned by Lebrun (1956) or Prioul (1981) to occur in wooded grassland types were coded as "C".
- Tanzania: Characteristic species were not indentified
- Uganda: Species mentioned in the main text were coded "C".

Within the information on assemblages, coding "f" indicates that there is information that the species potentially occurs in the vegetation type since it occurs in the focal country and in the same woodland (or wooded grassland) type in other countries (see section 2.3).

16: We believe that these are transition zones to *Combretum* wooded grassland (Wc) since subtypes include *Acacia - Combretum* mixtures (mapping unit 19a) and *Acacia tortilis - Terminalia* (mapping unit 19b).

Table 6. Species composition of Biotic *Acacia* wooded grassland (We)

Species	Regional status	(Ethiopia)	(Kenya)	(Rwanda)	(Tanzania)	WecU (Uganda subtype)	WesU (Uganda subtype)
Abutilon angulatum		f		xe		f	f
Acacia abyssinica		f	x	f	f	f	f
Acacia brevispica		f	Ceu	f	f	f	f
Acacia drepanolobium	characteristic	f	Ceu		f	f	x
Acacia gerrardii	indicator	f	Cae	C	f	C	C
Acacia hockii	indicator	f	Ce	x	f	x	x
Acacia kirkii	indicator		Ca	C	f	f	f
Acacia lahai		f	x		f	f	f
Acacia mellifera	not characteristic (indicator for (deciduous bushland)	f	Cu		f	f	f
Acacia nilotica	not characteristic (indicator for deciduous bushland)	f	x		f	f	f
Acacia polyacantha		f	Ca	C	f	f	f
Acacia senegal	indicator	C	x	C	f	x	f
Acacia seyal	characteristic	C	Ce	C	f	f	x
Acacia sieberiana		f	x	C	f	x	f
Acacia tortilis	not characteristic (indicator for deciduous bushland)	C	Ccu		f	f	f
Acacia xanthophloea			Ca		f		
Acokanthera schimperi	characteristic (indicator for evergreen bushland)	f	x	f	f	f	f
Albizia adianthifolia			f	C	f	x	f
Albizia amara	not characteristic (indicator for Somalia-Masai edaphic grassland)	f	Cc	C	f	f	f
Albizia antunesiana				x	f		
Albizia petersiana			f	xb	f	f	f
Albizia versicolor			f	x	f	f	f
Allophylus rubifolius		f	x	xb	f	f	f
Annona senegalensis		f	f	x	f	f	f
Balanites aegyptiaca		f	f	f	f	f	x
Berberis holstii		f	x		f	f	f
Bersama abyssinica		f	x	x	f	f	f
Boscia angustifolia		f	x	xb	f	f	f
Boscia salicifolia		f	x		f	f	x
Bridelia scleroneura		f	f		f	x	f

Species	Regional status	(Ethiopia)	(Kenya)	(Rwanda)	(Tanzania)	WecU (Uganda subtype)	WesU (Uganda subtype)
Buddleja polystachya		f	x		f	f	f
Caesalpinia volkensii			x		f	f	f
Canthium lactescens		f	x	f	f	f	f
Capparis tomentosa	characteristic (indicator for evergreen bushland)	f	x	f	f	f	f
Carissa spinarum	characteristic (indicator for evergreen bushland)	f	x	f	f	f	f
Clausena anisata		f	x	f	f	f	f
Clerodendrum myricoides		f	x	f	f	f	f
Combretum collinum		f	f	x	f	f	f
Combretum molle		f	x	xb	f	f	x
Commiphora africana	not characteristic (indicator for deciduous bushland)	f	f	x	f	f	f
Commiphora habessinica		f	x	xbe	f	f	f
Cordia africana		f	x	x	f	f	f
Cordia monoica	not characteristic (indicator for deciduous bushland)	f	x		f	f	f
Crossopteryx febrifuga		f	f	x	f	f	f
Crotalaria agatiflora		f	x	f	f	f	f
Croton macrostachyus		f	x	f	f	f	f
Cussonia arborea		f	x	xb	f	f	f
Cussonia holstii	characteristic (indicator for evergreen bushland, transition to forest)	f	f	xb	f	f	f
Cussonia spicata			x		f	f	f
Dichrostachys cinerea		x	x	f	f	f	f
Dodonaea viscosa	characteristic (indicator for evergreen bushland)	f	x	f	f	f	f
Dombeya buettneri		f		x			
Dombeya kirkii		f	x	f	f	f	f
Dombeya rotundifolia		f	x	x		f	f
Dovyalis abyssinica		f	x		f	f	f
Dovyalis macrocalyx			x	f	f	f	f
Ehretia cymosa		f	x	f		f	f
Elaeodendron buchananii	characteristic (indicator for evergreen bushland, transition to forest)	f	f	xb	f	f	f
Entada abyssinica		f	f	C	f	x	f
Erythrina abyssinica		f	x	x	f	f	f
Erythrina burttii			x		f		
Euclea divinorum	characteristic (indicator for evergreen bushland)	f	x	f	f	f	f
Euclea racemosa	characteristic (indicator for evergreen bushland)	f	f	xb	f	f	f

Species	Regional status	(Ethiopia)	(Kenya)	(Rwanda)	(Tanzania)	WecU (Uganda subtype)	WesU (Uganda subtype)
Euphorbia abyssinica		f	x		f	f	f
Euphorbia candelabrum	indicator	C	x	C	f	x	f
Euphorbia tirucalli		f	x	f	f	f	f
Faidherbia albida		C	x		f	f	f
Faurea rochetiana		f	f	xb	f	f	f
Faurea saligna			x	f	f	f	f
Ficus glumosa		f	x	xz	f	f	f
Ficus natalensis			x	f	f	f	f
Ficus ovata		f	x	f	f	f	f
Flacourtia indica		f	x	f	f	f	f
Flueggea virosa		f	x	f	f	f	f
Galiniera saxifraga		f	f	xe	f	f	f
Garcinia livingstonei		f	x		f	f	f
Gardenia ternifolia		f	x	x	f	x	f
Gardenia volkensii		f	x		f	f	f
Grewia bicolor	characteristic (indicator for evergreen bushland)	f	x		f	f	f
Grewia mollis		f	x	f	f	f	f
Grewia similis	characteristic (indicator for evergreen bushland)	f	x	f	f	f	f
Grewia tembensis	characteristic (listed both for evergreen bushland and deciduous bushland)	f	x				
Harrisonia abyssinica		f	x	f	f	f	f
Hypericum quartinianum		f	x		f	f	f
Hypericum roeperanum		f	x		f	f	f
Indigofera swaziensis			x		f	f	f
Jatropha curcas			x		f	f	f
Kigelia africana		f	f	x	f	f	f
Lannea fulva			f	xb	f	f	f
Lannea humilis	not characteristic (indicator for Somalia-Masai edaphic grassland)	f	f	x	f	f	x
Lannea rivae		f	x		f		
Lannea schimperi		f	x	x	f	f	x

Species	Regional status	(Ethiopia)	(Kenya)	(Rwanda)	(Tanzania)	WecU (Uganda subtype)	WesU (Uganda subtype)
Lannea schweinfurthii		f	x	x	f	f	f
Lippia kituiensis			x		f		
Manilkara mochisia			x		f		
Maytenus senegalensis		x	x	xb	f	x	f
Millettia dura			x	f	f	f	f
Ormocarpum trachycarpum		f	x		f	f	f
Ormocarpum trichocarpum		f	x	f	f	f	f
Osyris lanceolata		f	x	f	f	f	f
Ozoroa insignis		f	x	x	f	f	f
Pappea capensis		f	x	x	f	f	f
Parinari curatellifolia			x	C	f	f	f
Pavetta crassipes		f	x		f	f	f
Pavetta oliveriana		f	x	f	f	f	f
Pericopsis angolensis				x	f		
Phoenix reclinata	(palm species)	f	x	f	f	f	f
Phytolacca dodecandra		f	x	f	f	f	f
Piliostigma thonningii		f	f	x	f	f	f
Pistacia aethiopica		f	x		f	f	f
Pittosporum viridiflorum		f	x	f	f	f	f
Plectranthus barbatus		f	x		f	f	f
Pleurostylia africana			x	f	f	f	f
Psydrax schimperiana		f	x	f	f	f	f
Pterolobium stellatum	characteristic (indicator for evergreen bushland)	f	x	x	f	f	f
Rhamnus prinoides		f	x	f	f	f	f
Rhamnus staddo		f	x	f	f	f	f
Rhoicissus revoilii		f	x	f	f	f	f
Rhoicissus tridentata		f	x	f	f	f	f
Rhus natalensis	characteristic (indicator for evergreen bushland)	f	x	f	f	f	f
Rhus tenuinervis		f	x		f		
Rhus vulgaris		f	x	f	f	f	f
Rubus apetalus		f	x	f	f	f	f
Rubus volkensii		f	x		f	f	f

Species	Regional status	(Ethiopia)	(Kenya)	(Rwanda)	(Tanzania)	WecU (Uganda subtype)	WesU (Uganda subtype)
Schrebera alata	characteristic (indicator for evergreen bushland, transition to forest)	f	f	xbe	f	f	f
Scutia myrtina	characteristic (indicator for evergreen bushland)	f	x	f	f	f	f
Securidaca longipedunculata		f	f	x	f	f	f
Senna didymobotrya		f	x	x	f	f	f
Senna septemtrionalis			x	f	f	f	f
Senna singueana		f	f	x	f	f	f
Strychnos henningsii		f	x		f	f	f
Strychnos innocua		f	f	xb	f	f	f
Strychnos spinosa		f	f	xbe	f	f	f
Syzygium guineense		f	x	f	f	f	f
Tarenna graveolens	characteristic (indicator for evergreen bushland)	f	x	xb	f	f	f
Terminalia brownii		x	x		f	f	f
Terminalia mollis			f	x	f	f	f
Uvaria scheffleri			x		f	f	f
Vangueria apiculata		f	x	f	f	f	f
Vangueria infausta			x	x	f	f	f
Vangueria madagascariensis		f	x		f	f	f
Vepris nobilis		f	x	f	f	f	f
Vernonia auriculifera		f	x	f	f	f	f
Vitex doniana		f	f	xbz	f	f	f
Warburgia ugandensis		f	x		f	f	f
Ximenia americana		f	x	x	f	f	f
Xymalos monospora			x	f	f	f	f
Zanthoxylum chalybeum		f	f	xb	f	f	f
Zanthoxylum usambarense		f	x	f	f		
Ziziphus abyssinica		f	x	f	f	f	x
Ziziphus mauritiana		f	x		f	f	f
Ziziphus mucronata		f	x	x	f	f	f
Ziziphus pubescens		f	x		f	f	f

7. Kalahari woodland (Wk)

7.1. Description

Kalahari woodland occurs in the Kalahari Sands of the upper Zambezi basin. Dry forest was the original climax vegetation type in the most favourable soils,[17] with evergreen *Cryptosepalum exfoliatum* ssp. *pseudotaxus* forest (mapped in VECEA as Zambezian dry evergreen forest [Fm]) in the north and deciduous *Baikiaea plurijuga* forest (mapped in VECEA as Zambezian dry deciduous forest and scrub forest [Fn]) in the south. Kalahari woodland is either secondary (due to fire and cultivation) to these original dry forests or is part of a catenary sequence from forests on ridges to seasonally waterlogged depressions. It is not easy to distinguish between these two types of Kalahari woodland (White 1983 p. 97).

Trees that are widespread in Kalahari woodland (White 1983 p. 97) include ***Acacia erioloba*** (characteristic of southern Kalahari woodland, ***Albizia antunesiana***, ***Amblygonocarpus andongensis***, ***Baikiaea plurijuga*** (dominant species of the original forest, characteristic of southern Kalahari woodland), ***Bobgunnia madagascariensis*** (synonym: *Swartzia madagascariensis*), ***Brachystegia longifolia***, characteristic of northern Kalahari woodland), ***Brachystegia puberula*** (also a miombo dominant [Wm], characteristic of northern Kalahari woodland), ***Brachystegia spiciformis***, ***Brachystegia wangermeeana***, characteristic of northern Kalahari woodland), ***Burkea africana***, ***Combretum psidioides, Combretum zeyheri***, ***Cryptosepalum exfoliatum* ssp. *pseudotaxus*** **(**dominant species of the original forest, characteristic of northern Kalahari woodland), ***Dialium englerianum, Diplorhynchus condylocarpon***, ***Erythrophleum africanum***, ***Julbernardia paniculata*** (characteristic of northern Kalahari woodland), ***Ochna pulchra , Parinari curatellifolia***, ***Pseudolachnostylis maprouneifolia***, ***Schinziophyton rautanenii*** (characteristic of southern Kalahari woodland), ***Strychnos pungens*** and ***Terminalia sericea***. Many of these species are generally widespread in the Zambezian region (J. Timberlake, personal communication). As a consequence, these species are not unique (i.e. not indicators) for Kalahari woodland.

Kalahari scrub woodland occurs in between Kalahari woodland and Kalahari suffrutex grassland (see edaphic grasslands [g]). It is characterized especially by *Diplorhynchus condylocarpon* and other characteristic species include *Brachystegia brachystemma*, *Burkea africana*, *Hymenocardia acida* and *Parinari curatellifolia* (White 1983 p. 99).

17: It is not certain whether forest was the climax vegetation type in all areas with favourable soils. It is possible, for example, that *Cryptosepalum* forest is only the climax vegetation type on higher landscape positions (J. Timberlake, personal communication).

7.2. VECEA region

Within the VECEA region, Kalahari woodland only occurs in Zambia (Figure 7.1, see also Volume 6).

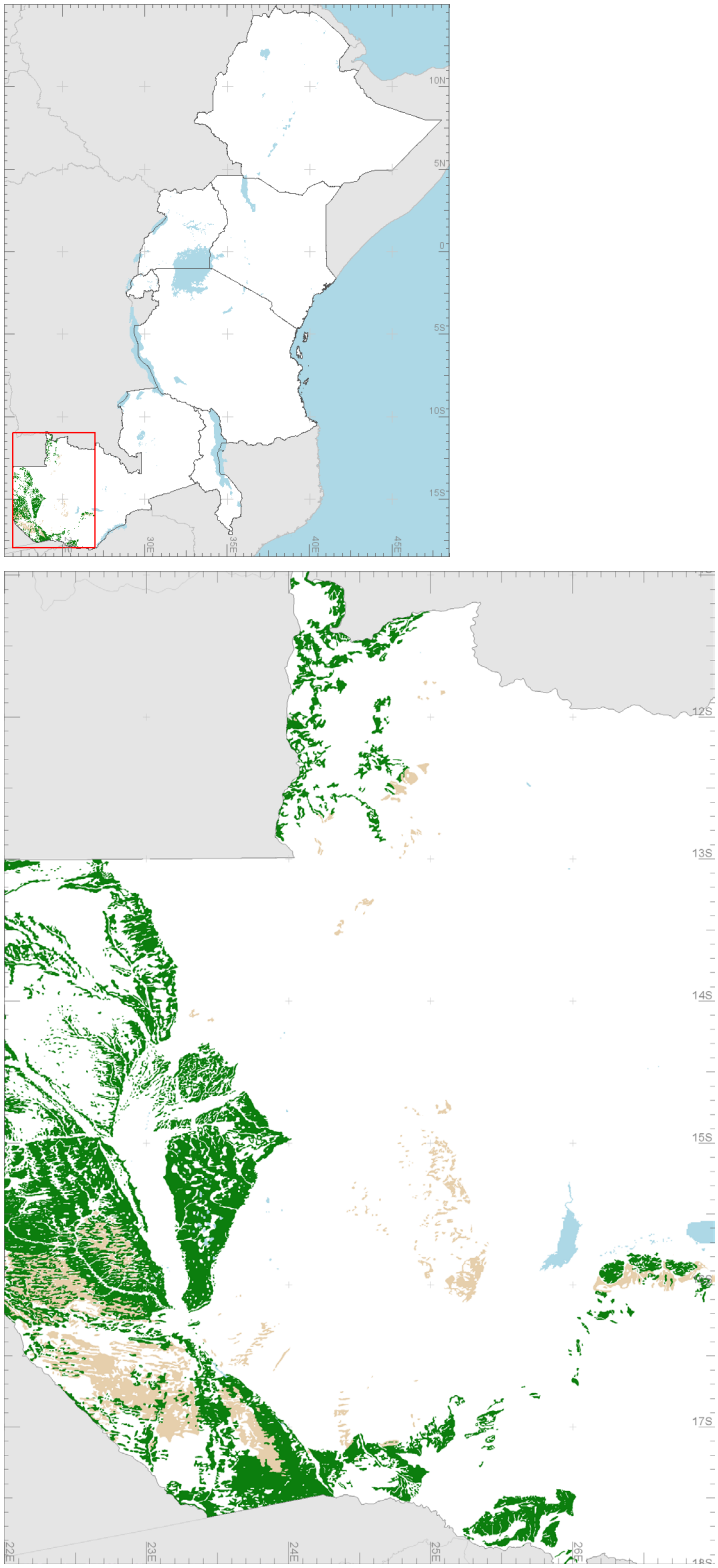


Figure 7.1. Mapped distribution of Kalahari woodland in the VECEA region (Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda and Zambia). Where this vegetation type does not occur in mosaic, it is depicted by green polygons. This vegetation type is also mapped in mosaic with edaphic grassland (Wk/g; shown in greyish-brown).

Fanshawe (1971 pp. 44 – 45 [*i.e.* within the description of Kalahari woodland]) describes five stages of a catenary regression from *Baikiaea* forest (Fn, see Volume 2) to grassland:

- *Guibourtia coleosperma* woodland [16] at the top of the catena is a two-storeyed woodland with an open or lightly closed overwood of 18 to 24 m high. Characteristic species include ***Amblygonocarpus andongensis, Baikiaea plurijuga*** (locally relic), ***Brachystegia longifolia*** (dominant in miombo woodland, invasive), ***Brachystegia spiciformis*** (dominant in miombo woodland, invasive), ***Burkea africana***, *Combretum collinum*, ***Cryptosepalum exfoliatum* ssp. *pseudotaxus, Dialium englerianum, Erythrophleum africanum***, *Guibourtia coleosperma*, ***Julbernardia paniculata*** (dominant in miombo woodland, invasive), ***Parinari curatellifolia, Schinziophyton rautanenii*** (locally) and *Terminalia* ***sericea***.
- Burkea - Erythrophleum woodland represents the next stage. The canopy is more open and the underwood is never stratified. Species such as ***Baikiaea plurijuga, Parinari curatellifolia and Schinziophyton rautanenii*** are now rare or absent. The really fire-hardy species like ***Burkea africana*** and ***Erythrophleum africanum*** are now dominant. *Guibourtia coleosperma* is still present but obviously dying out.
- At the next stage of *Burkea - Diplorhynchus* scrub there is no longer a canopy (even a very open one). ***Erythrophleum africanum*** is still present, though not dominant as it is not as fire-hardy like ***Burkea africana***. Suffrutices (see edaphic grasslands [g], see Volume 5) are common on the fringes.
- The stage of *Diplorhynchus* scrub consists of 2 m high scattered and fire-damaged ***Diplorhynchus condylocarpon*** and *Hymenocardia acida* (see edaphic grasslands [g]) over a dense carpet of suffrutices 30 cm high.
- The stage of *Parinari capensis* suffrutex (wooded grassland) consists of the suffrutex carpet of the previous stage without any emergent species. **This vegetation type was described by White (1983) and within VECEA as an edaphic grassland type (g).**
- Grassland without suffrutices is a fire-induced biotic grassland that resulted from the *Parinari capensis* suffrutex wooded grassland.

Fanshawe (1971 p. 46) describes isolated blocks of Kalahari woodland (such as in Senanga district) that have resulted from differential erosion along the margin of Kalahari woodland and grassland. Fanshawe brings up that these areas could be termed "bush groups" especially since riparian or dambo margin species are occasionally found on their margins as a result from fluctuations in the water table. These areas were mapped as mosaics of Kalahari woodland and edaphic grassland (Wk/g) in the VECEA map (see Volume 6).

Investigation of environmental distribution of Kalahari woodland in the VECEA region (Figure 7.1; limits are for areas of the VECEA map where this vegetation type is not mapped as mosaic) shows that nearly all samples occur in an interval from 750 – 1250 m. The altitude interval where most of samples occur is the same for this vegetation type (1000 – 1250 m; 84.8%

of samples) as for all woodlands and wooded grasslands combined (40.9%). Kalahari woodland receives between 600 and 1200 mm annual rainfall (> 90% of samples). The rainfall interval where most of samples occur is the same for this vegetation type (800 – 1000 mm; 39.4% of samples) as for all woodlands and wooded grasslands combined (34.4%).

.....

16: The coding of the Trapnell *et al.* (1950) soil - vegetation map is based on the soil type with a suffix for the vegetation type. In the legend of the Fanshawe vegetation map (Edmonds 1976), an indication is given that "Kalahari woodlands on sands" correspond to K2 (Northern *Brachystegia* woodlands on Kalahari bracken sands; these consist of ***Brachystegia longifolia, Brachystegia spiciformis*** and associated **Cryptosepalum** and ***Guibourtia coleosperma*** [synonym: *Copaifera coleosperma*]), K3 (Central ***Julbernardia paniculata - Brachystegia*** woodlands on Kalahari Sand; *Brachystegia* species are ***Brachystegia longifolia*** and ***Brachystegia spiciformis***; associated species are **Cryptosepalum** and ***Guibourtia coleosperma***, K4 (Southern *Julbernardia globiflora - Brachystegia* woodlands on Kalahari Sands; *Brachystegia* species are *Brachystegia boehmii* and ***Brachystegia spiciformis***), K5 (***Brachystegia spiciformis*** woodlands on Kalahari Sands; *Julbernardia globiflora* is sometimes present and ***Guibourtia coleosperma*** and locally *Brachystegia bakeriana* are associated species), K7 (***Burkea africana - Guibourtia coleosperma - Baikiaea plurijuga*** deciduous woodlands and forests), K9 (***Dialium englerianum*** woodlands on Kalahari Sand where ***Dialium englerianum*** is dominant and ***Burkea africana*** and other "sand species" are associated) and SK5 (*Diplorhynchus* and other scrub-grasslands on Kalahari Sand plains). We suspect that K8 (***Burkea africana*** woodlands on Kalahari Sand; other species include ***Erythrophleum africanum*** and *Pterocarpus angolensis*; there is a *Burkea - Erythrophleum* subtype where *Combretum* spp. become associated) should also have been included in the corresponding types listed in the legend.

7.3. Species composition

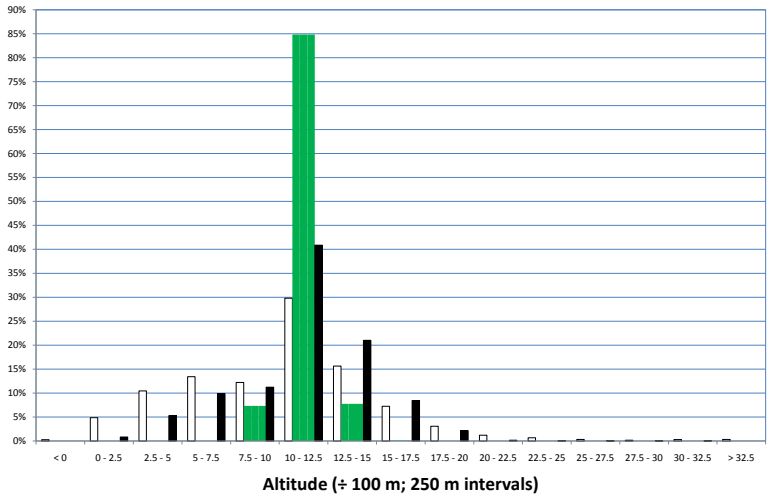
Species composition was obtained from the following references:

- Zambia: Fanshawe (1971). Species listed for the species composition table for "Kalahari woodland" provided on pages 46 to 47 were coded "x" (unless they were characteristic species).

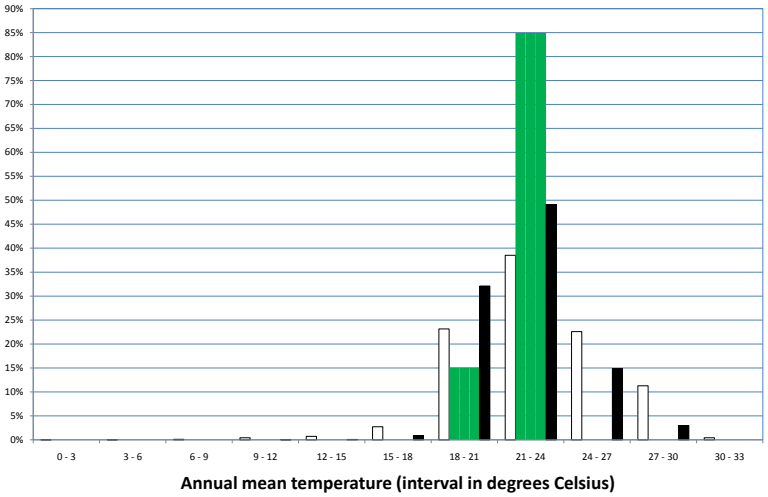
Characteristic species were determined as:

- Zambia: Canopy species were coded "C".

(a)



(b)



(c)

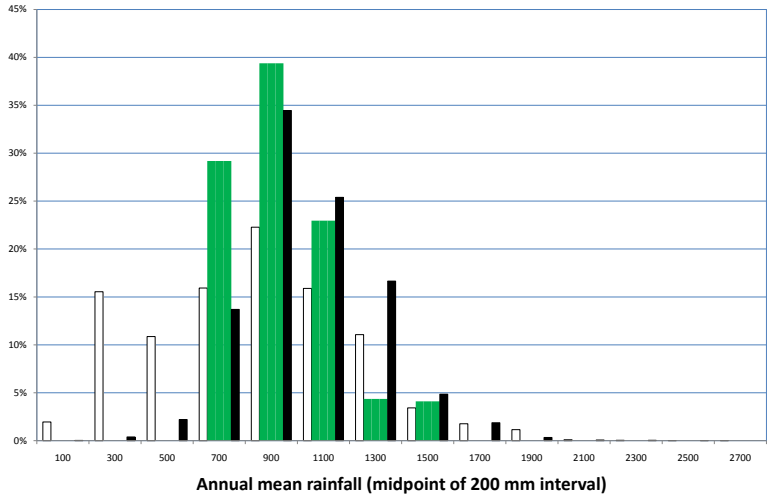


Figure 7.2. Histograms of the distribution of altitude (a), mean annual temperature (b) and mean annual rainfall (c). Bars at the centre of each interval show the percentage of samples within Kalahari woodland (Wk, *n* = 9,030). Bars on left (open) show the overall percentage of samples (*n* = 740,047). Bars on the right (black) show the percentages of samples within woodland or wooded grassland (*n* = 354,078).

Table 7. Species composition of Kalahari woodland (Wk)

Species	**Regional status (see section 2.3)**	**(Zambia)**
Acacia erioloba	characteristic for Kalahari Sands	C
Albizia antunesiana	characteristic	x
Allophylus africanus		x
Amblygonocarpus andongensis	characteristic	C
Baikiaea plurijuga	indicator (forest remnant of southern Kalahari Sands)	C
Baphia massaiensis		x
Bauhinia petersiana		x
Bobgunnia madagascariensis	characteristic	x
Brachystegia bakeriana		x
Brachystegia floribunda		C
Brachystegia longifolia	characteristic for northern Kalahari Sands	C
Brachystegia spiciformis	characteristic	C
Burkea africana	characteristic (also occurs in Kalahari scrub woodland)	C
Combretum collinum	not characteristic (characteristic for undifferentiated woodland and Chipya woodland)	C
Combretum psidioides	indicator	x
Combretum zeyheri	characteristic	x
Cryptosepalum exfoliatum	indicator (forest remnant of northern Kalahari Sands [*Cryptosepalum exfoliatum* ssp. *pseudotaxus*])	C
Dialium englerianum	indicator	C
Dichrostachys cinerea		x
Diplorhynchus condylocarpon	characteristic (also main species in Kalahari scrub woodland)	x
Erythrophleum africanum	characteristic	C
Guibourtia coleosperma		C
Hymenocardia acida	characteristic for Kalahari scrub woodland	x
Isoberlinia angolensis		C
Julbernardia globiflora		C
Julbernardia paniculata	characteristic for northern Kalahari Sands	C
Markhamia obtusifolia	not characteristic (indicator for undifferentiated woodland)	x
Myrsine africana		x
Ochna pulchra	indicator	x
Parinari capensis	characteristic for Kalahari suffrutex grassland	x
Parinari curatellifolia	characteristic (also characteristic for Kalahaari scrub woodland)	C
Pseudolachnostylis maprouneifolia	characteristic	x
Rhus tenuinervis		x
Schinziophyton rautanenii	indicator (characteristic for southern Kalahari Sands)	C
Smilax anceps		x
Strychnos cocculoides		x
Strychnos pungens	indicator	x
Syzygium guineense	not characteristic (indicator for Chipya woodland [*Syzygium guineense* ssp. *guineense*])	C
Terminalia sericea	characteristic	C
Uapaca kirkiana		x
Uapaca nitida		x
Vitex madiensis		x
Vitex mombassae		x
Ximenia americana		x

8. Miombo woodland (Wm)

8.1. Description

Miombo woodland is floristically and physiognomically very different from other types of woodland. It is nearly always dominated by species of ***Brachystegia*** (we encountered 15 species when compiling national species compositions, see below) either alone or with ***Isoberlinia angolensis, Julbernardia globiflora*** or ***Julbernardia paniculata***. The name "muyombo" (plural: "miyombo") is a Kinyamwezi name that refers to the tree *Brachystegia boehmii* (Lind and Morrison p. 81; one of our co-authors is a botanist and a Mnyamwezi who confirms the local name of this species). Because the dominant species are extremely gregarious, few other species enter the canopy (except in the more stunted variants). The appearance of miombo is distinctive because of the shape of the dominant trees with boles that are mostly short and relatively slender, with branches that are at first markedly ascending before spreading out to support a light, shallow and flat-topped crown and with leaves that are pinnate. Miombo woodland is mostly 10 to 20 m high, but scrub woodland can as short as 3 m. Most miombo woodlands are semi-deciduous, but some are completely deciduous and some are almost evergreen (White 1983 pp. 92 - 93). There is a marked flush of new leaves (of flaming reds, salmons, pinks and coppery tinges of all hues) just before the rains, a time during which miombo woodlands become especially beautiful (Burtt *et al.* 1942; Lind and Morrison 1974 p. 83).

Miombo woodland is the prevalent vegetation throughout the greater part of the Zambezian region, especially on the main plateau and its flanking escarpments where the soils are freely drained but the rooting environment is restricted. Miombo soils ofte have a restricted rootingenvironment [18] since they are shallow and stony, or since a laterite or gley horizon[19] occurs near the surface. On moister and deeper soils in higher rainfall areas, miombo has probably replaced Zambezian dry evergreen forest (Fm)[20] or Zambezian transition woodland (an ecotone in between Zambezian dry evergreen forest, see description of Zambezian dry evergreen forest) after cultivation and fire. Areas on certain deep soils where ***Brachystegia longifolia, B. spiciformis*** and ***B. utilis*** reach a height of 30 m are probably areas where miombo has replaced Zambezian dry evergreen forest[21] or Zambezian transition woodland (White 1983 p. 92).

Most of the dominant species of miombo woodland are widely distributed, have wide ecological amplitudes and combine in kaleidoscopic patterns. It is therefore difficult further subclassify miombo woodland based on distribution of the dominant species (but see below). However, it is possible to make a distinction between wetter miombo and drier miombo based on **associated vegetation types** (White 1983 p. 93):

- Wetter miombo woodland is associated with Zambezian dry evergreen forest and thicket (Fm), Zambezian swamp forest (fs), Zambezian evergreen riparian forest (fr) and wet dambos. Annual

18: This statement is very often not true as as soils under Miombo woodland can be very deep (even up to 8 m; J. Timberlake, personal communication).

19: The statements regarding stony or laterite/gley horizons may be true in plateau regions where miombo is relatively stunted and patchy. It is not the case on escarpment soils which are deep and stone free (P. Smith, pers. comm.). Whereas miombo of the Rift Valley escarpments and steeper hills slopes in Malawi are often on lithosols, this is not always the case. Deeper soils in Kasungu District (Malawi) are covered by typical miombo woodland (C. Dudley, pers. comm.).

20: The interpretation that areas within the Zambezian floristic region that have deeper soils would only have Zambezian dry evergreen forest as the climax vegetation type - and not Miombo woodland - is not generally accepted. It is known that Miombo woodland occurs in areas with deeper soils, and it is not certain that all these areas with deeper soils previously supported Zambezian dry evergreen forest (P. Smith and J. Timberlake, pers. comm.; see also comments for Zambezian dry evergreen forest in Volume 2).

21: Neither Trapnell thought nor I think that miombo has replaced dry evergreen forest. We think (thought) instead that Chipya woodland (Cy in the VECEA map) is part of that succession (P. Smith, personal communication).

rainfall is usually more than 1000 mm, but less on Kalahari Sand. Nearly all the dominant species of miombo woodland are included and ***Brachystegia floribunda, B. glaberrima, B. taxifolia, B. wangermeeana*** and *Marquesia macroura* (a principal canopy associate) are widespread.

- Drier miombo woodland is associated with Zambezian dry deciduous forest and thicket (Fn), Zambezian deciduous riparian forest (see fr) and dry dambos. Annual rainfall is less than 1000 mm. ***Brachystegia boehmii, B. spiciformis and Julbernardia globiflora*** are often the only dominants that are present, whereas *Brachystegia floribunda* is absent or very local.

Scrub miombo woodland occurs at high altitudes, on certain shallow soils and in ecotones between miombo woodland and dambo grassland. Towards the altitudinal limits of miombo (between 1600 and 2100 m), scrub miombo woodland occurs that is no more than 6 m tall and is usually dominated by ***Brachystegia spiciformis*** and more rarely by ***Brachystegia floribunda, B. microphylla, B. taxifolia*** or ***Uapaca kirkiana*** (a species that occurs scattered in miombo woodland as small trees). Scrub miombo woodland on shallow soils occurs on soils overlying laterite (3 m tall scrub woodland of ***Brachystegia boehmii***) and soils derived from siltstone (3 to 5 m tall scrub woodland of ***Brachystegia stipulata*** and ***Julbernardia globiflora***). Most of the dominant species of miombo woodland are usually absent from scrub miombo woodland (usually 4 to 7 m tall) at the edges of dambos, except for ***Brachystegia boehmii*** (White 1983 p. 99).

Zanzibar-Inhambane transition woodland (communities that are intermediate between forest and woodland where Zanzibar-Inhambane forest species occur together with heliophilous ['sun-loving'] Zambezian woodland species) is dominated by ***Brachystegia spiciformis***. Some of these communities are stable, whereas others are clearly seral as forest encroachment can be observed (as some patches in the Shimba Hills where saplings of the forest species *Paramacrolobium coeruleum* [characteristic for moister variants of Zanzibar-Inhambane undifferentiated forest, Fp] form an almost pure understorey). ***Brachystegia spiciformis*** forms almost pure stands on white sterile sands where complete succession to forest is unlikely, as in the Arabuko-Sokoke forest (Fp; White 1983 p. 188).

The dominant species that were encountered when compiling the species composition for miombo include ***Brachystegia allenii, Brachystegia boehmii, Brachystegia bussei, Brachystegia floribunda, Brachystegia glaberrima, Brachystegia glaucescens***[22]***, Brachystegia longifolia, Brachystegia manga, Brachystegia microphylla, Brachystegia puberula, Brachystegia spiciformis, Brachystegia stipulata, Brachystegia taxifolia, Brachystegia utilis, Brachystegia wangermeeana, Isoberlinia angolensis, Julbernardia globiflora*** and ***Julbernardia paniculata.***

Among other ***Brachystegia*** species listed by White (1983 pp. 92 -93), ***Brachystegia bakeriana*** and ***Brachystegia russelliae*** occur in Zambia (based on information from the African Flowering Plants Database), but

22: *Brachystegia glaucescens* is now - incorrectly - treated as a synonym of *Brachystegia microphylla*. However, these species are morphologically and ecologically different (P. Smith and J. Timberlake, personal communication)

these are among a limited number of *Brachystegia* species that occur on Kalahari Sand (the most widespread species is ***Brachystegia spiciformis***). ***Brachystegia russelliae*** is a geoxylic suffrutex (see descriptions of Kalahari woodlands [Wk]), whereas ***Brachystegia bakeriana*** is sometimes only 1.3 m high due to frost or unfavourable soil conditions(White 1983 pp. 92 and 98). ***Brachystegia angustistipulata*** and ***Brachystegia torrei*** are species that are confined to the eastern part of the Zambezian region (i.e. east of the Kalahari Sand) according to White; we have some evidence from the African Flowering Plants Database that ***Brachystegia angustistipulata*** occurs in Tanzania.

Figure 8.1 Wetter miombo woodland in Zambia (M. Bingham).

Figure 8.2 Wetter miombo woodland in Zambia. Annual grass fires are typical in miombo woodland. Usually not all grass burns each year. (M. Bingham)

Figure 8.3 Miombo woodland (probably near the foothill of Mt. Mulanje as this photograph was obtained from the Mulanje Mountain Conservation Trust; C. Dudley)

Figure 8.4 Some of the typical birds of miombo woodland in their natural habitat. Shell guide to East African birds (1960, reproduced with permission from URL *http://ufdc.ufl.edu/UF00077050).*

Figure 8.5. *Brachystegia microphylla* upland woodland. *Brachystegia microphylla* is a miombo species that is virtually confined to rocky hills and escarpments (White 1983 p. 93). Gillman (1949, Fig 13). Image obtained from URL: *http://www.jstor.org/stable/211155*

Figure 8.6. Miombo woodland near Morogoro (Tanzania). Photograph by Frank Mbago.

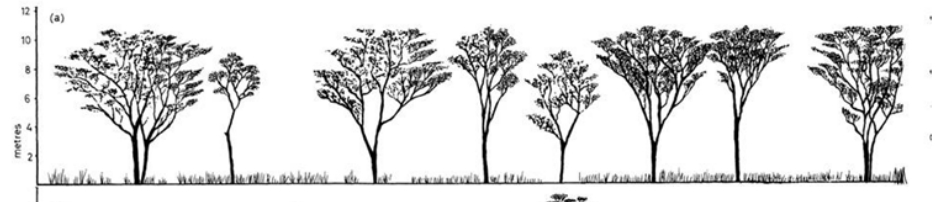


Figure 8.7. Profile diagram of Miombo woodland. Pratt et al. (1966, Fig 3a). Image obtained from URL: *http://www.jstor.org/stable/2401259*

8.2. VECEA region

Within the VECEA region, miombo woodland occurs in Malawi, Tanzania and Zambia. It is possible to discriminate between the subtypes of drier miombo woodland (Wmd, see Figure 8.8 and Volume 6), wetter miombo woodland (Wmw; see Figure 8.9 and Volume 6) and miombo woodland on hills and rocky outcrops (Wmr; see Figure 8.10 and Volume 6). This vegetation type also occurs in the coastal areas of Kenya and Tanzania, but was not mapped separately in the Zanzibar-Inhambane coastal mosaic mapping unit of the VECEA map.

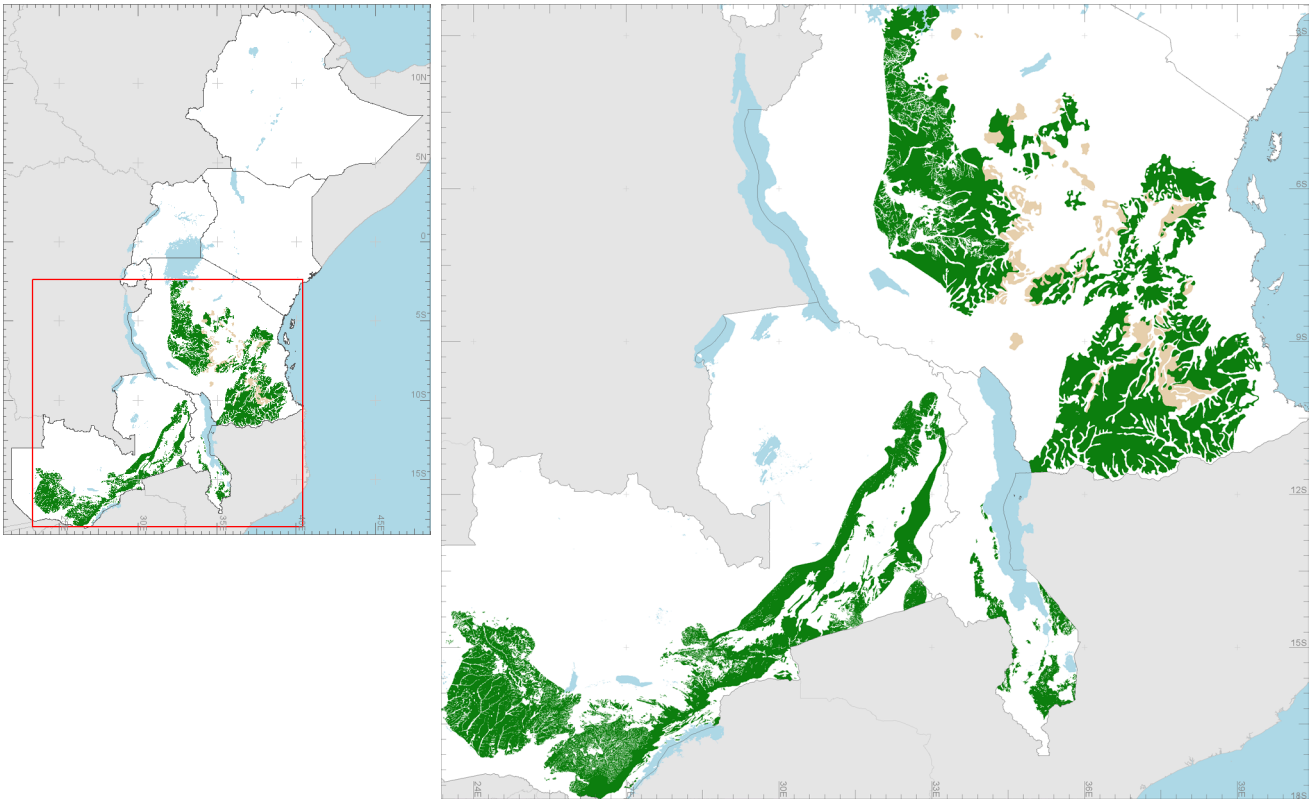


Figure 8.8. Mapped distribution of drier miombo woodland in the VECEA region (Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda and Zambia). Where this vegetation subtype does not occur in mosaic, it is depicted by green polygons. In Tanzania, it is also mapped as part of different vegetation mosaics (shown in greyish-brown).

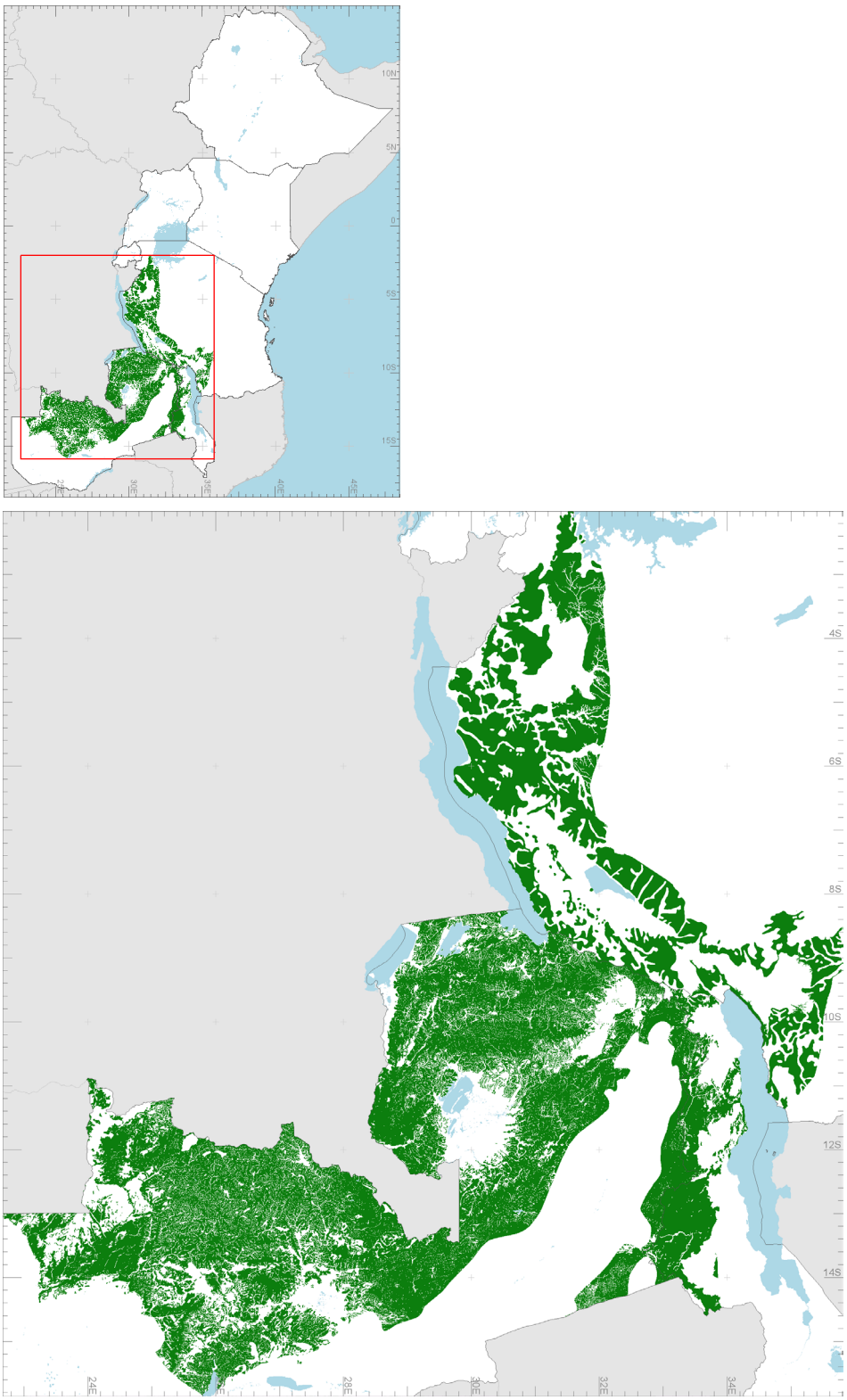


Figure 8.9. Mapped distribution of wetter Miombo woodland in the VECEA region (Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda and Zambia). Green polygons depict where we mapped this vegetation subtype.

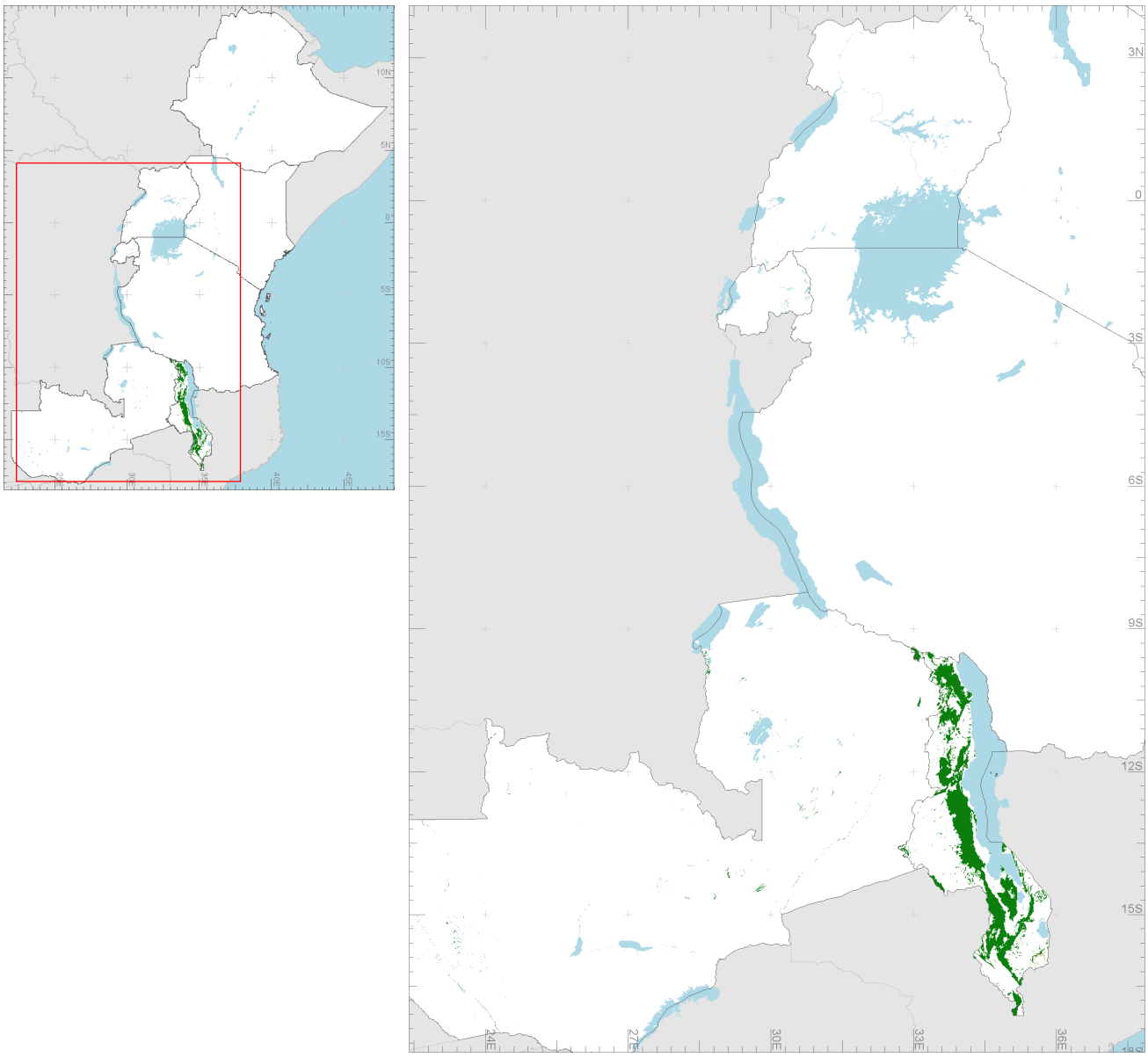


Figure 8.10. Distribution of miombo woodland on rocks and woody outcrops in the VECEA region (Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda and Zambia). Green polygons show where we mapped this vegetation subtype. We expect that this vegetation subtype also exists in Tanzania. The distribution of this vegetation subtype was exaggerated in Malawi because it corresponded with the original subtype of "*Brachystegia* escarpment, hill and foothill woodland" and therefore probably included some areas of drier or wetter miombo. Soils are often stony in this original vegetation type, however (C. Dudley, personal communication).

In Malawi, earlier researchers have discriminated between three types of miombo woodland: (i) *Brachystegia – Julbernardia* plateau woodland; (ii) *Brachystegia – Isoberlinia* plateau woodland; and (iii) *Brachystegia* escarpment, hill and foothill woodland. However, we could not find substantive information on the differentiation between the two plateau subtypes of *Brachystegia-Isoberlinia* and *Brachystegia-Julbernardia*, especially since the reference for the *Brachystegia-Isoberlinia* subtype (Young and Brown 1962) was very limited. The third type of *Brachystegia* escarpment, hill and foothill woodland is even more problematic as the canopy is composed of a variable mixture of *Brachystegia* species and a large proportion of species species from Undifferentiated woodland (Wn) or riparian forests (fr, see volume 2). Although the majority of Malawi was originally covered by some form of miombo woodland and this vegetation type has been collected thoroughly, little quantitative vegetation analysis has been done. It is therefore possible that the classification of miombo woodland needs to be altered in the future (C. Dudley pers. comm.).

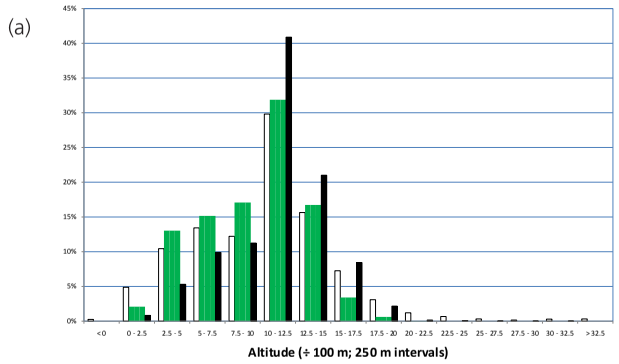
In Tanzania, the original map (described by Gillman 1949) did not distinguish miombo woodland from other types of woodland as this was a physiognomic map. Although Gillman (1949) did not allocate a specific mapping unit to miombo woodland, he gave some information that allows identifying the areas where this vegetation occurs. The description that he gives on page 32 can be summarized as: "The vast extent of the *Brachystegia* - other species woodland (locally referred to as miombo) almost immediately catches the eye. In two major units, one in the northwest with a substantial outlier in Central Province and one in the southeast, this vegetation type covers 460,000 square kilometres after excluding enclosed miombo-free areas - or almost half of the country. Comparison with geological and soil maps finds that miombo woodland is present on nearly every soil type, with the exception of (i) heavy and badly drained soils; (ii) too well or too rapidly draining Pliocene duricrusts (coincident with Itigi thickets [VECEA mapping unit bi, see Volume 4]); or (iii) the terra rossas of the karstic Pleistocene coral limestones of the coast (see VECEA mapping unit fc and Volume 2).

In Zambia, miombo woodland was originally mapped separately as miombo woodland on plateau, escarpment and valley soils (original mapping unit 11) and as miombo woodland on hills and rocky outcrops (mapping unit 12). Fanshawe (1971 pp. 44 - 45) describes that plateau miombo woodland grades imperceptibly into hill miombo woodland of inselbergs, rock outcrops and rock pavements. ***Brachystegia microphylla*** is dominant on inselbergs in the north of Zambia, whereas ***Brachystegia glaucescens*** is dominant on inselbergs in the south. Shallow pockets of soil over rock pavements are dominated by ***Brachystegia taxifolia*** or ***Cryptosepalum exfoliatum* ssp. *pseudotaxus*** (the dominant species of Cryptosepalum Zambezian dry evergreen forest [Fm]). Inselbergs and rock outcrops contain evergreen thickets that are relics from the evergreen forests that occupied plateaus and hills during pluvial phases (a similar pattern can be observed in termite mound vegetation [T]).

Zanzibar-Inhambane transition woodland dominated by ***Brachystegia spiciformis*** occurs in the coastal areas of Kenya and Tanzania (see section

8.1). We did not map these areas separately within the Zanzibar-Inhambane regional mosaic (see Volume 6).

Investigation of environmental distribution of miombo woodland in the VECEA region (Figures 8.11, 8.12 and 8.13; limits are for areas of the VECEA map where this vegetation type is not mapped as mosaic) shows that there is a considerable overlap in the altitude distribution of drier and wetter miombo woodland. Drier miombo woodland generally occurs between 250 and 1500 m (> 90% of samples), whereas wetter miombo woodland generally occurs between 750 m (> 95% of samples). Both these vegetation types have most of their samples in the 1000 – 1250 m interval; this is also the interval where most samples occur for all woodlands and wooded grasslands combined. There is less overlap in the annual rainfall that these two vegetation types receive, although both vegetation types have between 94% - 96% of their samples in the range of 600 to 1400 mm. In drier miombo woodland, 66.7% of samples receive less than 1000 mm annual rainfall. In wetter miombo woodland, 68.8% of samples receive more than 1000 mm annual rainfall.



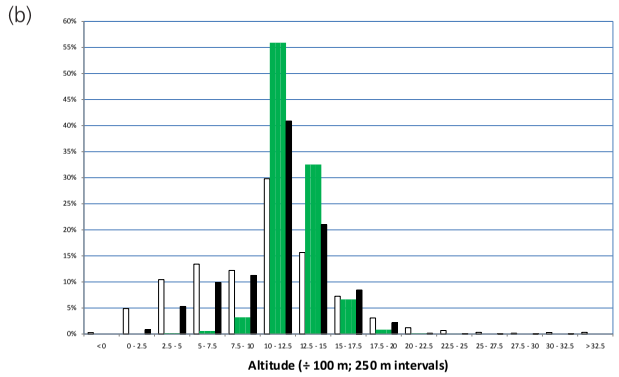
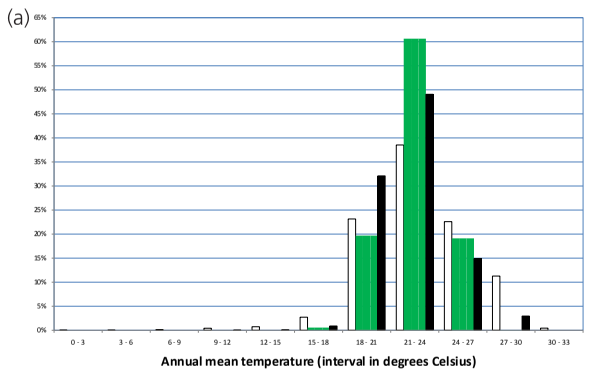


Figure 8.11. Histograms of the distribution of altitude within drier miombo woodland (a, *n* = 68,524) and wetter miombo woodland (b, *n* = 116,907). Bars at the centre of each interval show the percentage of samples within drier or wetter miombo woodland. Bars on left (open) show the overall percentage of samples (*n* = 740,047). Bars on the right (black) show the percentages of samples within woodland or wooded grassland (*n* = 354,078).



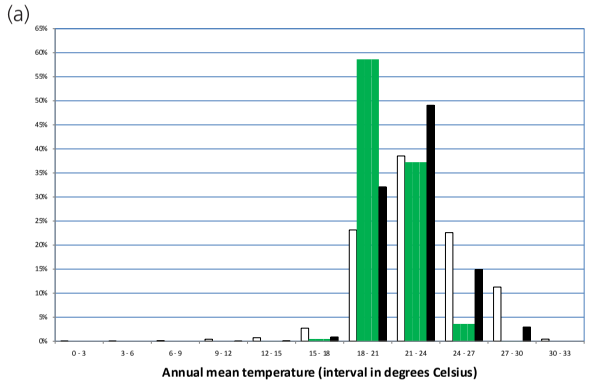
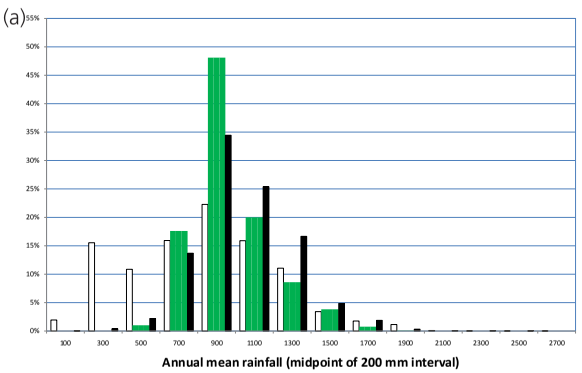


Figure 8.12. Histograms of the distribution of mean annual temperature within drier miombo woodland (a, *n* = 75,101) and wetter miombo woodland (b, *n* = 110,319). Bars at the centre of each interval show the percentage of samples within drier or wetter miombo woodland. Bars on left (open) show the overall percentage of samples (*n* = 740,047). Bars on the right (black) show the percentages of samples within woodland or wooded grassland (*n* = 354,078).



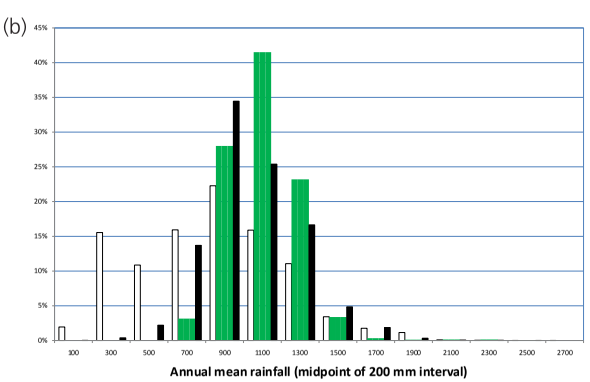


Figure 8.13. Histograms of the distribution of mean annual rainfall within drier miombo woodland (a, *n* = 75,101) and wetter miombo woodland (b, *n* = 110,319). Bars at the centre of each interval show the percentage of samples within drier or wetter miombo woodland. Bars on left (open) show the overall percentage of samples (*n* = 740,047). Bars on the right (black) show the percentages of samples within woodland or wooded grassland (*n* = 354,078).

8.3. Species composition

Species composition was obtained from the following references:

- Malawi: Dowsett-Lemaire & Dowsett (2002), Jackson (1972), Robertson (1984), Young and Brown (1962) and unpublished data from Liwonde National Park by our Malawian co-author. Species expected to occur in the subtype of "*Brachystegia - Julbenardia* plateau woodland" were coded "xj" (unless they were characteristic species; mainly Robertson [1984] was consulted for this subtype). Species expected to occur in the subtype of " *Brachystegia* escarpment, hill and foothill woodland" were coded "xe" (unless they were characteristic species). The reference for the third subtype of "*Brachystegia-Isoberlinia* plateau woodland" (Young and Brown 1962) was very limited.
- Tanzania: We only relied on floristic information to infer the species composition of miombo woodlands in Tanzania.
- Zambia: Fanshawe (1971). Species listed for the species composition table for "miombo woodland" provided on pages 43 to 44 were coded "x". In a separate column ("WmrZ"), species listed in the main text for hills and rocky outcrops were coded "C".
- Miombo scrub woodland: White (1983 p. 99). Species listed to occur in scrub woodland near the altitudinal edges of miombo woodland, on shallow soils overlying laterite or derived from siltstone or at the edges of dambos were coded "x".
- Coastal areas of Kenya and Tanzania: Burgess and Clarke (2000 Appendix 2 Table 8). Species listed for "eastern African coastal *Brachystegia* forest" were coded "x" (unless they were characteristic species).

Characteristic species were determined as:

- Malawi: Species identified to be present as large trees (20 - 30 m) were coded as "C", unless they were also identified as dominant species. Dominant species for *Brachystegia* escarpment, hill and foothill woodland were coded as "Db". Dominant species for *Brachystegia-Isoberlinia* plateau woodland were coded as "Di". Dominant species for *Brachystegia-Julbernardia* plateau woodland were coded as "Dj".
- Tanzania: Characteristic species were not determined.
- Zambia: Canopy species were coded "C".
- Coastal areas of Kenya and Tanzania: species listed as dominant species were coded "C".

Within the information on assemblages, coding "f" indicates that there is information that the species **potentially occurs** in the vegetation type since it occurs in the focal country and in the same woodland (or wooded grassland) type in other countries (see section 2.3).

Table 8. Species composition of miombo woodland (Wm)

Species	Regional status (see section 2.3)	(Malawi)	(Tanzania)	(Zambia)	WmrZ (Zambia subtype)	Wms(physiognomic subtype)	WmC (coast)
Brachystegia allenii	dominant (virtually confined to rocky hills and escarpments). [White 1983 p. 93]. This species is mostly associated with dambo margins in the north of Mozambique (J. Timberlake, pers. comm.). In Malawi, it is found on rocky hills and escarpments (C. Dudley, pers. comm.).	xj	f	C	f		
Brachystegia boehmii	dominant (both on escarpments, ridges and certain plateau soils; often one of the few dominants of drier miombo; scrub woodland on shallow soils or at edges of dambos)	xej	f	C		x	
Brachystegia bussei	dominant (virtually confined to rocky hills and escarpments)	Dej	f	C	f		
Brachystegia floribunda	dominant (more characteristic of deeper plateau soils; widespread in wetter miombo; absent or very local in drier miombo; sometimes in scrub woodland towards the altitudinal limits of miombo woodland)	xe	f	C		x	
Brachystegia glaberrima	dominant (more characteristic of deeper plateau soils; widespread in wetter miombo)		f	C			
Brachystegia glaucescens	dominant (virtually confined to rocky hills and escarpments). [Brachystegia glaucescens is now - incorrectly - treated as a synonym of Brachystegia microphylla. However, these species are morphologically and ecologically different; P. Smith and J. Timberlake, personal communication])	Ce		f	C		
Brachystegia longifolia	dominant (more characteristic of deeper plateau soils; also in northern Kalahari woodland)	xj	f	C			
Brachystegia manga	dominant (more characteristic of deeper plateau soils)	xe	f	C			
Brachystegia microphylla	dominant (virtually confined to rocky hills and escarpments; sometimes in scrub woodland towards altitudinal limits of miombo woodland)	De	f	f	C	x	C
Brachystegia puberula	dominant (not east of Kalahari sands; also in northern Kalahari woodland)		f	f			
Brachystegia spiciformis	dominant (more characteristic of deeper plateau soils; often one of the only dominants of drier miombo; also in Kalahari woodland; dominant in Zanzibar-Inhambane transition woodland; scrub woodland near the altitudinal limits of miombo woodland)	Dej	f	C		x	C
Brachystegia stipulata	dominant (also in scrub woodland on certain shallow soils derived from siltstone)	xj	f	x		x	
Brachystegia taxifolia	dominant (both on escarpments, ridges and certain plateau soils; widespread in wetter miombo; sometimes in scrub woodland towards altitudinal limits of miombo)		f	C	C	x	
Brachystegia utilis	dominant (both on escarpments, ridges and certain plateau soils)	xej	f	C			
Brachystegia wangermeeana	dominant (more characteristic of deeper plateau soils; widespread in wetter miombo; also in northern Kalahari woodland)		f	C			
Isoberlinia angolensis	dominant	Di	f	C			
Julbernardia globiflora	dominant (often one of the few dominants of drier miombo woodland; also in scrub woodland on certain shallow soils derived from siltstone)	Dj	f	C		x	
Julbernardia paniculata	dominant (also in northern Kalahari woodland)	Dj	f	C			
Acacia nigrescens	not characteristic (indicator for Mopane woodland and Undifferentiated woodland)	Ce	f	f			
Acacia polyacantha	not characteristic (indicator for Undifferentiated woodland)	xj	f	f			f

Species	Regional status (see section 2.3)	(Malawi)	(Tanzania)	(Zambia)	WmrZ (Zambia subtype)	Wms(physiognomic subtype)	WmC (coast)
Acacia sieberiana	not characteristic (indicator for Undifferentiated woodland)	xej	f	f			f
Afzelia quanzensis	characteristic (principal canopy associate). (White 1983 p. 95). This species occurs at a wide range of altitudes in the Zambezian region and is therefore not exclusive to miombo woodland (P. Smith, pers. comm.). This species is not a principal canopy associate of miombo woodland, but more occasional, especially closer to rocky outcrops (J. Timberlake, pers. comm.). This species is never numerous and can be found more often in Undifferentiated woodland and Zambezian dry deciduous forest (Fn; C. Dudley, pers. comm.).	xe	f	f			x
Albizia amara	not characteristic (indicator for Undifferentiated woodland)	xej	f	f			
Albizia antunesiana	not characteristic (characteristic for Chipya woodland and Kalahari woodland [White 1983 pp. 96 - 97]); a common species in miombo woodland (P. Smith; pers. comm.)	xj	f	x			
Albizia versicolor	not characteristic (indicator for Undifferentiated woodland)	xej	f	f			f
Allophylus africanus		xe	f	f			
Anisophyllea boehmii	not characteristic (indicator for Chipya woodland)		f	x			
Anisophyllea pomifera	indicator (principal canopy associate). [White 1983 p. 93]); this is not a canopy species (P. Smith, pers. comm.)	f	f	C			
Antidesma venosum	(this is not a miombo species, but a riverine species instead [P. Smith, pers. comm.])	xj	f	f			f
Bauhinia petersiana		xej	f	x			
Bobgunnia madagascariensis	not characteristic (characteristic for Chipya woodland, Kalahari woodland and scrub woodland at edges of dambos. [White 1983]). This species is frequently found in escarpment miombo woodland (P. Smith, pers. comm.).	xej	f	x		x	
Burkea africana	characteristic (principal canopy associate; also scrub woodland at edges of dambos)	Cej	f	f		x	
Cassia abbreviata	not characteristic (indicator for Undifferentiated woodland)	xej	f	f			f
Combretum adenogonium	not characteristic (indicator for Undifferentiated woodland)	xej	f	x			
Combretum collinum	not characteristic (characteristic for Undifferentiated woodland and Chipya woodland)	xej	f	x			f
Combretum molle	not characteristic (indicator for Undifferentiated woodland)	xej	f	f			f
Combretum zeyheri	(This is a ubiquitous species that is also frequently found in miombo woodland [P. Smith, pers. comm.])	xej	f	x			f
Crossopteryx febrifuga		xej	f	f			f
Croton sylvaticus							x
Cryptosepalum exfoliatum	not characteristic (indicator for northern Kalahari woodland [*Cryptosepalum exfoliatum* ssp. *pseudotaxus*])	f	f	x	C		
Cussonia arborea		xe	f	x			
Dalbergia nitidula		xe	f	x			f
Dichrostachys cinerea	(This species is frequently found in miombo [P. Smith, pers. comm.]. This species occurs in miombo, but in my experience is more common in mopane and Undifferentiated woodland [C. Dudley, pers. comm.])	xej	f	x			f

Species	Regional status (see section 2.3)	(Malawi)	(Tanzania)	(Zambia)	WmrZ (Zambia subtype)	Wms(physiognomic subtype)	WmC (coast)
Diospyros kirkii		xej	f	x			
Diplorhynchus condylocarpon	not characteristic (characteristic for Chipya woodland and Kalahari woodland [White 1983]). This is a ubiquitous species that is also frequently found in miombo (P. Smith, pers. comm.).)	xej		x			
Dombeya rotundifolia	characteristic (principal canopy associate)	xej		x			
Erythrophleum africanum	characteristic (principal canopy associate)	xe	f	C			
Faurea rochetiana	scrub woodland at edges of dambos		f	x		x	
Faurea saligna	indicator (principal canopy associate)	xe	f	C			C
Flacourtia indica		xej	f	x			f
Flueggea virosa		xej	f	f			f
Hexalobus monopetalus		xj	f	x			
Hymenaea verrucosa	characteristic (forest species in Zanzibar-Inhambane transition woodland)						x
Kigelia africana	not characteristic (indicator for Undifferentiated woodland)	xj	f	f			f
Kirkia acuminata	not characteristic (indicator for mopane woodland)	Ce	f	f			
Landolphia kirkii		f	f	x			f
Lannea discolor	not characteristic (indicator for Kalahari woodland)	xe		f			
Lannea schweinfurthii	not characteristic (indicator for Undifferentiated woodland)						x
Lonchocarpus capassa	not characteristic (indicator for Undifferentiated woodland)	xe	f	f			f
Manilkara sansibarensis	characteristic (forest species in Zanzibar-Inhambane transition woodland)						x
Margaritaria discoidea							x
Markhamia obtusifolia	not characteristic (indicator for Undifferentiated woodland)	xej	f	x			f
Markhamia zanzibarica		xe	f	f			f
Marquesia macroura	indicator (principal canopy associate)		f	C			
Maytenus senegalensis		xj	f	f			f
Monotes africana	(This species is characteristic of escarpment miombo woodland in Zambia [P. Smith, pers. comm.])	xj		f			
Myrsine africana		f	f	x			
Ormocarpum kirkii		xe	f	f			f
Oxytenanthera abyssinica	(lowland bamboo species)	xe	f	f			
Ozoroa insignis	not characteristic (indicator for Chipya woodland)	xej	f	f			f
Parinari curatellifolia	characteristic (principal canopy associate; also on shallow soils overlaying laterite and in scrub woodland at edges of dambos)	xj	f	C		x	f
Pericopsis angolensis	characteristic (principal canopy associate)	xj	f	C			

Species	Regional status (see section 2.3)	(Malawi)	(Tanzania)	(Zambia)	WmrZ (Zambia subtype)	Wms(physiognomic subtype)	WmC (coast)
Piliostigma thonningii	not characteristic (indicator for Undifferentiated woodland)	xe	f	f			f
Pleurostylia africana		xj	f	f			f
Pseudolachnostylis maprouneifolia	characteristic (principal canopy associate). [White 1983 p. 95]). This is a ubiquitous species that occurs under a wide range of altitudes in the Zambezian region, including miombo woodland (P. Smith, pers. comm.).	xej	f	x			
Pterocarpus angolensis	characteristic (principal canopy associate)	xeij	f	C			f
Sclerocarya birrea	not characteristic (characteristic for mopane woodland and Undifferentiated woodland)						x
Securidaca longipedunculata		xej	f	x			f
Senna singueana		xj	f	f			f
Smilax anceps	not characteristic (Chipya woodland indicator)		f	x			
Steganotaenia araliacea		xj	f	f			
Sterculia africana		xe	f	f			f
Sterculia quinqueloba		xe	f	f			f
Stereospermum kunthianum	(I have never seen this species in miombo [P. Smith, pers. comm.]. This species is found at edges of miombo at 500 m elevation in Liwonde National Park [C. Dudley, pers. comm.]).	xej	f	f			f
Strychnos cocculoides		xj	f	x			f
Strychnos innocua		xej	f	x			f
Strychnos spinosa		xj	f	f			f
Syzygium guineense	not characteristic (indicator for Chipya woodland and scrub woodland at edges of dambos [*Syzygium guineense* ssp. *guineense*]) [White 1983 p. 97]). This species is frequently found in miombo, often on dambo margins (P. Smith, pers. comm.).	f	f	C		x	f
Terminalia sericea	characteristic (principal canopy associate). This species is more widespread than miombo and an indicator of sandy substrates (P. Smith, pers. comm.). This species is a sub-canopy species that is usually found in miombo woodland, although it would seem to be more associated with sandy substrates (C. Dudley, pers. comm.).	xej	f	f			
Thespesia garckeana	negative indicator (undifferentiated woodland)	xe	f	f			
Uapaca kirkiana	sometimes in scrub woodland near altitudinal limits of miombo woodland (White 1983 p. 99). This is a species that characterizes miombo woodland (P. Smith, pers. comm.). Several species of Uapaca occur scattered in miombo as small trees less than 10 m tall (White 1983 p. 93).	xj	f	x		x	
Uapaca nitida	Several species of Uapaca occur scattered in miombo as small trees less than 10 m tall.	xj	f	x			f
Uapaca sansibarica	Several species of Uapaca occur scattered in miombo as small trees less than 10 m tall.	f	f	x			f
Vangueria infausta		xej	f	f			f
Vangueriopsis lanciflora	not characteristic (indicator for Kalahari woodland and scrub woodland at edges of dambos)	xj	f	f		x	

Species	Regional status (see section 2.3)	(Malawi)	(Tanzania)	(Zambia)	WmrZ (Zambia subtype)	Wms(physiognomic subtype)	WmC (coast)
Vitex doniana		xe	f	f			f
Vitex madiensis			f	x			
Vitex mombassae		xj	f	x			f
Vitex payos		xe	f				f
Xeroderris stuhlmannii	not characteristic (indicator for Undifferentiated woodland)	xe	f	f			f
Ximenia americana		xej	f	f			f
Xylopia parviflora		xj	f	f			f
Ziziphus abyssinica	not characteristic (indicator for Undifferentiated woodland)	xj	f	f			f
Ziziphus mucronata	not characteristic (indicator for Undifferentiated woodland)	xj	f	f			f

9. North Zambezian undifferentiated woodland and wooded grassland (synonym: undifferentiated woodland, Wn)

9.1. Description

The name of "North Zambezian undifferentiated woodland and wooded grassland" directly corresponds to the name given by White for this vegetation type (White 1983 p. 95). **Given that this name is quite long, we use the abbreviation of "Undifferentiated woodland (Wn)" throughout this and other VECEA volumes. A synonym for this vegetation type is "Munga woodland".**[23]

Undifferentiated woodland can be more easily defined by the absence of the dominant species of miombo woodland (Wm) and mopane woodland and scrub woodland (Wo) than by its own floristic composition. Although the dominants of miombo woodland are usually absent, some of the associated species are frequently present such as *Afzelia quanzensis*, *Burkea africana*, *Dombeya rotundifolia*, *Pericopsis angolensis*, *Pseudolachnostylis maprouneifolia*, *Pterocarpus angolensis* or *Terminalia sericea*. Despite its small area, it is composed of many more tree species than either miombo or mopane (White 1983 p. 95).

Frank White reserved the term of "undifferentiated forests" to forests that undergo rapid and kaleidoscopic changes in structure and species composition over short distances (White 1983 p. 47). We expect that a similar definition applies to "undifferentiated woodlands" and "undifferentiated wooded grasslands" since White (1983 p. 95) describes that "there is considerable floristic overlap between different examples and variation is more or less continuous".[24] We have evidence that the vegetation type of "undifferentiated woodland" of The Vegetation Map of Africa (White 1983) corresponds - at least partially - to *Combretum* wooded grassland types of some national references (see Box 1).

Undifferentiated woodland occurs towards or slightly beyond the drier climatic limits of miombo woodland (Wm) on certain soils that are unsuitable for mopane woodland and wooded grassland (Wo) – for example freely drained granite soils. The most extensive occurrences appear to be largely secondary, however (White 1983 p. 95).

White describes two main variants of Undifferentiated woodland (Wn): (i) riparian woodland and wooded grassland; and (ii) Undifferentiated woodland on upper valley soils in Zambia (White 1983 p. 95).

- Riparian woodland and wooded grassland is extensively developed on alluvium fringing the larger permanent watercourses in the drier half of the Zambezian region. Most riparian woodland is probably degraded riparian forest (fr) or riparian transition woodland since it is a favourite habitat of elephants. Riparian woodland can also be an

23: One of the direct references that White (1983 p. 95) provides for the North Zambezian Undifferentiated woodland are pages 50 to 55 of Fanshawe (1971) - these are the pages where Fanshawe describes and gives the species composition of "Munga woodland". Fanshawe (1971 p. 51) says that the term "Munga" was coined by Frank White (1965) as a term that was preferable to "savanna". The White (1965 p. 667) manuscript describes that "Within the enormous areas occupied by miombo woodland, there exist patches of various extent from which miombo is excluded because of soil differences. The soils are usually heavier and more fertile than miombo soils and are often deeper (…) They often occur on alluvium (…) Present day vegetation characteristically consists of tall, dense grassland with a varying density of fire-resistant trees. These trees comprise the "Munga" element. "Munga" is as Tonga word for "thorn tree" which is applied to several species of *Acacia*, including ***Acacia sieberiana***, *Acacia albida* (now: *Faidherbia albida*) and ***Acacia polyacantha*** which are frequent and characteristic components of this vegetation type."

24: One example of "kaleidoscopic changes" (referring to changes in species composition over space rather than over time) within Undifferentiated woodland was described for Lengwe National Park (Malawi) by Hall-Martin. Whereas various vegetation subtypes can be clearly distinguished on the ground and be included on maps at smaller scales (1:50,000 to 1:25,000), at larger scales (as used in the base maps used by the VECEA project) these types can only be mapped as mosaics. As one walks through Undifferentiated woodland, one passes through variable sized areas of different species complexes that each can be characterized floristically, structurally and edaphically. Whether these patches are "real" or mainly related to random processes of seed dispersal, germination and survival is not certain, but sharp boundaries can be observed between these patches (C. Dudley, pers. comm.).

edaphic climax - this is especially the case for seasonally flooded heavy clay soils.

- Upper valley soils in Zambia are formed at lower altitudes than the surrounding plateaux, have greater fertility than soils of the plateau and favour intensively rooting species since they provide a good rooting environment. The original vegetation was probably thicket with numerous emergent trees, dry forest (Fm or Fn) or transition woodland. These original communities have been replaced by secondary woodlands and wooded grasslands.

Species that were listed both for riparian and upper valley sites include ***Acacia polyacantha, Acacia sieberiana, Afzelia quanzensis***, ***Albizia harveyi, Burkea africana***, ***Ficus sycomorus, Kigelia africana, Lonchocarpus capassa*** (current name: *Philenoptera violacea*), ***Pseudolachnostylis maprouneifolia***, ***Pterocarpus angolensis***, ***Terminalia sericea, Trichilia emetica*** and ***Xeroderris stuhlmannii*** (White 1983 p. 95).

Undifferentiated woodland (Wn) corresponds to mapping unit 29c of the vegetation map of Africa (White 1983). White (1983) distinguishes a separate mapping unit 35a which he named "Transition from undifferentiated woodland to *Acacia* deciduous bushland and wooded grassland". The only description that White (1983 p. 62) gave for this vegetation type in the Zambezian region is of a woodland and wooded grassland that is dominated by *Acacia* and broad-leaved trees that is greatly modified by fire and extensively developed on the alluvium in the Rukwa valley (Tanzania).

However, White (1983) refers to an article by Pielou (1952). Pielou (1952) provides a description and two profile diagrams (see Figure 9.5) that depict an "escarpment" zone and a "fringing bush" zone. (The latter occurs on a flat area in between the escarpment and the "alkaline plain" of Lake Rukwa, and was described as wooded grassland by Pielou [1952]). Unfortunately, various species were not identified, including *Acacia* and *Combretum* species. In the VECEA map, we reclassified the physiognomic class of "bushland and thicket" that occurred in the vicinity of Lake Rukwa as "Transition from undifferentiated woodland to *Acacia* deciduous bushland and wooded grassland" (see Volume 6). We expect that the area mapped in the VECEA map therefore mainly depicts the "fringing bush" zone."

Box 1. The correspondence between the "undifferentiated woodlands" of the Vegetation Map of Africa (White 1983) and *Combretum* wooded grassland types

Within the VECEA map, we have not mapped *Combretum* wooded grassland (mapping unit Wc) within the Zambezian region. We made this decision for cartographic and floristic reasons. However, we have various lines of evidence that within the Zambezian region, *Combretum* wooded grasslands are equivalent - at least partially - to Undifferentiated woodland (especially where Undifferentiated woodland occurs in catena sequences in between Miombo woodland [Wm] and edaphic grassland ["dambos", g]).:

- Fanshawe (1971) describing Undifferentiated woodland mentions that both lower valley and upper valley types of Munga woodland can be further subdivided in (i) *Combretum-Terminalia* variants on the more elevated, better drained sites; and (ii) *Acacia* variants on the less elevated, poorer drained sites.
- The soil - vegetation map of Zambia that was prepared by Trapnell *et al.* (1950) distinguishes between *Combretum - Pericopsis, Acacia - Combretum* and *Pterocarpus - Combretum* vegetation types, whereas these types all correspond to Undifferentiated woodland (as indicated on the legend of the Edmonds and Fanshawe [1976] map).
- Trapnell and Langdale-Brown (1972, p. 133) describing *Combretum* wooded grassland (Wc), mention that various broad-leaved *Combretum* species are associated with smaller-leaved species of ***Terminalia sericea*** in the "monsoon sector" of Tanzania (*i.e.* areas with a one-season summer rainy season typically occupied by miombo woodland [Wm]). They further mention that in the "monsoon sector", the characteristic combination is *Combretum* with Papilionaceae, notably *Pericopsis angolensis* and ***Xeroderris stuhlmannii*** (synonym: *Ostryoderris stuhlmannii*) The corresponding vegetation map of East Africa includes the topographic sequence of 3c / 4, indicating higher lying *Brachystegia* and other species woodlands of Tanganyika ('miombo') in a topographic sequence with lower lying wooded grassland (see volume 6).
- White (1983 p. 95) includes various *Combretum* species (*Combretum adenogonium, C. collinum*, *C. imberbe* and *C. molle*) and one *Terminalia* species (*Terminalia mollis*) in Undifferentiated woodland.
- Central African Rail Link Development Survey (1952) vegetation maps (8 and 12) for Tanzania includes woodland of Combretaceae ± Papilionaceae (map symbol J). The maps clearly depict the pattern that *Combretum* woodland occurs in a catenary sequence between miombo woodland and edaphic "valley grasslands" (see Figure 9.1). Moreover, the documentation of the map (CARLDS 1952 p. 64) mentions that "mixed types of Combreta-

ceae woodland with *Brachystegia - Isoberlinia* woodland [*i.e.* miombo woodland]) (…) occur on broken topography where *Brachystegia-Isoberlinia* vegetation on hill tops and upper slopes alternates with Combretaceae woodland on colluvial soils on lower slopes and valley bottoms (CARLDS 1952, page 64).

- Gillman (1949, p. 28) describes the central plateau catena [25]mapping unit from the vegetation map of Tanzania (that he made) carrying the typical vegetation sequence of *Brachystegia* and other species woodland (miombo) on the comparatively well drained ridges and their upper and middle slopes, grassland in the valley bottoms, and *Combretum* and other species wooded grassland or bushland in varying widths between the miombo woodland and grassland. (This description corresponds well with the *Combretum - Acacia - Piliostigma* woodland and thicket subtype of Malawi's central plateau; C. Dudley, pers. comm.)
- Lind and Morrison (1974 p. 81) describe that Miombo woodlands occupy two great blocks (a central plateau in the north and a south-eastern plateau) that are remnants of Miocene and Tertiary peneplains. On these moderately undulating peneplain, broad, flat and gently sloping ridges alternate with shallow, low-grade, flat-bottomed and seasonally inundated valleys that are known as 'mbugas'. The well-drained ridges bear miombo on their upper and middle slopes, the valley bottoms bear grassland and the narrow marginal region in between bears bushland or wooded grassland with *Combretum* and other species. Lind and Morrison (1974 p. 90) further mention that in Tanzania, Combretaceous wooded grasslands are not so widespread and are mainly found in the catena of the miombo woodlands.
- Burtt et al. (1942 p. 111) describe *Combretum zeyheri* - ***Terminalia sericea - Xeroderris*** woodlands that occur in the Lake Province of Tanzania (around Shinyanga) between *Brachystegia spiciformis* woodland and hard-pan alluvium below.

25: Gillman (1949 p. 25) defines a catena (or "catenary complex") as "a distributional sequence of vegetation types determined by a given set of regularly repeated physiographic or hydrographic conditions (including their effect on soils), the arrangement of vegetation types being a function of local differences in topography that are constantly repeated over the catenary area." He also mentions that "the catena (…) is merely a device to permit a more correct representation of the vegetational facts on a small-scale map than the usual misrepresentation that results from showing only a single dominant type."

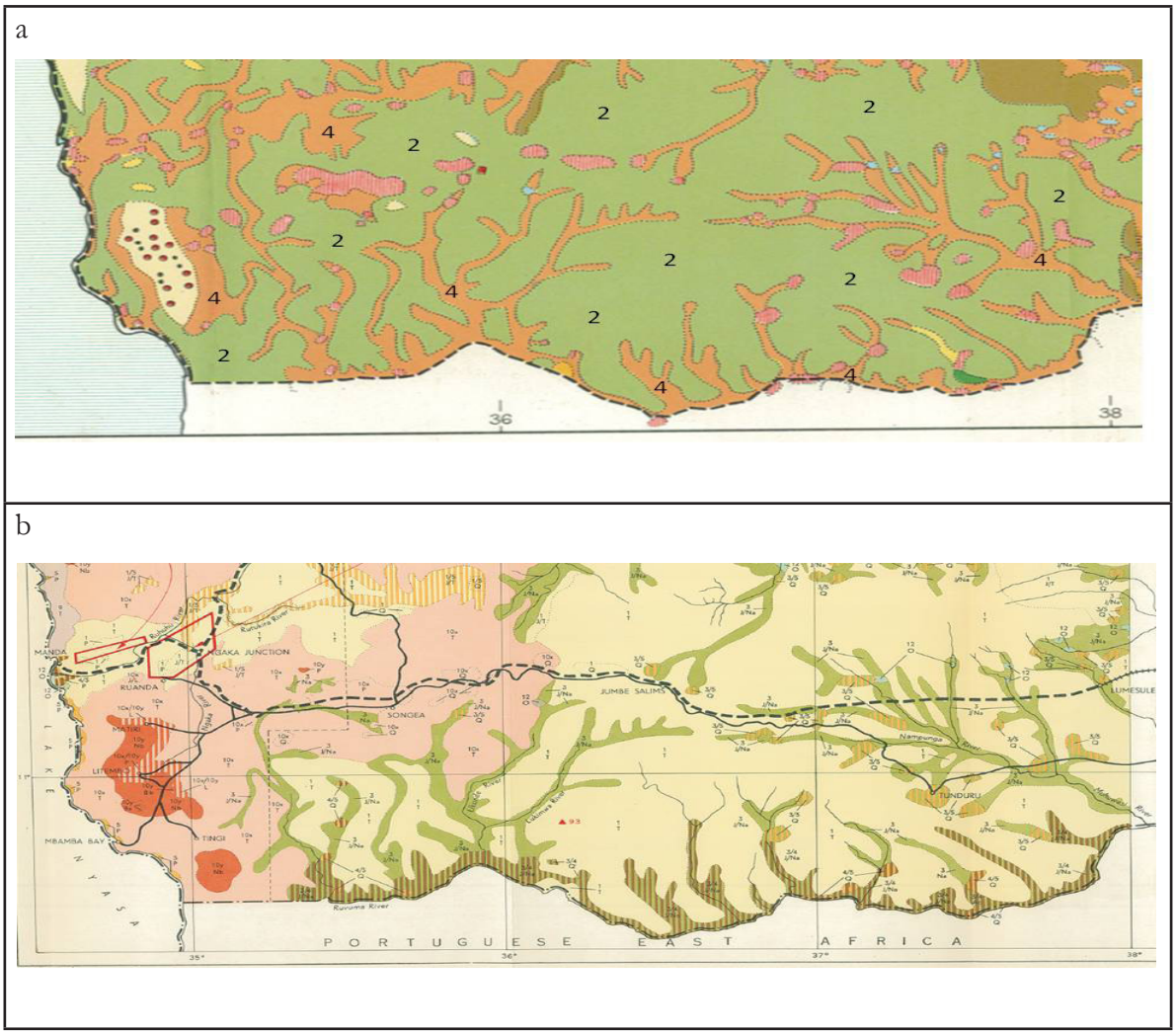


Figure 9.1 Most areas that were mapped as wooded grassland in the south-west of the Gillman (1949) physiognomic map correspond with areas that are mapped as Combretaceae ± Papilionaceae woodland in the Central African Rail Link Development Survey (CARLDS 1952) maps.

a: south-west of the Gillman (1949) map; 2: woodland (coding added afterwards); 4: wooded grassland (coding added afterwards). b: CARLDS (1952) Map 8; T: *Brachystegia-Isoberlinia* woodland; J: Woodland of *Combretaceae* ± *Papilionaceae*; Na: valley grassland. (In the CARLDS maps, different colours correspond to different soil types).)These figures show the same patterns that can be observed in the Kasungu landscape of Malawi; C. Dudley, pers. comm.)

Figure 9.2 *Acacia polyacantha* on the Kafue flats in Zambia. *Acacia polyacantha* is a typical species of North Zambezian undifferentiated woodland ("Undifferentiated woodland" in the VECEA map), occurring both in riparian and upper valley subtypes (White 1983 p. 95). Photograph by M. Bingham.

Figure 9.3 Undifferentiated woodland near Morogoro in Tanzania. *Brachystegia* species (dominant in miombo woodland) are absent in this vegetation type (F. Mbago).

Figure 9.4 Undifferentiated woodland near Morogoro in Tanzania. This vegetation type was originally described as "*Combretum* savannah", but was reclassified in the VECEA map as Undifferentiated woodland (Wn). The species in the centre is the co-dominant *Acacia nigrescens*. Burtt *et al*. (1942, Fig 48). Image obtained from URL: *http://www.jstor.org/stable/2256690*.

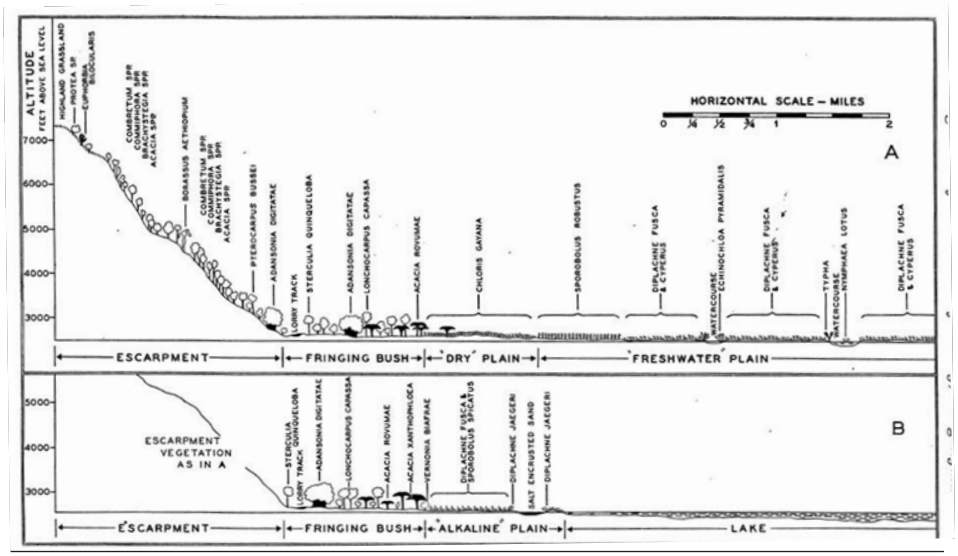


Figure 9.5. Transition from undifferentiated woodland to *Acacia* deciduous bushland and wooded grassland (mapping unit 35a in White 1983) next to Lake Rukwa (Tanzania). White (1983) does not describe mapping unit 35a in his treatment of the Zambezian floristic region, whereas White (1983 p. 62) directly refers to Pielou (1952). Pielou (1952 Fig 2). Image obtained from URL: *http://www.jstor.org/stable/2256807*.

9.2. VECEA region

Within the VECEA region (Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda and Zambia), Undifferentiated woodland (Wn) occurs in Malawi, Tanzania and Zambia (see Figure 9.6 and Volume 6).

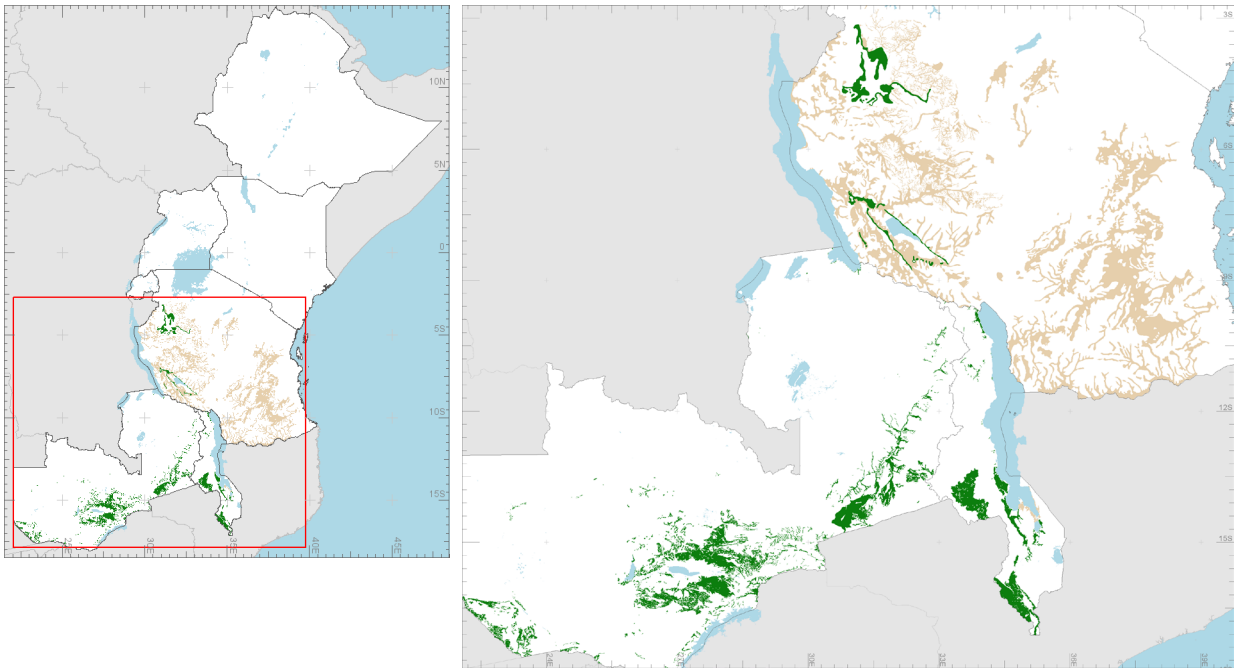


Figure 9.6. Mapped distribution of Undifferentiated woodland (Wn) in the VECEA region (Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda and Zambia). Where this vegetation type does not occur in mosaic, it is depicted by green polygons. In Tanzania, most of this vegetation type is mapped as mosaics with edaphic grassland (g) and are depicted by greyish-brown polygons; these mosaics occur in catenas of miombo woodland – Undifferentiated woodland – edaphic grassland. Areas shown in green in south-western Tanzania mainly belong to the subtype of "Transition from undifferentiated woodland to *Acacia* deciduous bushland and wooded grassland (Wnt)".

For Malawi, Undifferentiated woodlands were one of the hardest vegetation types to characterize. Undifferentiated woodlands in Malawi are woodlands with numerous and confusingly overlapping species assemblages; therefore, "mixed" seems to be the key word to describe this vegetation type (C. Dudley, personal observations).

An analysis of the base maps that were used for Malawi (see volume 6) led to the discrimination of five subtypes of Undifferentiated woodland for Malawi:

(i) *Combretum - Acacia - Piliostigma* woodland and thicket. This vegetation type is relatively well known. It occurs on the Central Plateau of Malawi in a catenary sequence with miombo woodland (Wm) and dambo grassland (g, see volume 5), a sequence that is constantly repeated across the landscape (C. Dudley, personal observations).

(ii) *Acacia – Adansonia - Hyphaene - Sterculia* woodland and thicket of the shores of Lake Malawi. This vegetation type occurs along the more fertile lake shore plains. Nowadays only relics of large trees of *Acacia, Adansonia, Hyphaene* and *Sterculia* species remain. Where cultivation has been abandoned, a thicket of *Acacia, Combretum* and *Commiphora* species has become established. Information in insufficient to classify it together with subtype i or together with subtype iv. Another possibility is that these woodlands are relics from a lakeshore forest (Dowsett-Lemaire and Dowsett [2002]; *Sterculia appendiculata* is a characteristic species of riverine forest [fr] in Malawi, see volume 2 [this species is not a "useful tree species" and therefore not listed in section 9.3]). (C. Dudley, personal observations).

(iii) *Acacia – Adansonia – Cordyla - Sclerocarya - Sterculia* woodland and thicket of the Lower Shire Valley. This vegetation type occurs along the floor of the Lower Shire river valley. The present condition of the vegetation type is similar to that of the type immediately above (ii). Information in insufficient to classify it together with type i or type iv or as a relic of riverince forest (C. Dudley, personal observations).

(iv) Undifferentiated woodland and thicket of the Lower Shire Valley escarpments and foothills. This vegetation type is well known. Above 300 m, these woodlands approach miombo woodland (Wm; C. Dudley, personal observations).

(v) Undifferentiated woodland and thicket of islands in Lake Malawi. Although no survey information was available, we expect that these islands have similar species composition as the nearby lake shore hills (i.e. subtype iv). These islands have only been isolated in the last several hundred years as a consequence of the increased level of Lake Malawi (Owen *et al.* 1990). Most of these islands have been inhabited for generations and are nearly treeless (C. Dudley, personal communication).

In the Zambian national reference (Fanshawe 1971), Undifferentiated woodland[26] was further classified in Upper valley, Lower valley and Kalahari site groupings. Both the Upper valley and Lower valley woodlands can be

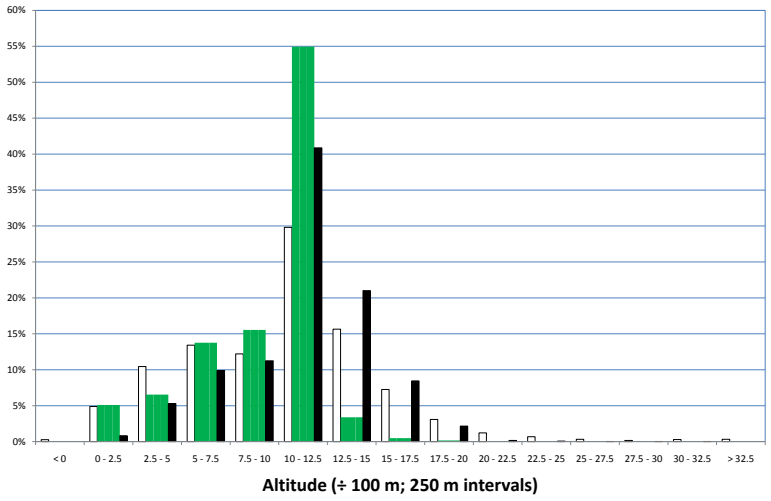
26: One of the direct references that White (1983 p. 95) provides for Undifferentiated woodland are pages 50 to 55 of Fanshawe (1971) - these are the pages where Fanshawe describes and gives the species composition of "Munga woodland". Fanshawe (1971 p. 51) says that the term "Munga" was coined by Frank White (1965 "The savanna woodlands of the Zambezian and Sudanian domains") as a term that was preferable to "savanna". The White (1965 p. 667) manuscript describes that "Within the enormous areas occupied by miombo woodland, there exist patches of various extent from which miombo is excluded because of soil differences. The soils are usually heavier and more fertile than miombo soils and are often deeper (…) They often occur on alluvium (…) Present day vegetation characteristically consists of tall, dense grassland with a varying density of fire-resistant trees. These trees comprise the "Munga" element. "Munga" is as Tonga word for "thorn tree" which is applied to several species of *Acacia*, including *Acacia sieberiana, Acacia albida* (now: *Faidherbia albida*) and *Acacia polyacantha* which are frequent and characteristic components of this vegetation type." However, White (1983 p. 95) does not list the synonym of "Munga".

further subdivided into (i) a *Combretum - Terminalia* variant on the more elevated and better drained sites; and (ii) an *Acacia* variant on the less elevated and poorer drained sites [27] . Common species for the three site groupings are provided (see section 9.3), but no information is given on differences in species composition between the *Combretum - Terminalia* variant and *Acacia* variants (Fanshawe 1971 p. 52). However, the *Acacia - Combretum* and allied vegetation described by Trapnell *et al.* (1950 p. 19) are specified to contain ***Acacia polyacantha***, *Acacia tortilis* (synonym: *Acacia heteracantha*) and *Faidherbia albida*. The identities of *Combretum* species identities are not provided by Trapnell *et al.* (1950). The *Combretum - Pericopsis* vegetation of Trapnell *et al.* (1950 p. 19) contains various *Combretum* species (not specified) in association with *Pericopsis angolensis*, *Terminalia mollis* (synonym: *Terminalia torulosa*) and ***Xeroderris stuhlmannii***. The *Pterocarpus - Combretum* vegetation types of Trapnell *et al.* (1950 p. 19) contains ***Pterocarpus angolensis***, *Pterocarpus rotundifolius* and unspecified *Combretum* species.

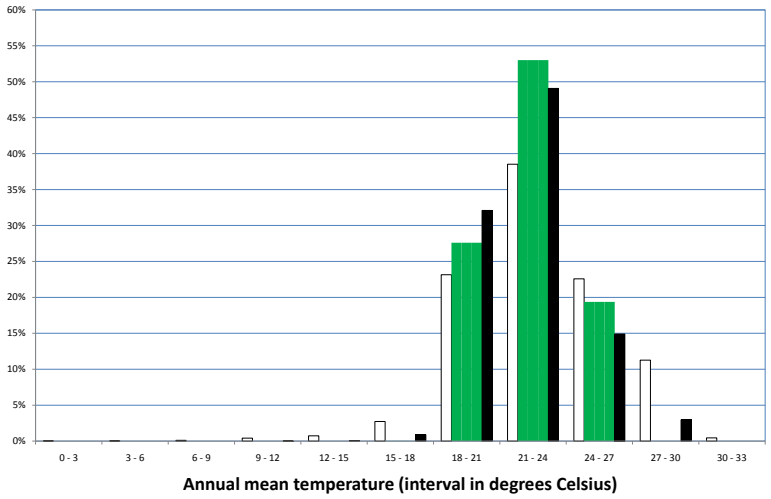
Investigation of environmental distribution of Undifferentiated woodland in the VECEA region (Figure 9.7; limits are for areas of the VECEA map where this vegetation type is not mapped as mosaic) shows that more than 95% of the samples occur in an interval from 0 – 1250 m. Although many samples occur in the altitude interval of 1000 – 1250 m (54.9%; this is also the interval where most woodlands and wooded grasslands combined occur), this vegetation type also occurs at generally lower altitudes. Undifferentiated woodland generally receives between 600 and 1000 mm annual rainfall (> 90% of samples). The rainfall interval where most of samples occur is the same for this vegetation type (800 – 1000 mm; 74.2% of samples) as for all woodlands and wooded grasslands combined (34.4%).

27: The coding of the Trapnell *et al.* (1950) soil - vegetation map is based on the soil type with a suffix for the vegetation type. In the legend of the Fanshawe vegetation map (Edmonds and Fanshawe 1976), an indicating is given that "Munga woodland on heavy soils" corresponds to U2 (*Combretum - Pericopsis and Pterocarpus - Combretum* vegetation on upper valley soils), R ("R" in red font on a yellow background; *Combretum - Pericopsis* and *Pterocarpus - Combretum* vegetation on allied chocolate-red loams), K12 (*Acacia - Combretum* and allied vegetation on transitional Kalahari Sands), L3 (*Acacia - Combretum* and allied vegetation on lower valley and other alluvium), U3 (*Acacia - Combretum* on upper valley soils) and SK1 (*Hyphaene palm* country on marginal transitional [Kalahari] sands).

(a)



(b)



(c)

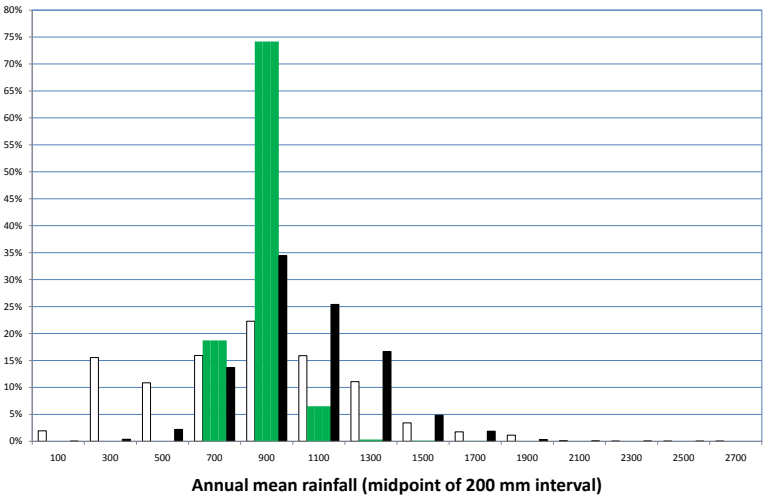


Figure 9.7. Histograms of the distribution of altitude (a), mean annual temperature (b) and mean annual rainfall (c). Bars at the centre of each interval show the percentage of samples within Undifferentiated woodland (Wn, *n* = 15,118). Bars on left (open) show the overall percentage of samples (*n* = 740,047). Bars on the right (black) show the percentages of samples within woodland or wooded grassland (*n* =354,078).

9.3. Species composition

Species assemblages were obtained from the following references:

- Malawi: Brown and Young (1964), Dowsett-Lemaire and Dowsett (2002), Jackson (1972), Robertson (1984), Stobbs (1970) and Young and Brown (1962) supplemented with unpublished data from our Malawian co-author (C. Dudley). Species that were listed were coded "x", unless they were characteristic species. Species listed for the subtypes of "*Acacia – Adansonia - Hyphaene - Sterculia* woodland and thicket" or "*Acacia – Adansonia – Cordyla - Sclerocarya - Sterculia* woodland and thicket" were coded "xa", unless they were characteristic species. Species listed for the subtype of "*Combretum - Acacia - Piliostigma* woodland and thicket" were coded "xc", unless they were characteristic species. Species listed for the subtype of "Undifferentiated woodland - thicket of the Lower Shire Valley escarpment and foothills" were coded "xu", unless they were characteristic species.
- Tanzania: Central African Rail Link Development Survey (CARLDS 1952). Species listed to occur in woodland of Combretaceae ± Papilionaceae were coded "C" since all these species were assumed to be characteristic species. Unfortunately, among the characteristic Combretaceae species, only *Pteleopsis myrtifolia* was referred to by its species identity, whereas the other characteristic Combretaceae species were listed by the generic names of *Combretum* and *Terminalia*.
- Zambia: Fanshawe (1971). Species listed for the species composition table for "Munga woodland" provided on pages 53 to 55 were coded "x" (unless they were characteristic species). Species listed in the main text to be common overwood species of lower valley sites were coded "xl". Species listed in the main text to be common overwood species of upper valley sites were coded "xu". Species listed in the main text to be common overwood species of Kalahari sites were coded "xk". Species listed in the main text to occur in edaphic munga scrub were coded "xe".
- Transition from undifferentiated woodland to *Acacia* deciduous bushland and wooded grassland (column "WntT"): Pielou (1952). Species listed for the escarpment zone were coded "Ce" and those for the "fringing bush" zone were coded "Cb".

Characteristic species were determined as:

- Malawi: Species identified to be present as large trees (20 - 30 m) or medium-sized trees (10 - 20 m) for the "*Combretum - Acacia - Piliostigma* woodland and thicket" subtype were coded "Cc", unless they had marginal occurrence. Species identified to be present as large trees (20 - 30 m) or medium-sized trees (10 - 20 m) for the "Undifferentiated woodland - thicket of the Lower Shire Valley escarpment and foothills" subtype were coded "Cu".

- Tanzania: All the species that were listed were assumed to be characteristic species.
- Zambia: Species from the canopy were coded "C".
- Transition from undifferentiated woodland to *Acacia* deciduous bushland and wooded grassland: All species were assumed to be characteristic species

Within the information on assemblages, coding "f" indicates that there is information that the species **potentially** occurs in the vegetation type since it occurs in the focal country and in the same woodland (or wooded grassland) type in other countries (see section 2.3). No floristic commitments were made for the transition from undifferentiated woodland to *Acacia* deciduous bushland and wooded grassland (WntT).

Table 9. Species composition of north Zambezian undifferentiated woodland and wooded grassland (synonym: undifferentiated woodland, Wn)

Species	Regional status (see section 2.3)	(Malawi)	(Tanzania)	(Zambia)	WntT (Tanzania subtype)
Acacia erioloba	characteristic (riparian woodland)			Ck	
Acacia gerrardii		f	f	C	
Acacia mellifera			f	x	
Acacia nigrescens	characteristic (riparian woodland)	Cu	f	C	
Acacia nilotica		xu	f	xe	
Acacia polyacantha	indicator	Cc xau	C	C	
Acacia robusta	indicator (riparian woodland, *Acacia robusta* ssp. *clavigera*)		f	C	
Acacia seyal		xa	f	xeu	
Acacia sieberiana	indicator	Cc xu	f	C	
Acacia tortilis	indicator (riparian woodland. This is probably *Acacia tortilis* ssp. *spirocarpa* (J. Timberlake, pers. comm.))	xu	f	Cl	
Acacia xanthophloea					Cb
Adansonia digitata	characteristic (riparian woodland)	Cau	f	Cl	Cbe
Afzelia quanzensis	characteristic	Cu	f	Cu	
Albizia amara	indicator (upper valley soils)	Cc xu	f	C	
Albizia anthelmintica		xu	f	x	
Albizia harveyi	indicator	Cu xu	f	C	
Albizia versicolor	indicator (upper valley soils)	Cc xu	f	C	
Amblygonocarpus andongensis	not characteristic (characteristic for Chipya woodland and Kalahari woodland)	f	f	Cu	
Annona senegalensis			C		
Antidesma venosum		xcu	f	x	
Bauhinia petersiana		xu	f	xe	
Borassus aethiopum	indicator (riparian woodland, palm species)	f	C	Cu	Ce
Boscia salicifolia		xau	f	x	
Brachystegia bussei	not characteristic (indicator for miombo woodland)	Cc			
Brachystegia longifolia	not characteristic (characteristic for miombo woodland and Kalahari woodland)	f	C	f	
Burkea africana	characteristic	Ccu	f	Cu	
Capparis tomentosa		f	f	x	
Cassia abbreviata	indicator (upper valley soils)	xcu	f	x	
Clerodendrum myricoides			f	x	Ce
Combretum adenogonium	indicator (upper valley soils)	xcu	f	xe	
Combretum collinum	characteristic (upper valley soils)	xc	f	xu	
Combretum imberbe	characteristic (riparian woodland)	Cu	f	Cl	
Combretum molle	indicator (upper valley soils)	xcu	f	x	
Combretum zeyheri	not characteristic (characteristic for Chipya woodland and Kalahari woodland)	Cc xu	f	x	
Commiphora africana		xu	f	f	
Commiphora habessinica			f	x	
Cordyla africana	indicator (riparian woodland)	Cau	f	f	
Crossopteryx febrifuga		xcu	f		
Croton megalobotrys	indicator (riparian woodland)	f	f	x	
Dalbergia boehmii	indicator (upper valley soils)	f	f	Cu	

Species	Regional status (see section 2.3)	(Malawi)	(Tanzania)	(Zambia)	WntT (Tanzania subtype)
Dalbergia melanoxylon		xu	f	x	
Dalbergia nitidula		xu	f	f	
Dichrostachys cinerea		xu	f	x	
Diospyros kirkii		xu	f	xe	
Diplorhynchus condylocarpon	not characteristic (characteristic for Chipya woodland and Kalahari woodland)	xu		x	
Entada abyssinica		f	f	x	
Erythrina abyssinica		f	f	C	Ce
Erythrophleum africanum	not characteristic (characteristic for Chipya woodland and Kalahari woodland)	xu	C	Cu	
Euclea divinorum		xu	f	f	
Faidherbia albida	indicator (riparian woodland)	Cau	f	Cl	
Faurea rochetiana			f	x	
Ficus sycomorus	indicator	f	f	C	
Flacourtia indica		xu	f	f	
Flueggea virosa		xc	f	x	
Gardenia ternifolia		xu	f		
Grewia bicolor		xu	f	x	
Harungana madagascariensis		f	f	x	
Hyphaene petersiana	indicator (riparian woodland, palm species)	Cau	f	Cu	
Kigelia africana	indicator	f	f	C	Cb
Kirkia acuminata	not characteristic (indicator for mopane-Mopane woodland)	Cu	f	Cl	
Lannea discolor	not characteristic (indicator for Kalahari woodland)	xu		x	
Lannea schweinfurthii	not characteristic (indicator for riparian woodland)	xu	f	C	
Lonchocarpus capassa	indicator	Ccu	C	C	Cb
Markhamia obtusifolia	indicator (upper valley soils)	xcu	f	x	
Maytenus senegalensis		f	f	x	
Oxytenanthera abyssinica	(bamboo species indigenous to Africa)	xu	f	x	
Ozoroa insignis	not characteristic (indicator for Chipya woodland)	Cc	f	x	
Parinari curatellifolia	not characteristic (characteristic for Chipya woodland and Kalahari woodland)	xu	f	C	
Peltophorum africanum	indicator (upper valley soils)	f		Cu	
Pericopsis angolensis	characteristic (upper valley soils)	xu	C	Cu	
Phoenix reclinata	(palm species)	f	f	x	
Piliostigma thonningii	indicator (upper valley soils)	Cc xu	C	xe	Cbe
Pseudolachnostylis maprouneifolia	characteristic	Cc xu	C	x	
Pterocarpus angolensis	characteristic	Cc	f	Cu	Ce
Pterocarpus lucens		f		Cl	
Pterocarpus rotundifolius	indicator (upper valley soils)	xu	f	Cu	
Salvadora persica		xu	f	x	
Schinziophyton rautanenii	not characteristic (indicator for southern Kalahari woodland)		f	C	
Sclerocarya birrea	characteristic (riparian woodland)	Cau	C	Cl	
Securidaca longipedunculata		xu	f	x	

Species	Regional status (see section 2.3)	(Malawi)	(Tanzania)	(Zambia)	WntT (Tanzania subtype)
Sesbania sesban		f	f	x	
Sterculia africana		Cu	f	f	
Sterculia quinqueloba		Cu	f	f	Cb
Stereospermum kunthianum		xcu	C	f	
Strychnos cocculoides		f	f	x	
Strychnos potatorum		Cc		Ck	
Strychnos spinosa		xc	f	x	
Syzygium guineense	not characteristic (indicator for Chipya woodland, *Syzygium guineense* ssp. *guineense*)	f	f	x	
Tamarindus indica	indicator (riparian woodland)	Xu	f	Cl	Cbe
Terminalia mollis	indicator (upper valley soils)		f	C	
Terminalia prunioides			f	x	
Terminalia sericea	characteristic	Cu	C	C	
Thespesia garckeana	indicator (upper valley soils)	xu	f	x	
Trema orientalis		f	f	C	
Trichilia emetica	indicator	f	f	C	
Uapaca kirkiana					Ce
Vernonia amygdalina		f	f	x	
Xeroderris stuhlmannii	indicator	Cu	C	Cl	
Ximenia americana		xu	f	x	
Ziziphus abyssinica	indicator (upper valley soils)	Cc	f	C	
Ziziphus mauritiana		f	f	C	

10. Mopane woodland and scrub woodland (Wo)

10.1. Description

Vegetation communities that are dominated by ***Colophospermum mopane*** are widespread in the drier half of the Zambezian region. Nearly everywhere mopane woodland (which can reach heights of 20 to 25 m[28]) occurs in mosaic with mopane scrub woodland. Despite differences in height and density of different mopane communities, there is a remarkable physiognomic uniformity due to the almost complete dominance of ***Colophospermum mopane*** and its typical appearance. The butterfly-shaped leaves consisting of a single pair of large leaflets can easily be recognized (see Figure 10.6). The mopane tree also has a distinctive crown with rigid, irregular and markedly ascending branches which give off slender, tortuous and more spreading laterals. In most situations mopane is deciduous for about five months, but near Lake Kariba (16° 57' S, 27° 57' E) it is almost evergreen (White 1983 p. 94).

Mopane is capable of growing under a wide range of climatic and edaphic conditions.[29] The mopane tree is flammable once the bark is burnt or if there is a crown fire, but fires are unusual since the ground layer is normally sparse (if the canopy is opened by browsing elephants, a shrubby mopane grassland will be formed where multiple coppice shoots are produced from the stems of charred original trees). ***Colophospermum mopane*** and miombo dominant species scarcely occur together[30] and their floras are also almost totally dissimilar (White 1983 p. 94).

The upper rainfall limit of mopane is 800 mm, whereas the upper altitude limit is at 1400 m[31] (like most Zambezian tree species, mopane is killed back by frost). Where annual rainfall is 500 mm or less, mopane grows on most types of soils, except on heavy clay soils and towards the drier limits of its range. Where annual rainfall is higher than 500 mm, mopane only flourishes on soils that are shallow or that have a heavy or deflocculated topsoil. Mopane typically[32] occurs on soils with high concentrations of sodium, where sodium has caused clay particles to form an impervious layer that resulted in a soil with low water-storage capacity and poor depth penetration; however, mopane does not occur on true saline soils in which water soluble salts exceed 0.2 - 0.3 percent (White 1983 p. 94).

28: Mopane woodland can reach heights of up to 30 m (C. Dudley, personal observations)

29: see also Timberlake's 1995 bibliography and review:

Timberlake, J.R. (1995). *Colophospermum mopane*: annotated bibliography and review. Zimbabwe Bulletin of Forestry Research 11. Harare: Zimbabwe Forestry Commission. 49 pp.

30: Miombo species occur where mopane is near the edge of its range (as in Vwaza Wildlife Reserve in Malawi) or on sites with unfavorable edaphic factors (as in Majete Wildlife Reserve in Malawi; C. Dudley, pers. comm.).

31: Timberlake (1995) gives the following ranges: altitude from 200 to 1200 m (but mainly 300 to 1000 m); mean annual rainfall from 100 to 800 mm (but mainly 400 - 700 mm). Although the species is reported to be intolerant of severe frost, some stands can be found in some severely frost-prone areas south of Bulawayo (Zimbabwe). Mopane is generally not dominant in vegetation where mean annual rainfall is below 350 - 400 mm, but deeper and moisture-retentive soils may allow the species to occur in drier areas (Timberlake 1995).

32: These statements only apply to higher rainfall areas (J. Timberlake, pers. comm.)

Figure 10.1Open mopane woodland in Malawi. In this mopane woodland subtype, mopane trees are widely spaced (100 $^{ha-1}$) but the understorey is almost nonexistent. The average height of the mopane is 14 m, DBH 17 cm. Photograph by C. Dudley.

Figure 10.2. "Cathedral" mopane woodland from Malawi. In this mopane woodland subtype, mopane trees are wide spaced (100 $^{ha-1}$) and the understorey is patchy but present. The average height of the mopane is 20 m, DBH 30 cm. Photograph by C. Dudley.

Figure 10.3 Mopane woodland – thicket subtype from Malawi. Left: showing mopane, *Fockea multiflora* (the python vine) and *Euphorbia lividiflora* (an endangered species) with understorey of *Croton*. This vegetation type has degraded much mainly due to destruction by elephants. Right: Mopane tree with a *Fockea multiflora* liana. Photographs by C. Dudley.

Figure 10.4 The location of mopane woodland and edaphic grassland (g) in the Chikalogwe Plain, (Liwonde National Park, Malawi). Photograph by C. Dudley.

Figure 10.5 Mopane woodland in the Luangwa valley in Zambia. Photograph by M. Bingham (July 2005).

Figure 10.6 Close-up of leaves of the mopane tree. Photograph by C. Dudley.

10.2. VECEA region

Within the VECEA region (Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda and Zambia), mopane woodland occurs in Malawi and Zambia (see figure 10.7 and Volume 6).

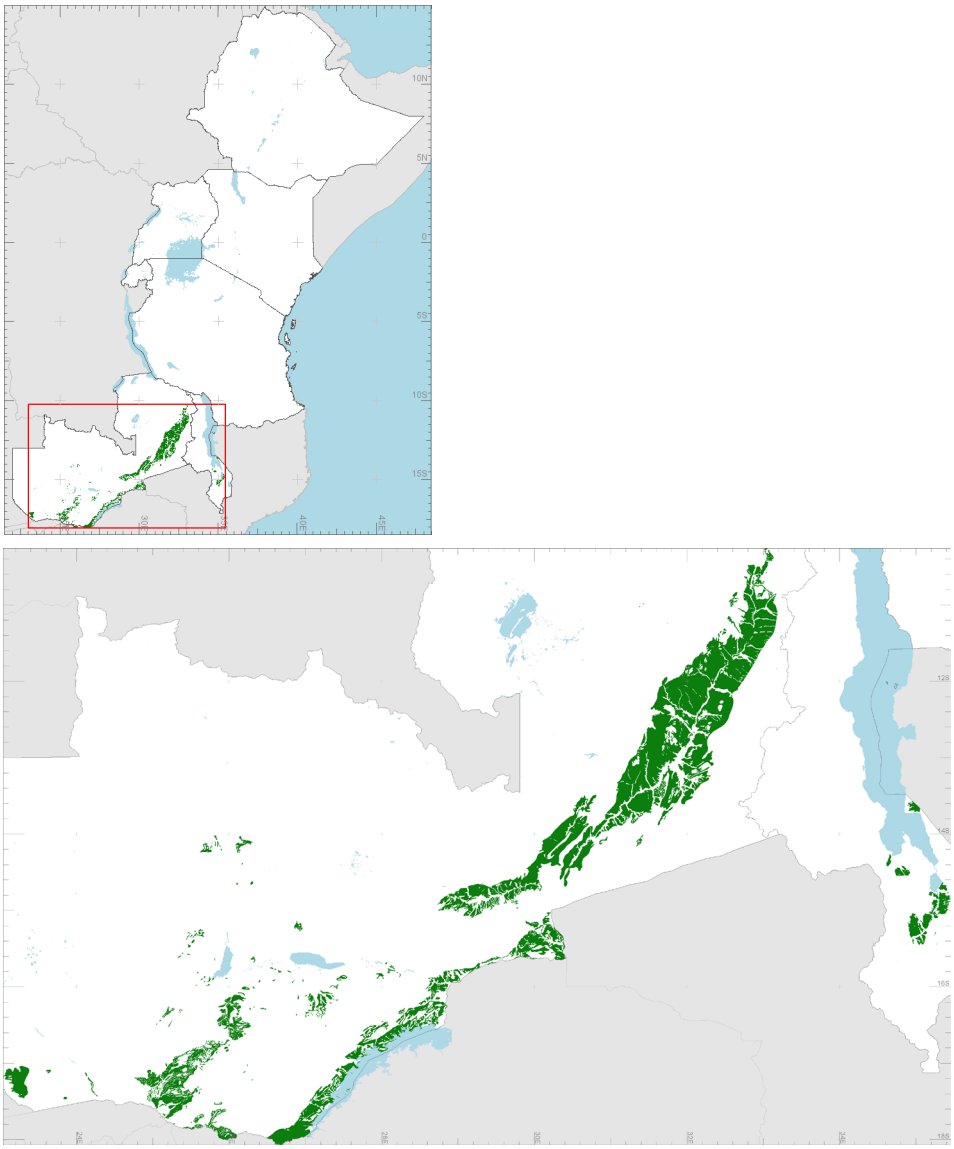


Figure 10.7. Mapped distribution of mopane woodland in the VECEA region (Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda and Zambia). Green polygons depict where we mapped this vegetation type.

In Malawi, our national co-author (C. Dudley) considers mopane woodland to be a complex of three types that merge into one another in complex ways (probably as a result of differences in soil and water retention characteristics of soils):

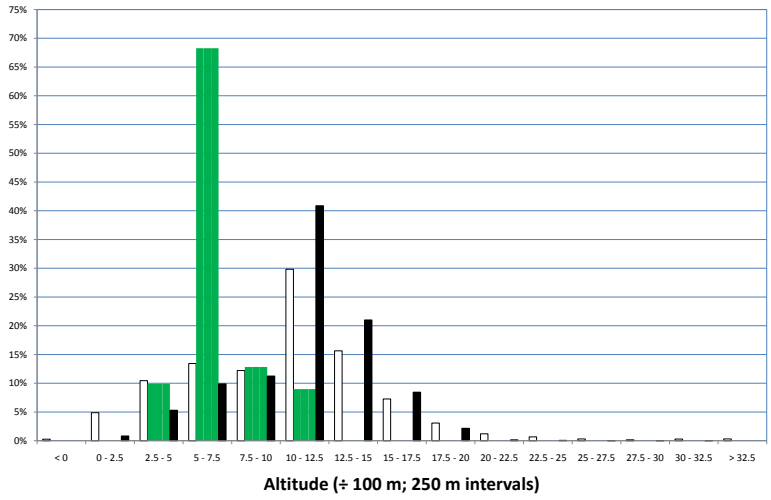
- Normal mopane woodland. In this vegetation type, 90% of the canopy (average height 14 m, but occasionally 20 m; average cover 45%) consists of ***Colophospermum mopane***. Only three other species are present in the canopy. There is little understorey.
- Cathedral mopane woodland. This vegetation type also has 90% of the canopy consisting of ***Colophospermum mopane***, but the trees are older, bigger (average height 22 m) and more spaced out and cover percentages are larger (up to 60%). Understorey is more featured and variable.
- Mopane woodland – thicket. This is a vegetation type that is spatially more limited. The upper canopy is a mixture of ***Colophospermum mopane*** (avererage height of 13 m and average cover of 30%) and *Acacia tortilis* (average height of 10 m and average cover of 13%). Unlike in the other mopane subtypes, the understorey is dense with numerous succulents and lianas.

In Zambia, mopane woodland was originally mapped as "Mopane woodland on clays" [33] (original mapping unit 14). The main species composition table described the ecotone from mopane woodland to Undifferentiated woodland. Scattered elements of Undifferentiated woodland occur in places. Fanshawe (1971 p. 49) also gives some information on the mopane - miombo ecotone.

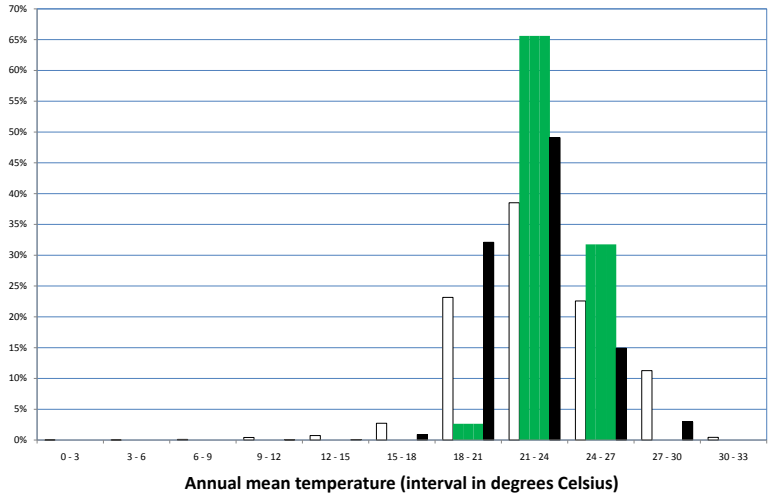
Investigation of environmental distribution of mopane woodland in the VECEA region (Figure 10.8) shows that all samples occur in an interval of 250 to 1250 m. This range in altitude corresponds well with the limits given by Timberlake (1995; i.e. 200 to 1200 m). The altitude interval where most of the samples occur for this vegetation type (500 – 750 m; 68.3%) is well below the altitude interval where most samples occur for all woodland and wooded grassland vegetation types combined (1000 – 1250 m; 40.9%). Mopane woodland generally receives between 600 and 1000 mm annual rainfall (> 95% of samples). The rainfall interval where most of samples occur is the same for this vegetation type (800 – 1000 mm; 71.7% of samples) as for all woodlands and wooded grasslands combined (34.4%). This indicates that mopane generally seems to occur in areas with higher rainfall than indicated by White (1983; *i.e.* areas with rainfall below 800 mm) and Timberlake (1995; i.e. a range of 100 - 800 mm). Mopane is known to grow well in Liwonde National Park in Malawi, where rainfall has averaged 1000 mm over a period of 17 years (C. Dudley, pers. comm.).

33: The coding of the Trapnell *et al.* (1950) soil - vegetation map is based on the soil type with a suffix for the vegetation type. In the legend of the Fanshawe vegetation map (Edmonds and Fanshawe 1976), an indicating is given that "mopane woodland on clays" corresponds to L1 (***Colophospermum mopane*** woodlands on brown lower valley soils, skeletal soils etc.) and S1 (***Colophospermum mopane*** on grey alluvial soils).

(a)



(b)



(c)

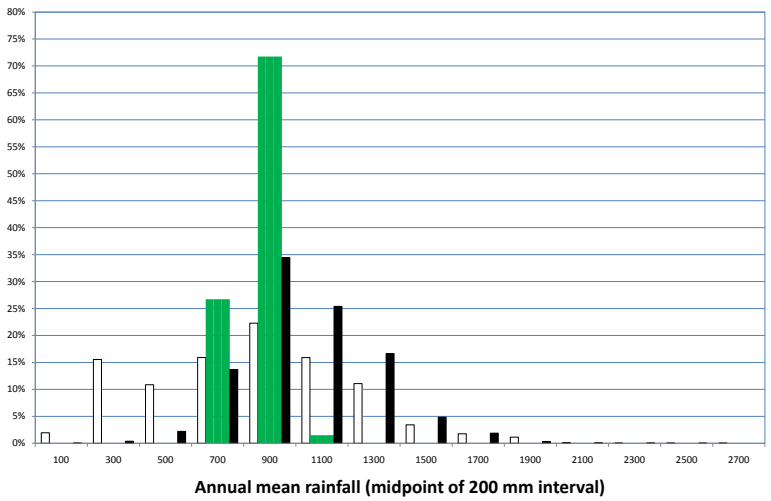


Figure 10.8. Histograms of the distribution of altitude (a), mean annual temperature (b) and mean annual rainfall (c). Bars at the centre of each interval show the percentage of samples within mopane woodland and scrub woodland (Wo, *n* = 11,937). Bars on left (open) show the overall percentage of samples (*n* = 740,047). Bars on the right (black) show the percentages of samples within woodland or wooded grassland (*n* = 354,078).

10.3. Species composition

Species assemblages were obtained from the following references:

- Malawi: Information from the work of our Malawian co-author (Cornell Dudley) supplemented by information from Dowsett-Lemaire & Dowsett (2002) and Hall-Martin and Drummond (1980). Species expected to occur in the "normal" subtype were coded "xn". Species expected in the "cathedral" subtype were coded "xc". Species expected for the subtype of "***Colophospermum mopane*** woodland - thicket" were coded "xt"
- Zambia: Fanshawe (1971). Species listed for the species composition table for "Mopane woodland - commoner species of the Mopane - Munga (*i.e.* Undifferentiated woodland [Wn]) ecotone" provided on page 50 were coded "x" (unless they were characteristic species). Species listed in the main text to for the rich variant (an open deciduous woodland occurring on sandstone or mudstone) were coded "xw". Species listed in the main text for the impoverished variant (a low open scrub of mopane occurring on skeletal mudstone, basalt and pebble beds) were coded "xs". In a separate column ("WomZ"), species listed for the mopane - miombo ecotone in the main text were coded "x".

Characteristic species were determined as:

- Malawi: Species identified to be present as large trees (20 - 30 m) were coded as "C". ***Colophospermum mopane*** was identified as the dominant species and coded "D". In thickets, ***Colophospermum mopane*** is co-dominant ("CD")
- Zambia: ***Colophospermum mopane*** was identified as the dominant species and coded "D". Other canopy species (several of these were described in the main text as "scattered elements of the Munga woodland") were coded "C".

Within the information on assemblages, coding "f" indicates that there is information that the species **potentially** occurs in the vegetation type since it occurs in the focal country and in the same woodland (or wooded grassland) type in other countries (see section 2.3). No floristic commitments were made to the mopane - miombo ecotone ("WomZ").

Table 10. Species composition of Mopane woodland and scrub woodland (Wo)

Species	Regional status (see section 2.3)	(Malawi)	(Zambia)	WomZ (Zambia subtype)
Colophospermum mopane	dominant	Dnc CDt	D	
Abutilon angulatum		f	x	
Acacia nigrescens	characteristic	xnc	C	
Acacia nilotica		xnc	xw	
Acacia senegal			xs	
Adansonia digitata	characteristic	xt	C	
Adenium obesum			x	
Afzelia quanzensis	not characteristsic (characteristic for miombo woodland and undifferentiated woodland) (White 1983 p. 95). This is a species that is often found in mopane woodland. As in miombo woodland, it frequently occurs closer to rocky outcrops (P. Smith, pers. comm.).	f	C	
Albizia amara	not characteristic (indicator for undifferentiated woodland)	f	C	
Albizia anthelmintica		xnct	xw	
Allophylus africanus		xct	f	
Balanites aegyptiaca	(this species is common in mopane; P. Smith, pers. comm.)		x	
Bauhinia petersiana		f	x	x
Brachystegia boehmii	not characteristic (indicator for miombo woodland)	f	C	
Capparis tomentosa		xt	f	
Combretum adenogonium	not characteristic (indicator for Undifferentiated woodland)	f	x	
Combretum imberbe	characteristic	f	C	
Commiphora africana		xnct	f	
Cordyla africana	not characteristic (indicator for Undifferentiated woodland)	Ct	f	
Dalbergia melanoxylon		xnct	xw	
Dichrostachys cinerea		xnc	x	
Diospyros kirkii		f	xs	
Diplorhynchus condylocarpon	not characteristic (indicator for Chipya woodland and Kalahari woodland)	f	f	x
Erythrina abyssinica		f	x	
Euphorbia candelabrum		f	x	
Flacourtia indica		f	x	
Grewia bicolor		xnt	xw	
Hyphaene petersiana	not characteristic (indicator for Undifferentiated woodland [palm species])		C	
Julbernardia globiflora	not characteristic (indicator for miombo woodland)	f	f	x
Kirkia acuminata	indicator	f	C	x
Lannea discolor	not characteristic (indicator for Kalahari woodland)	f	x	
Lannea schweinfurthii	not characteristic (indicator for Undifferentiated woodland)	xct	C	
Lonchocarpus capassa	not characteristic (indicator for Undifferentiated woodland)	f	C	
Markhamia zanzibarica		xc	f	x
Pterocarpus lucens	subdominant in Zambezian dry deciduous forest	f	C	
Salvadora persica		xnt	f	
Sclerocarya birrea	characteristic	f	C	x
Securidaca longipedunculata		f	x	
Strychnos potatorum			C	
Tamarindus indica	not characteristic (indicator for Undifferentiated woodland)	xnc	f	
Terminalia prunioides			x	
Ximenia americana	(this is a characteristic species for mopane woodland; P. Smith, pers. comm.)	xnt	xw	
Ziziphus mucronata	not characteristic (indicator for Undifferentiated woodland)	xnct	f	

11. *Terminalia sericea* woodland (Wt)

11.1. Description

Trapnell and Langdale-Brown (1972 p. 133) describing *Combretum* wooded grassland, mention that various broad-leaved *Combretum* species are associated with smaller-leaved species of *Terminalia sericea* in the "monsoon sector" of Tanzania (*i.e.* areas with a one-season summer rainy season typically occupied by miombo woodland [Wm] in catenas with Undifferentiated woodland [Wn]).

For the Zambezian region, White (1983) mentions that *Terminalia sericea* is an associated species for miombo woodland (Wm), mopane woodland (a principal associate in Angola), undifferentiated woodland (both North Zambezian and South Zambezian types), Chipya woodland and Kalahari woodland.

Terminalia sericea, often in association with *Burkea africana* and *Erythrophleum africanum* are indicators of sandy soils throughout the Zambezian region (P. Smith [pers. comm.]; see also Smith and Trapnell [2002]). As large parts of south-western Zambia are covered with *Burkea africana* and *Terminalia sericea*, possibly *Burkea - Terminalia* woodland should be distinguished as a regional vegetation type (indicative of sandy soils; P. Smith, pers. comm.). Rather than reclassifying *Terminalia sericea* woodland as one of the main Zambezian woodland types that were described by White (1983), we therefore decided to leave it as a distinct type.

11.2. VECEA region

Within the VECEA region, *Terminalia sericea* woodland was only mapped in Malawi (Figure 11.1; see also Volume 6).

Known references (Jackson [1954, 1972], Shaxson [1976] and Stobbs [1970]) described this vegetation type to only occur on the upper "wet fringes" of the Lake Chilwa floodplains[34]. However, these authors did not give details about species composition (C. Dudley, pers. comm.). Moreover, our Malawian co-author has not observed this vegetation type in the field.

Investigation of environmental distribution of *Terminalia sericea* woodland in the VECEA region (Figure 11.2) shows that more than 95% of the samples occur in an interval from 500 – 1000 m. Most areas receive between 1000 and 1600 mm rainfall (> 95% of samples), which is generally higher than in most woodlands and wooded grasslands. As this vegetation type only occurs locally, relatively few samples were obtained.

34: Possibly there are different edaphic types of *Terminalia sericea* woodland: Jackson (1972) refers to "*Terminalia sericea* semi-swamp woodlands" and "*Terminalia sericea* on sand bars".

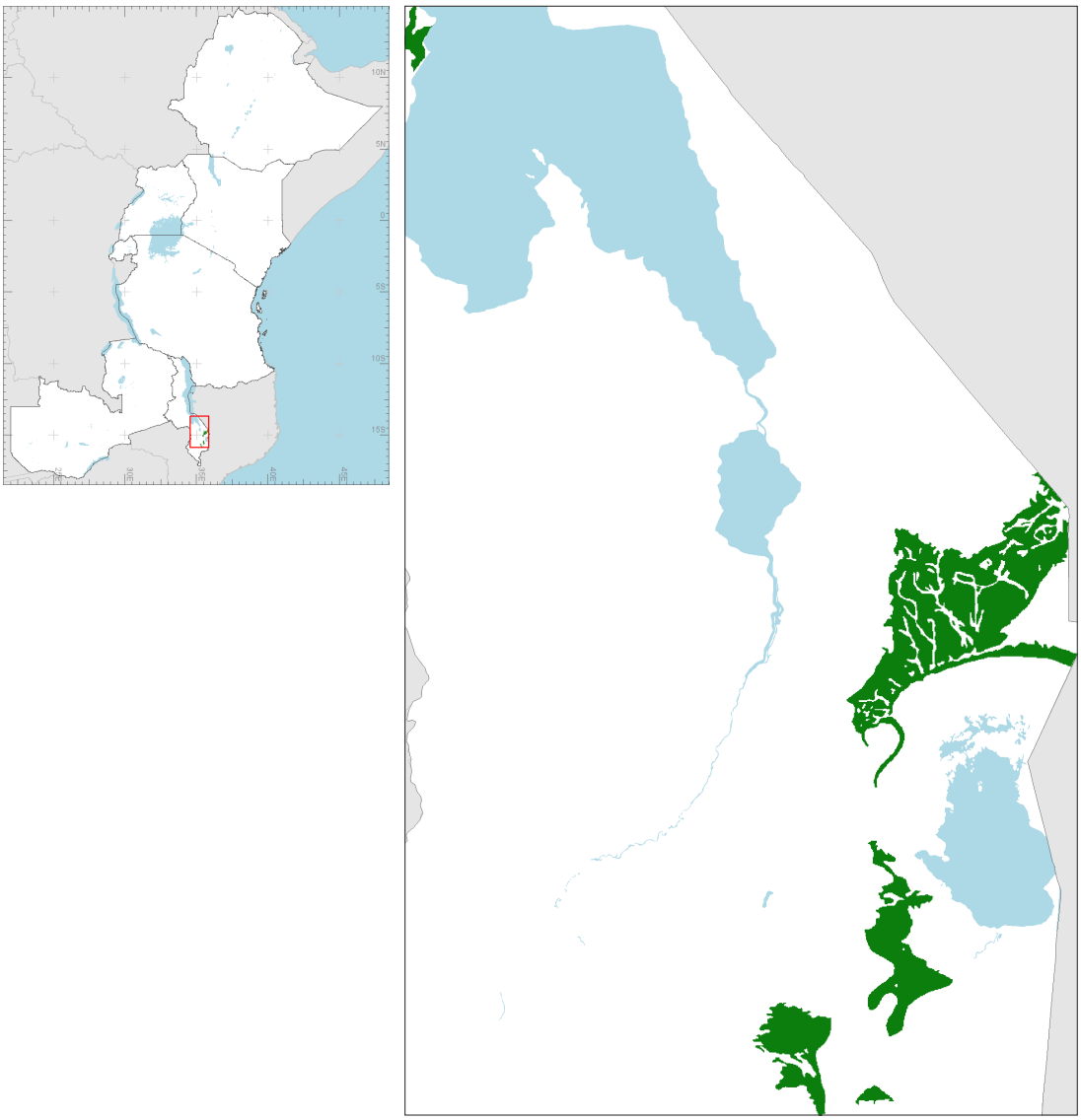
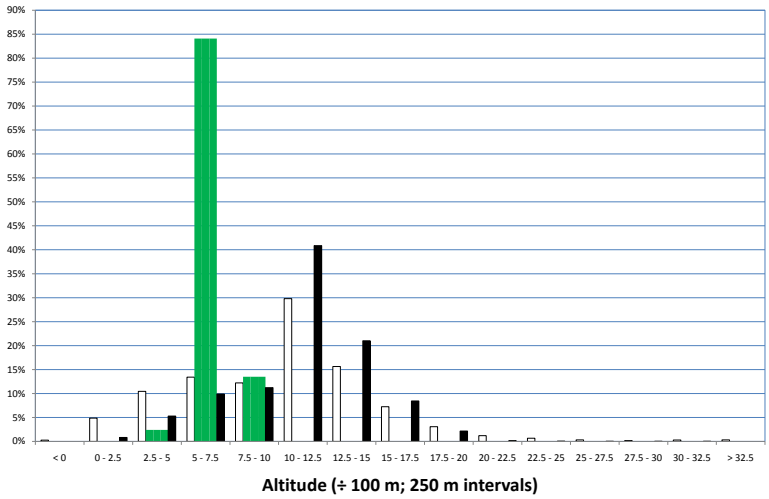
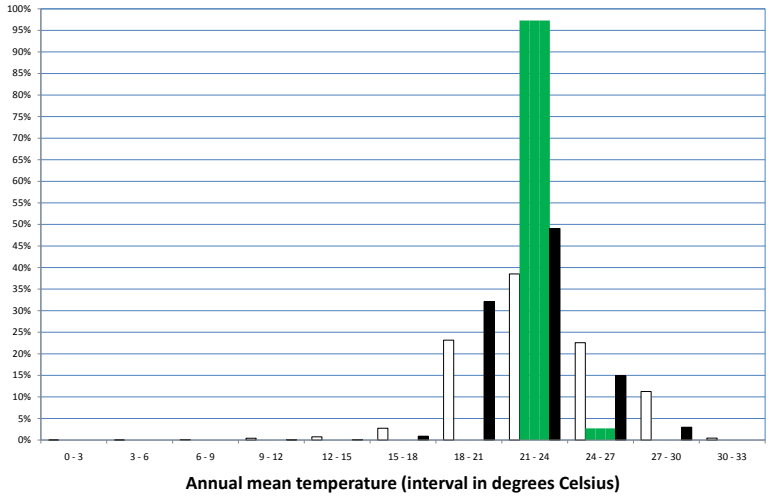


Figure 11.1. Mapped distribution of *Terminalia sericea* woodland in the VECEA region (Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda and Zambia). Green polygons depict where we mapped this vegetation type.

(a)



(b)



(c)

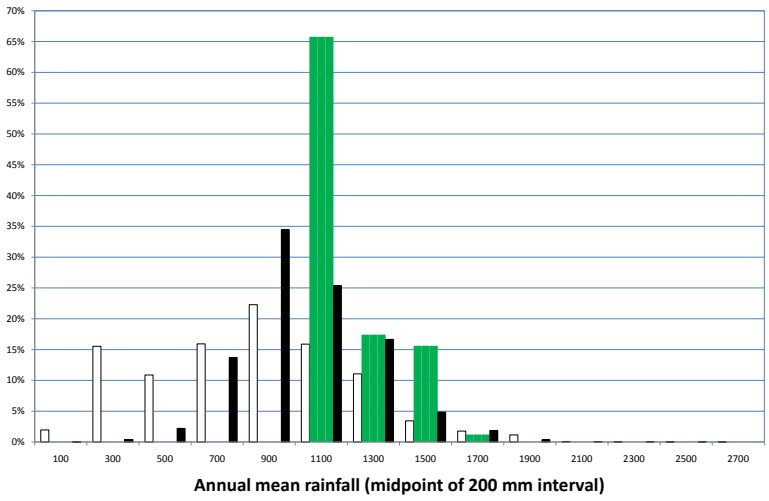


Figure 11.2. Histograms of the distribution of altitude (a), mean annual temperature (b) and mean annual rainfall (c). Bars at the centre of each interval show the percentage of samples within *Terminalia sericea* woodland (Wt, *n* = 333). Bars on left (open) show the overall percentage of samples (*n* = 740,047). Bars on the right (black) show the percentages of samples within woodland or wooded grassland (*n* =354,078).

11.3. Species composition

Species assemblages were obtained from the following references:

- Malawi: Species known by our Malawian co-author (Cornell Dudley) to occur in the area for "***Terminalia sericea*** woodland" were coded "x" (unless they were characteristic species)

Characteristic species were determined as:

- Malawi: ***Terminalia sericea*** was coded "C".

Table 11. Species composition of *Terminalia sericea* woodland (Wt)

Species	Regional status (see section 2.3)	WtM (Malawi)
Terminalia sericea	characteristic for miombo woodland, undifferentiated woodland, Chipya woodland and Kalahari woodland	C
Acacia xanthophloea	listed for Zambezian deciduous riparian forest	x
Brachystegia boehmii	indicator for miombo woodland	x

12. Chipya woodland and wooded grassland (Wy)

12.1. Description

Chipya woodland is a vegetation type that burns fiercely, consisting of markedly fire-resistant trees (also other than the Brachystegia, Julbernardia and Isoberlinia species that are dominant in miombo woodland [Wm]) that grow mixed in very tall grass. The name is derived from the Bemba name of 'cipya'.[35] Three herbaceous species (*Aframomum alboviolaceum*, *Pteridium aquilinum* and *Smilax anceps*) are almost universally present in Chipya woodland, but are absent from most types of miombo woodland (White 1983 p. 96). These herbaceous species were listed as "chipya indicators" by Fanshawe (1971 p. 15).[36]

Chipya woodland occurs on sites that were formerly occupied by Zambezian dry evergreen forest (Fm) or Zambezian transition woodland (an ecotone between miombo woodland [Wm] and Zambezian dry evergreen forest [Fm]. Chipya woodland consist of a complex mosaic representing different stages of degradation and reestablishment of the original vegetation, with one extreme being tall almost pure grassland and the other extreme being a community of evergreen species with a virtually closed canopy. The whole physiognomic spectrum spans Chipya woodland, Chipya wooded grassland and Chipya grassland; the term of "woodland" therefore under represents the physiognomy variation within this vegetation type (White 1983 p. 96). Chipya woodland occurs locally on suitable soils where rainfall exceeds 1000 mm per year. It is most extensively developed on the alluvial soils of lake basins and their associated river systems (White 1983 p. 96).

Fire-hardy trees in Chipya woodland that are sometimes 20 m or higher include ***Afzelia quanzensis***, ***Albizia antunesiana***, ***Amblygonocarpus andongensis, Burkea africana, Erythrophleum africanum, Parinari curatellifolia*** and ***Pericopsis angolensis***. (White 1983 p. 96). These species are also important in other Zambezian vegetation types, whereas it is mainly their tolerance for fire which enables them to survive and flourish in Chipya woodland. For example, *Amblygonocarpus andongensis, Burkea africana* and *Erythrophleum africanum* are (together with *Terminalia sericea*) characteristic of sandy soils at varying altitudes throughout the Zambezian region, including Chipya woodland (Smith and Trapnell 2002).

35: the noun refers to "burnt place" and is derived from the Bemba verb of "kupya", meaning "to burn" (Smith and Trapnell 2002).

Smith, P.P. & Trapnell, C.G. (2002). Chipya in Zambia: a review. Kirkia 18: 16-34.

36: These three indicator species are relict evergreen species that also occur in Zambezian dry evergreen forest (Fm, see Volume 2) and upland riparian forest (fr). *Afromomum alboviolaceum* and *Pteridium aquilinum* also occur locally in wetter plateau miombo woodland (Smith and Trapnell 2002).

Figure 13.1 Chipya woodland and wooded grassland in Zambia. Photograph by M. Bingham.

Figure 13.2 Chipya woodland and wooded grassland in Zambia. Photograph by M. Bingham.

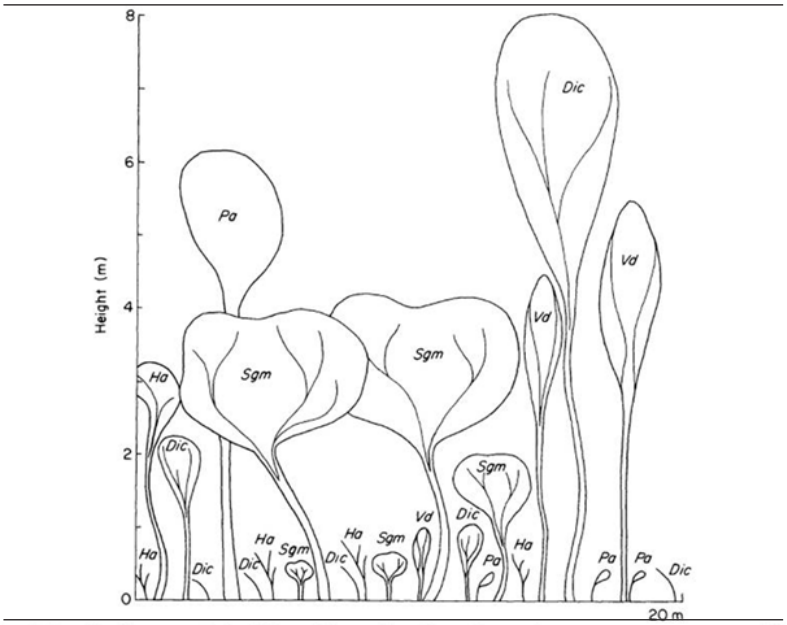


Figure 13.3 Profile diagram of a Chipya plot, including *Diplorhynchus condylocarpon* (Dic), *Hymenocardia acida* (Ha), *Pterocarpus angolensis* (Pa), *Syzygium guineense* ssp. *macrocarpum* (Sgm) and *Vitex doniana* (Vd). Lawton (1978, Figure 3). Image obtained from URL: *http://www.jstor.org/stable/2259187*

12.2. VECEA region

Within the VECEA region (Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda and Zambia), Chipya woodland was only mapped in Zambia. It possibly also occurs in Malawi.

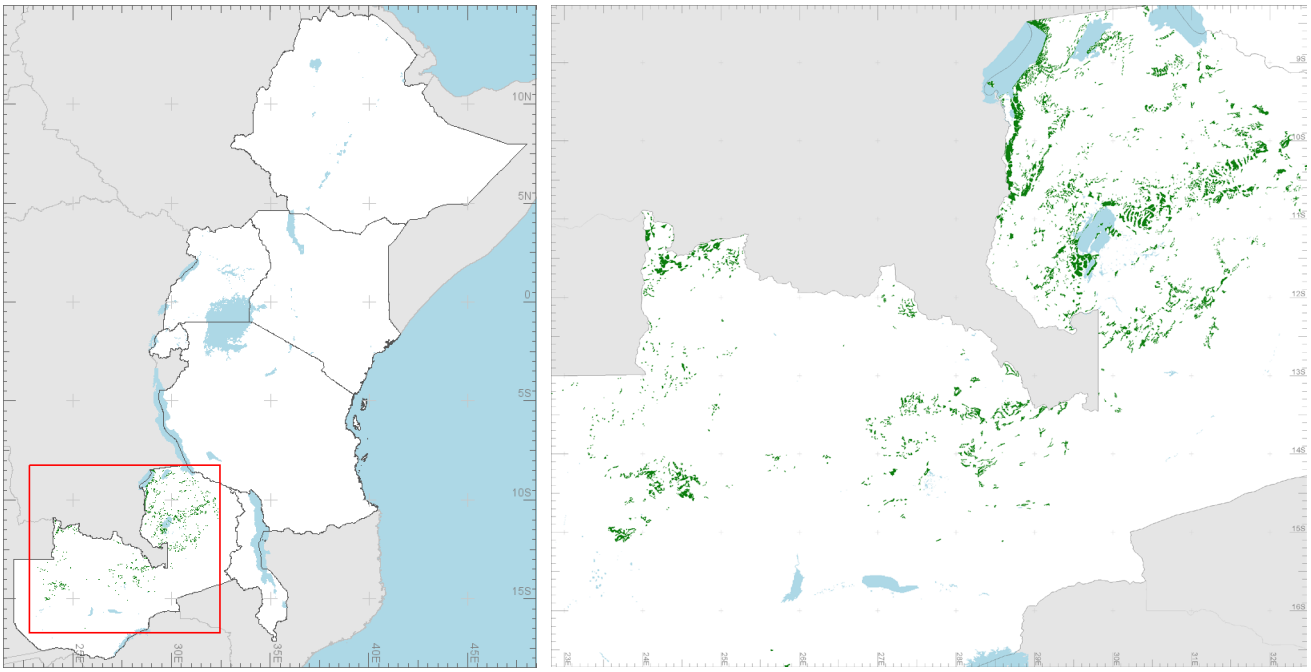


Figure 13.4. Mapped distribution of Chipya woodland in the VECEA region (Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda and Zambia). Green polygons depict where we mapped this vegetation type. It is possible that this vegetation type also occurs in Malawi and Tanzania.

Fanshawe (1971) distinguishes between four Zambian types of Chipya woodland: (i) lake basin Chipya woodland (original mapping unit 3); (ii) Kalahari Sand Chipya woodland (original mapping unit 5); (iii) Copperbelt Chipya woodland (original mapping unit 1 partially); and (iv) limestone Chipya woodland. [37]

Lake basin Chipya woodland is the result from total destruction of *Marquesia* forest (Fm, occurring in the Bangweulu lake basin). Total destruction from *Parinari* forest (Fm) and Itigi thicket (bi, see Volume 4) also lead to "lake-basin" types of Chipya. Lake basin Chipya woodland is a three-storeyed woodland with an open evergreen to deciduous canopy of 21 to 27 m high. The canopy is characterized by ***Afzelia quanzensis*** (locally), ***Albizia antunesiana, Burkea africana***, *Combretum collinum*, ***Erythrophleum africanum***, *Faidherbia albida*, *Ficus sycomorus* (locally), ***Parinari curatellifolia, Pericopsis angolensis***, *Pterocarpus angolensis*, *Sclerocarya birrea* (locally) and *Terminalia sericea* (Fanshawe 1971 p. 15).

Kalahari Sand Chipya woodland is the result from total destruction of *Cryptosepalum* forest (Fm). Characteristic canopy species are *Acacia goetzei*, ***Burkea africana***, *Combretum collinum*, *Dialium englerianum*, ***Erythrophleum africanum***, *Guibourtia coleosperma* (an extremely fire-resistant species that is a relic from *Cryptosepalum* forest), *Markhamia obtusifolia*, *Peltophorum africanum*,

37: The coding of the Trapnell *et al.* (1950) soil - vegetation map is based on the soil type with a suffix for the vegetation type. In the legend of the Fanshawe vegetation map (Edmonds 1976), an indicating is given that "lake basin Chipya" corresponds to B4 (*Erythrophloeum - Pterocarpus* etc. Chipya vegetation on lake basin and allied soils), "Kalahari Sand Chipya" corresponds to K11 and S (*Erythrophloeum - Pterocarpus* etc. Chipya vegetation on bracken sands [K11] and sand [S]) and Copperbelt Chipya (mapped together with *Parinari* forest) ;corresponds to R ("R" in red font on an orange background; *Erythrophloeum - Pterocarpus* etc. Chipya vegetation on soils of Red Earth class).

Pterocarpus angolensis, *Strychnos potatorum* and *Terminalia sericea*. (Fanshawe 1971 p. 17).

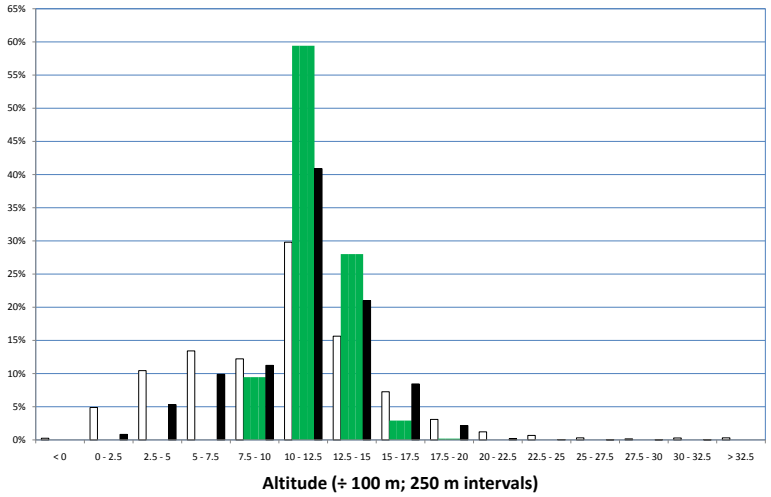
Copperbelt Chipya woodland is the result from partial destruction of *Parinari* forests (Fm). In Copperbelt Chipya woodland, the original forest overwood has been replaced by *Brachystegia spiciformis* (a dominant species of miombo woodland [Wm]) or *Brachystegia microphylla* (occasionally, also a dominant species of miombo woodland), but the original underwood is not (or only partially) destroyed (Fanshawe 1971 p. 13).

Limestone Chipya woodland is the result from total destruction from the Zambezian dry deciduous forest (Fn) that occurs on dolomitic limestone around Lake Kashiba. The dominant species in this Chipya woodland include *Acacia polyacantha*, *Erythrina abyssinica*, *Kigelia africana* and *Markhamia obtusifolia* (Fanshawe 1971 p. 23).

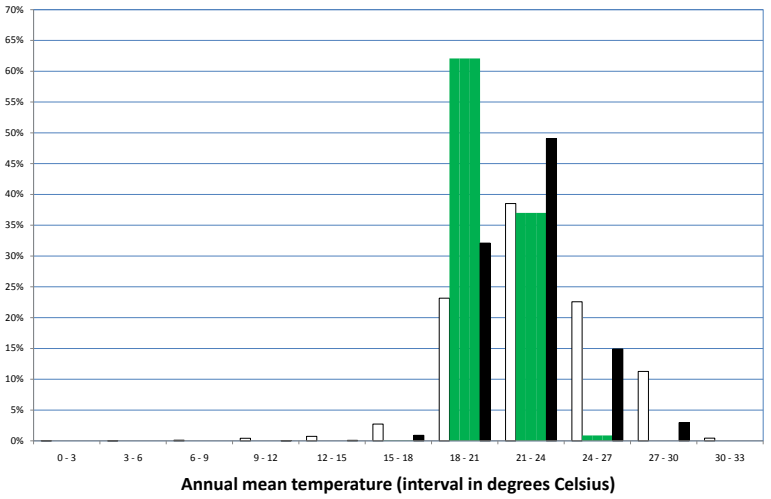
White (1983 p. 96) mentions that Chipya woodland occurs in parts of Malawi where rainfall exceeds 1000 mm per year, whereas we have not mapped Chipya woodland in Malawi.

Investigation of environmental distribution of Chipya woodland and wooded grassland in the VECEA region (Figure 12.5 shows that more than 95% of the samples occur in an interval from 750 – 1500 m. The altitude interval where most of samples occur is the same for this vegetation type (1000 – 1250 m; 59.4% of samples) as for all woodlands and wooded grasslands combined (40.9%). Chipya woodland and wooded grassland receives between 800 and 1600 mm annual rainfall (all samples). The rainfall interval where most samples occur for this vegetation type (1000 – 1200 mm; 45.0%) is higher than the rainfall interval where most samples occur for all woodlands and wooded grasslands combined (800 – 1000 mm; 34.4%). Less than 10% of samples receive less than 1000 mm annual rainfall: this agrees with the information provided by White (1983 p. 96) that Chipya woodland and wooded grassland generally receives more than 1000 mm annual rainfall.

(a)



(b)



(c)

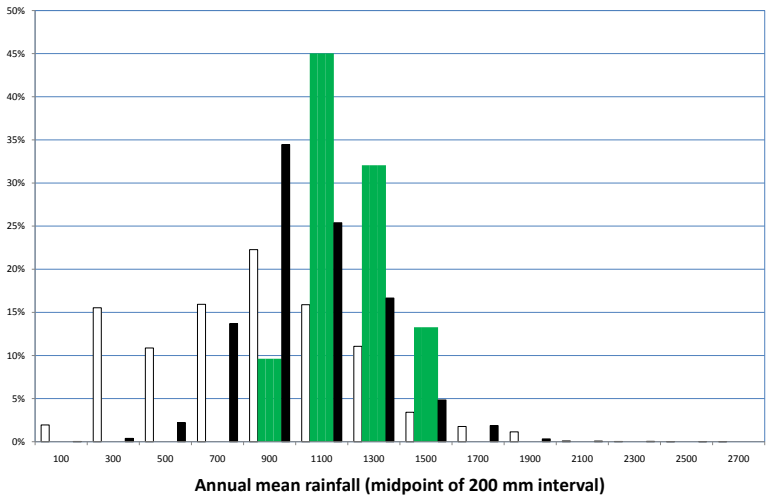


Figure 12.5. Histograms of the distribution of altitude (a), mean annual temperature (b) and mean annual rainfall (c). Bars at the centre of each interval show the percentage of samples within Chipya woodland and wooded grassland (Wy, *n* = 4,585). Bars on left (open) show the overall percentage of samples (*n* = 740,047). Bars on the right (black) show the percentages of samples within woodland or wooded grassland (*n* = 354,078).

12.3. Species composition

Species assemblages were obtained from the following references:

- Zambia: Fanshawe (1971). Species listed for the species composition table for "Chipya woodland" provided on pages 18 to 20 were coded "x" (unless they were characteristic species). Species indicated to be restricted in Copperbelt sites were coded "xc", those restricted to Kalahari Sand sites were coded "xk" and species restricted to Lake Basin sites were coded "xl".

Characteristic species were determined as:

- Zambia: Canopy species were coded "C". Species listed in the main text as characteristic canopy species for Copperbelt Chipya were coded "Cc", characteristic canopy species for Kalahari Sand Chipya were coded "Ck", characteristic species canopy species for Lake Basin Chipya were coded "Cl" and characteristic species for limestone Chipya were coded "Cs".

Table 12. Species composition of Chipya woodland and wooded grassland (Wy)

Species	Regional status (see section 2.3)	(Zambia)
Aframomum alboviolaceum	chipya indicator (herbaceous species that is absent from most types of miombo woodland and almost universally present in chipya)	x
Pteridium aquilinum	chipya indicator (herbaceous species that is absent from most types of miombo woodland and almost universally present in chipya)	x
Smilax anceps	chipya indicator (species that is absent from most types of miombo woodland and almost universally present in chipya)	x
Acacia polyacantha		Cs
Afzelia quanzensis	characteristic	Cl
Albizia adianthifolia		C
Albizia amara	not characteristic (indicator for Undifferentiated woodland)	C
Albizia antunesiana	characteristic	Cl
Amblygonocarpus andongensis	characteristic (indicator of sandy soils throughout the Zambezian region. Smith and Trapnell [2002])	C
Anisophyllea boehmii	indicator	x
Annona senegalensis		x
Antidesma venosum		x
Baphia massaiensis		x
Bauhinia petersiana		Cs
Bersama abyssinica		x
Bobgunnia madagascariensis	characteristic	x
Borassus aethiopum	not characteristic (indicator for Undifferentiated woodland - palm species)	xl
Brachystegia longifolia	not characteristic (miombo woodland and Kalahari woodland)	x
Brachystegia spiciformis	not characteristic (indicator for miombo woodland)	Cc
Burkea africana	characteristic	Ckl
Cassia abbreviata	not characteristic (indicator for Undifferentiated woodland)	x

Species	Regional status (see section 2.3)	(Zambia)
Combretum adenogonium	not characteristic (indicator for Undifferentiated woodland)	Cl
Combretum celastroides	indicator	Ckl
Combretum collinum	characteristic	Ckl
Combretum molle	not characteristic (indicator for Undifferentiated woodland)	x
Combretum zeyheri	characteristic	x
Dialium englerianum	not characteristic (indicator for Kalahari woodland)	Ck
Dichrostachys cinerea		x
Diplorhynchus condylocarpon	characteristic (this is an ubiquitous species in the Zambezian region that occurs primarily in fire-induced wooded grassland [Smith and Trapnell 2002])	Ckl
Dombeya rotundifolia	not characteristic (characteristic for miombo woodland and undifferentiated woodland)	x
Ekebergia benguelensis		x
Entada abyssinica		x
Erythrina abyssinica		Cs
Erythrophleum africanum	characteristic (indicator of sandy soils throughout the Zambezian region. Smith and Trapnell [2002])	Ckl
Faidherbia albida	not characteristic (indicator for Undifferentiated woodland)	Cl
Ficus sycomorus	not characteristic (indicator for Undifferentiated woodland)	Cl
Guibourtia coleosperma	(forest relic)	Ck
Harungana madagascariensis		x
Isoberlinia angolensis		C
Julbernardia globiflora		Cl
Julbernardia paniculata	not characteristic (characteristic for miombo woodland and Kalahari woodland)	C
Kigelia africana	not characteristic (indicator for Undifferentiated woodland)	Cs
Lannea discolor	not characteristic (indicator for Kalahari woodland)	x
Lannea schweinfurthii	not characteristic (indicator for Undifferentiated woodland)	C
Lonchocarpus capassa	not characteristic (indicator for Undifferentiated woodland)	C
Markhamia obtusifolia	not characteristic (indicator for Undifferentiated woodland)	Ckls
Marquesia macroura	(forest relic)	Cl
Maytenus senegalensis		x
Oldfieldia dactylophylla	indicator (White 1983 p. 97). This is an ubiquitous species in the Zambezian region that occurs primarily in fire-induced wooded grassland [Smith and Trapnell 2002])	x
Oxytenanthera abyssinica	bamboo species indigenous to Africa	xl
Parinari curatellifolia	characteristic	Cl
Pericopsis angolensis	characteristic (this is an ubiquitous species in the Zambezian region that occurs primarily in fire-induced wooded grassland [Smith and Trapnell 2002])	Cl
Piliostigma thonningii	not characteristic (indicator for Undifferentiated woodland)	Cl

Species	Regional status (see section 2.3)	(Zambia)
Pseudolachnostylis maprouneifolia	characteristic (this is an ubiquitous species in the Zambezian region that occurs primarily in fire-induced wooded grassland [Smith and Trapnell 2002])	Cl
Pterocarpus angolensis	characteristic	Ckl
Schinziophyton rautanenii	not characteristic (indicator for southern Kalahari woodland)	Ck
Sclerocarya birrea	not characteristic (characteristsic for mopane woodland and Undifferentiated woodland)	Cl
Securidaca longipedunculata		x
Stereospermum kunthianum		x
Strychnos cocculoides		x
Strychnos potatorum		Ck
Strychnos spinosa		x
Syzygium guineense	indicator (*Syzygium guineense* ssp. *guineense*)	Cs
Tecomaria capensis		x
Terminalia mollis	characteristsic for undifferentiated woodland)	x
Terminalia sericea	characteristic (indicator of sandy soils throughout the Zambezian region. Smith and Trapnell [2002])	Ckl
Vitex doniana		C
Ximenia americana		xc
Xylopia odoratissima	indicator	x
Zanha africana	indicator	C
Ziziphus abyssinica	not characteristic (indicator for Undifferentiated woodland)	C

13. Edaphic wooded grassland on drainage-impeded or seasonally flooded soils (edaphic vegetation type, wd)

13.1. Description

It is not always easy to discriminate between riverine wooded grasslands and edaphic wooded grasslands (there is a similar problem in differentiating riverine forest from swamp forests, see Volume 2). We were probably not consistent in allocating mapping units from national maps to riverine or edaphic wooded grasslands, but where proximity to a river was obvious, we preferred the classification of riverine wooded grasslands. The edaphic wooded grasslands that we classified as such typically contained *Acacia* species. Wooded grasslands dominated by palm species are sometimes riverine or indicative of conditions of impeded drainage, but we classified these vegetation types separately (VECEA mapping unit "P", see section 15) since they are easy to be distinguished in the field, from aerial photographs or even some satellite imagery.

White (1983) did not strictly apply a differentiation between edaphic wooded grassland (with cover percentages of 10 - 40% woody species) and edaphic grassland (with cover percentages of <10% woody species) since both types intergrade and edaphic wooded grasslands are often difficult to delimit from the more open grasslands with which they are associated (White 1983 pp. 50 - 52). **Within the VECEA map, we loosely defined "edaphic wooded grassland" as "edaphic grassland with scattered woody species" and "edaphic grassland" as "edaphic grassland without scattered woody species". This means that some vegetation types that would have been classified as "edaphic grasslands" in a strict physiognomic classification system (i.e. woody cover < 10%) may have been allocated to "edaphic wooded grasslands".**[38]

Although White (1983) described edaphic grasslands and wooded grasslands separately for the various floristic regions, we did not apply a floristic classification system to edaphic grasslands and edaphic wooded grasslands (although we directly relied on the information that was provided by White in descriptions of a particular floristic region).

Edaphic grassland areas of the Zambezian region were mapped and described as grasslands, including suffrutex grassland areas that are considered as wooded grasslands (mapping unit g, see Volume 5) by some authors.

In the Somalia-Masai region, water-receiving depressions covered with black and cracking clays are extensively developed in Central Tanzania; these depressions do not have sufficient run-off to carve stream beds and quickly evaporate in the dry season. The principal grasses that cover these

38: The definition of "grasslands" of Pratt *et al.* (1966) of "land dominated by grasses and occasionally other herbs; sometimes with widely scattered or grouped trees and shrubs, the canopy cover of which does not exceed 2%" may therefore provide a more accurate physiognomic definition of vegetation types that were classified as "edaphic grassland" by the VECEA project.

depressions ("mbugas" [39]) are ***Setaria incrassata*** and ***Themeda triandra***. The *mbugas* are treeless but are usually separated by an ecotone of wooded grassland that is dominated by various gall *Acacia* species, including ***Acacia drepanolobium, Acacia malacocephala, Acacia pseudofistula*** and ***Acacia seyal***. Seasonally waterlogged (wooded) grassland also occurs as ill-defined glades on non-cracking calcimorphic "hard pan" soils within deciduous bushland (Bd). The dominant grass species in these glades are dwarf grasses, including ***Microchloa indica***. The glades do not have trees or have scattered individuals of ***Acacia drepanolobium, Acacia mellifera, Acacia tanganyikensis, Acacia tortilis, Albizia amara, Albizia harveyi, Commiphora schimperi, Dalbergia melanoxylon, Lannea humilis, Sclerocarya birrea*** and ***Terminalia stuhlmannii***. Ill-defined areas of inland drainage in Somalia are covered with ***Cynodon dactylon*** and ***Chloris roxburghiana*** and have scattered ***Acacia tortilis*** (White 1983 p. 116).

Various types of edaphic wooded grassland are described for the Sudanian floristic region, including those occurring on the Pleistocene clays of the Nile Valley. Within the flood region, areas of slightly higher grounds that are only flooded to a shallow depth and where annual rainfall is in between 570 and 1000 mm are covered with ***Acacia seyal***. The transition zones in between swamp grasslands (containing ***Setaria incrassata***) and the better drained areas are sometimes dominated by the palm species ***Borassus aethiopum*** and ***Hyphaene thebaica***, either single or together (White 1983 p. 108).

Zanzibar-Inhambane edaphic (wooded) grassland cover large areas of grey-black cracking clay soils near the mouth of the Tana river. These grasslands are studded with thicket-covered termite mounds (described separately as Termitary vegetation [T, see Volume 4]). There are widely spaced individuals of ***Acacia zanzibarica***, ***Hyphaene compressa, Terminalia spinosa*** and ***Thespesia danis*** (White 1983 p. 189).

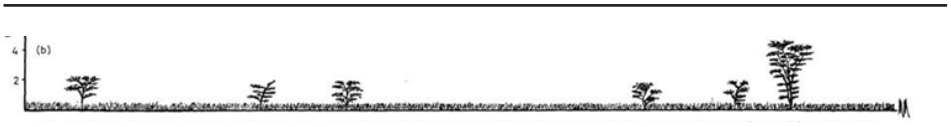


Figure 13.1Profile diagram of seasonally waterlogged wooded grassland with Acacia drepanolobium. Height of vegetation in meter. The grass species is Pennisetum mezianum. Pratt et al. (1966, Fig 5b). Image obtained from URL: *http://www.jstor.org/stable/2401259*.

39: The definition given (White 1983 p. 269) is of "water-receiving depressions in East Africa covered with grassland and Acacia-wooded grassland on seasonally satured, black, cracking clays. Mostly occurring at low altitudes and under a drier and hotter climate than dambos".

Figure 13.2 Edaphic wooded grassland with *Acacia drepanolobium* in Nairobi National Park (Kenya). Photograph by F. Gachathi (2009).

Figure 13.3 *Acacia seyal* var. *seyal* in Moyale District (Kenya) in an area with impeded drainage. Photograph by F. Gachathi (2009).

Figure 13.4 Typical East African bird species of edaphic wooded grassland within their habitat. Shell guide to East African birds (1960, reproduced with permission from URL *http://ufdc.ufl.edu/UF00077050)*.

Figure 13.5 Partly flooded "wooded grassland of the western Gambela region" with *Acacia nilotica, Acacia seyal* and *Balanites aegyptiaca*. West of Itang. Altitude approximately 450 m (September 1996). Photograph by I. Friis and Sebsebe Demissew. Reproduced from Biologiske Skrifter of the Royal Danish Academy of Sciences and letters, Vol. 58, Fig 17B. 2010.

Figure 13.6 *Acacia paolii* is common in places with black cotton soil (vertisols) that occur within *Acacia-Commiphora* bushland (Bd). In the original vegetation map of Ethiopia (Friis *et al*. 2010), areas with edaphic wooded grassland on black cotton soils that occur within areas of *Acacia-Commiphora* deciduous bushland (Bd) were not mapped separately in their " *Acacia-Commiphora* woodland and bushland proper" mapping unit; these include areas of *Acacia drepanolobium* (Friis *et al*. 2010 Fig 15E) and *Acacia paolii* (Friis *et al*. 2010 Fig 15G). Photograph by I. Friis and Sebsebe Demissew. Reproduced from Biologiske Skrifter of the Royal Danish Academy of Sciences and letters, Vol. 58, Fig 15G. 2010.

13.2. VECEA region

Edaphic wooded grassland on drainage-impeded or seasonally flooded soils occurs in each country of the VECEA region, although it was not mapped everywhere (Figure 14.7; see also Volume 6). The only country where this vegetation type was not described explicitly was Rwanda (but see below).

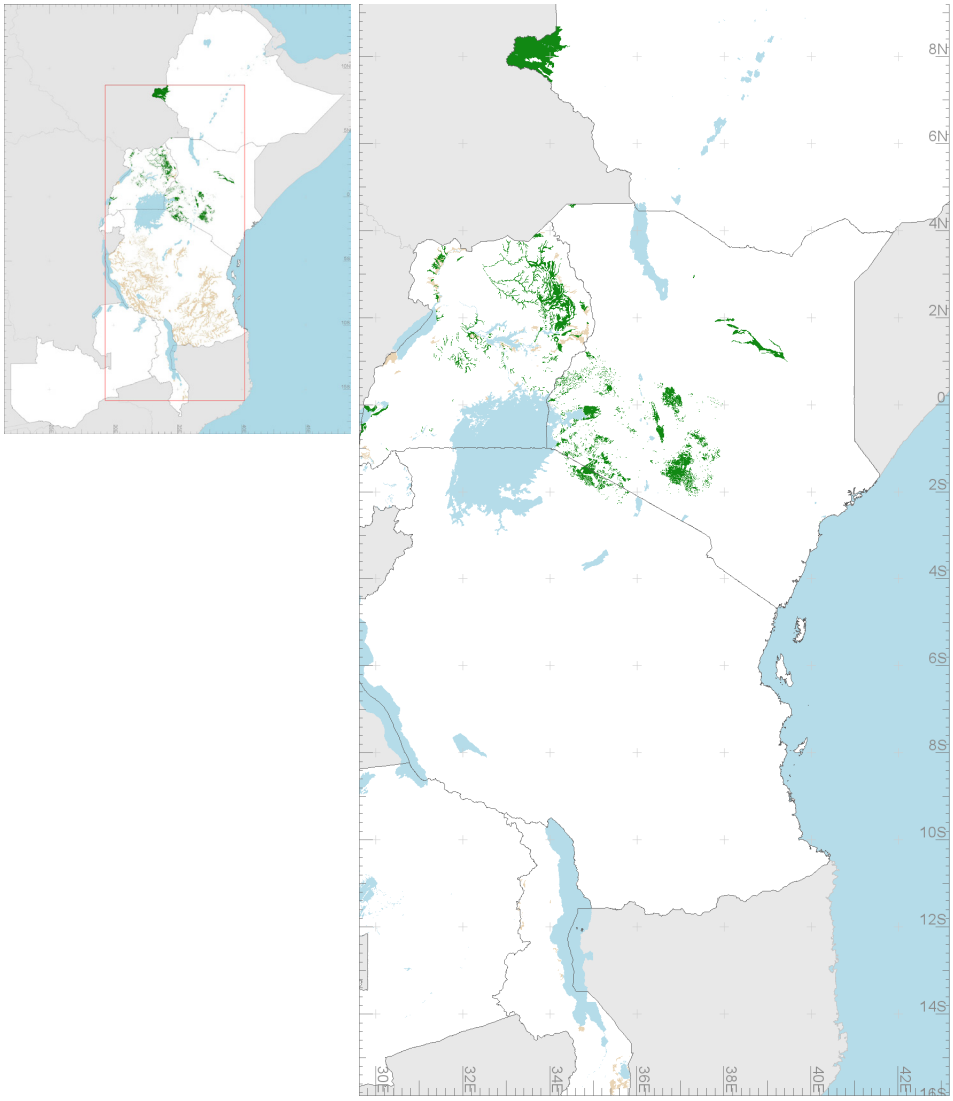


Figure 13.7. Mapped distribution of edaphic wooded grassland on drainage-impeded or seasonally flooded soils in the VECEA region (Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda and Zambia). Where this vegetation type does not occur in mosaic, it is depicted by green polygons. This vegetation type is also mapped as part of different vegetation mosaics (shown in greyish-brown). This vegetation type occurs in all VECEA countries, but was not mapped everywhere it occurs.

The Ethiopian wooded grassland of the western Gambela region (original mapping unit "WGG") is a vegetation type that is characterized by flooding, a tall grass stratum that burns annually and a canopy layer of trees that can both tolerate burning and temporary flooding (Friis *et al* 2010 pp. 55 and 58). Some areas that occur on areas with impeded drainage ("black cotton soil", *i.e.* a vertisol) within the area mapped in Ethiopia as "*Acacia-Commiphora* woodland and bushland proper" (original mapping unit ACB) are edaphic wooded grasslands with *Acacia drepanolobium* or *Acacia paolii* (Friis *et al.* 2010 pp. 48 - 52, figures 15C and 15G). Some *Acacia* species are also prominent on flat places with vertisols within the area mapped as "*Combretum-Terminalia* woodland and wooded grassland", such as areas occurring on a mixture of sand and black cotton soil in the Tekeze gorge (Friis *et al.* 2010 pp. 61 and 70). Probably some of the *Acacia* wooded grasslands of the original DAF-WG subtype could also be classified as edaphic wooded grassland on drainage-impeded or seasonally flooded soils (see discussion in Volume 2 for Afromontane undifferentiated forest [Fb]).

In Kenya, we classified edaphic wooded grassland on drainage-impeded or seasonally flooded soils by reclassifying all "Vegetation of soils with impeded drainage" subtypes from the Trapnell *et al.* (1966, 1969, 1976, 1986) map after excluding fresh-water swamps (original mapping unit 9; mapped in VECEA by mapping unit X), halophytic vegetation (original mapping unit 32; mapped in VECEA as mapping unit Z) and edaphic grassland types (original mapping units 8, 8a, 8b, 47 and 56A ; mapped in VECEA as mapping unit g). We included original mapping units 61a (*Acacia drepanolobium* with evergreen elements on pedocal and impeded drainage soils); 61b (allied *Acacia drepanolobium* savanna) and 61 c (allied *Acacia* - grassland mixtures). These are subtypes of what were originally "*Acacia* types derived from evergreen and semi-deciduous bushland" in the Trapnell *et al.* (1966, 1969, 1976, 1986) map.

The Range Management Handbook of Kenya (RMHK; Schwartz *et al.* 1991; Shaabani *et al.* 1992abc; Herlocker *et al.* 1993, Herlocker *et al.* 1994abcd) described "Woodland to grassland on seasonally waterlogged soils" for Marsabit District (original mapping type 11). In a harmonized GIS map that was later developed by Dennis Herlocker (he was the main botanist involved in the RMHK), mapping type 11 from Marsabit was changed to "*Lintonia - Acacia seyal* deciduous wooded grassland" (newer mapping unit 8.3; 8 indicates the physiognomy of deciduous wooded grassland) or (in an area bordering Isiolo district) to "*Sorghum* annual grassland" (newer mapping unit 28.3). Based on the earlier classification as edaphic wooded grassland, descriptions given for Isiolo district (such as the presence of *Acacia seyal*) and map positions, we reclassified mapping units 8.3 and 28.3 as edaphic grassland on drainage-impeded or seasonally flooded soils.

The Malawian "floodplain grasslands" have less than 10% cover of woody species (C. Dudley, personal observations), so in some physiognomic classification systems these would be classified as grasslands instead of wooded grasslands. For reasons explained in the previous section, these floodplain grasslands were included in the VECEA map with edaphic wooded grassland on drainage-impeded or seasonally flooded soils.

Gillman (1949 p. 29) mapped the "water-receiving depressions" described above for the Somalia-Masai region in Tanzania (*i.e.* "mbugas"; White 1983 p. 116) as the "Masailand rain-pond catena", and described this vegetation type as "a sea of dominating thornbush with irregularly distributed islands of (edaphic) grassland usually surrounded by a narrow fringe of wooded grassland". Gillman (1949 Fig. 30 p. 27) includes a photograph of the "rain-pond catena". White (1983 p. 116) refers to this photograph as one of the typical photographs for Somalia-Masai edaphic grassland.

In Uganda, we included the original subtypes of "*Acacia - Imperata* savanna on soils with impeded drainage", "*Acacia-Setaria* savanna on soils with impeded drainage", "*Acacia - Themeda* savanna on soils with impeded drainage", "*Combretum - Acacia drepanolobium - Hyparrhenia* savanna on soils with impeded drainage" and "*Combretum - Acacia - Hyparrhenia* savanna on soils with impeded drainage" in areas that were mapped by VECEA as edaphic wooded grassland on drainage-impeded or seasonally flooded soils.

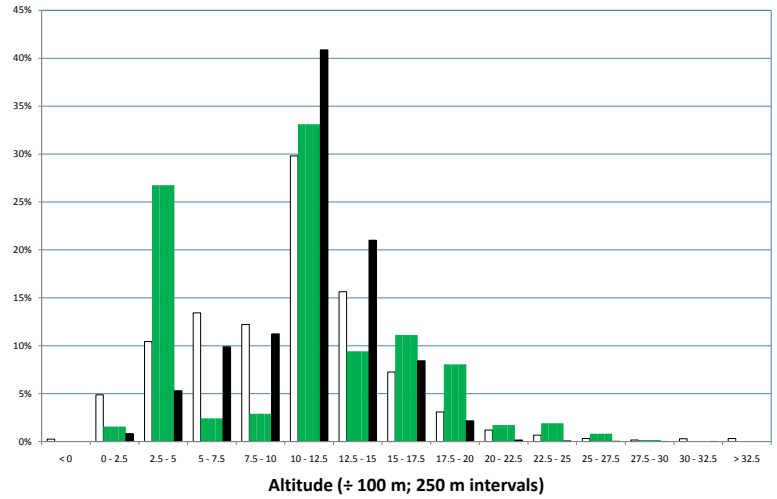
Edaphic wooded grassland on drainage-impeded or seasonally flooded soils was not mapped in Zambia. This vegetation type was originally not mapped, although it was originally described as "Munga scrub woodland types that occur on black impermeable clays over extensive areas of the Kafue flats" within the description of Undifferentiated woodland (Wn; Fanshawe 1971 p. 52).

Edaphic wooded grassland on drainage-impeded or seasonally flooded soils also occurs in the coastal areas of Kenya and Tanzania ("Zanzibar-Inhambane edaphic grassland"; White 1983 p. 189). These areas were mapped in the Zanzibar-Inhambane coastal mosaic (see Volume 6).

Edaphic wooded grassland on drainage-impeded or seasonally flooded soils was not described explicitly in Rwanda. However, there is some evidence that this vegetation type does occur in this country as Bloesch *et al.* (2009) mention that *Acacia polyacantha* occurs on badly drained soils.

Investigation of environmental distribution of edaphic wooded grassland on drainage-impeded or seasonally flooded soils in the VECEA region (Figure 13.8; limits are for areas of the VECEA map where this vegetation type is not mapped as mosaic) shows that this vegetation type occurs under a wide range of altitudes and rainfalls. This phenomenon agrees with the edaphic and other non-climatic conditions that lead to the occurrence of this vegetation type.

(a)



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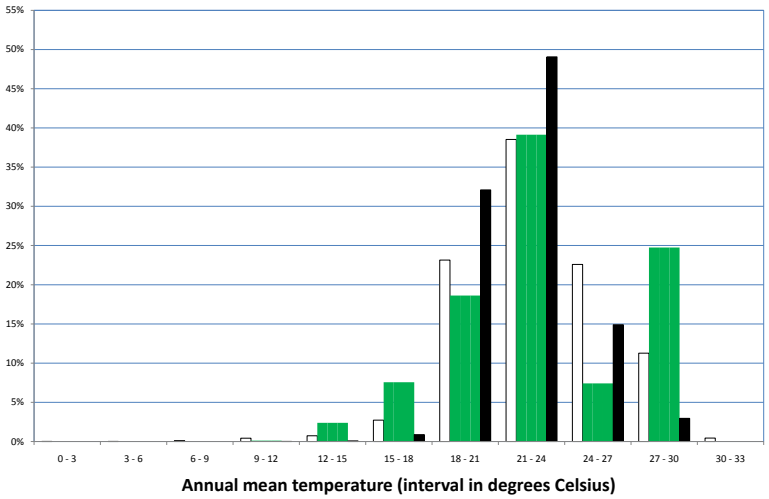

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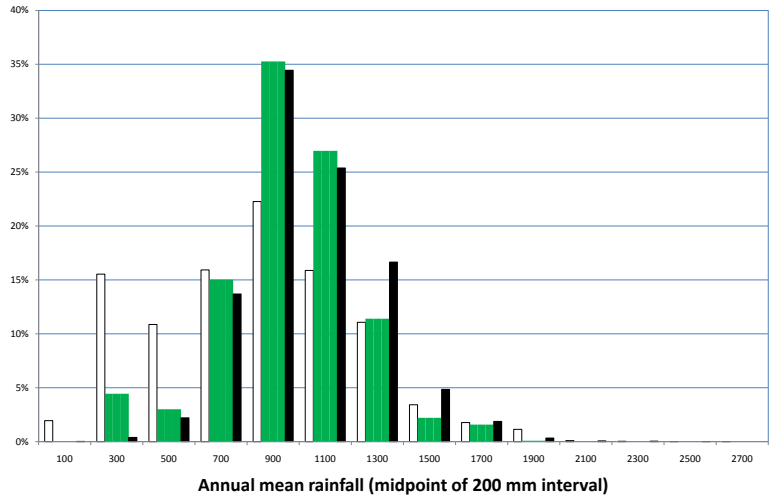


Figure 13.8. Histograms of the distribution of altitude (a), mean annual temperature (b) and mean annual rainfall (c). Bars at the centre of each interval show the percentage of samples within Edaphic wooded grassland on drainage-impeded or seasonally flooded soils (wd, *n* = 10,227). Bars on left (open) show the overall percentage of samples (*n* = 740,047). Bars on the right (black) show the percentages of samples within woodland or wooded grassland (*n* =354,078).

13.3. Species composition

Species assemblages were obtained from the following references:

- Ethiopia: Friis *et al.* 2010. Species mentioned in Appendix 3 for "Wooded grassland of the Western Gambela region " [WGG] were coded "x" (unless they were characteristic species)
- Kenya): Species that were expected to occur in edaphic wooded grassland on drainage-impeded or seasonally flooded soils based on information from Beentje (1994), the Flora of Tropical East Africa and field experience from our Kenyan co-author (F. Gachathi) were coded "x". Species associated with mapping units that we reclassified as edaphic wooded grassland on drainage-impeded or seasonally flooded soils from the Range Management Handbook of Kenya (RMHK; Schwartz *et al.* 1991; Shaabani *et al.* 1992abc; Herlocker *et al.* 1993, Herlocker *et al.* 1994abcd) were coded "xn".
- Malawi: Jackson (1969), Jackson and Wiehe (1958), Howard-Williams (1977) and information from fieldwork from our Malawian co-author (C. Dudley, pers. comm.). Species listed for "Flood plain grassland" were coded "x" (unless they were characteristic species)
- Tanzania (columns "wdeT" and "wdnT"): White (1983 p. 116): Those species that were listed for the wooded grassland **e**cotone around "mbugas" (black clays in water receiving depressions) were coded "C" in column "wdeT". In a separate column ("wdnT"), species that were listed to occur as scattered invididuals in **n**on-cracking edaphic grasslands inside *Acacia-Commiphora* bushland were coded "C".
- Uganda: Langdale-Brown *et al.* (1964). All species mentioned in the appendix to occur in "*Acacia-Imperata* savanna on soils with impeded drainage" (W4) were coded "x4", those species occurring in "*Combretum - Acacia - Hyparrhenia* savanna on soils with impeded drainage" (W5) were coded "x5", those speces occurring in "*Combretum - Acacia drepanolobium - Hyparrhenia* savanna on soils with impeded drainage" (W6) were coded "x6" and those occurring in "*Acacia - Themeda* savanna on soils with impeded drainage" (W7) were coded "x7" (unless they were characteristic species). Species from the grass layer were coded "g", using the same suffixes as woody species..
- Zambia: Fanshawe (1971). Species listed for Munga scrub woodland types that occur on black impermeable clays over extensive areas of the Kafue flats were coded "C".
- Coastal areas of Kenya and Tanzania: White (1983 p. 189). Tree species listed to be widely spaced within Zanzibar-Inhambane edaphic grassland on grey-black cracking clay soil near the mouth of the Tana river were coded "C".

Characteristic species were determined as:

- Ethiopia: Those species that were mentioned in the description for "Wooded grassland of the Western Gambela region " [WGG] type in the main text were coded as "C". Species mentioned to occur on

vertisols were coded as "Cv".

- Kenya: Species listed as part of the names for at least one of the mapping units of the Trapnell *et al.* (1966, 1969, 1976, 1986) map were coded "C".
- Malawi: Those species that were characterized as medium sized trees (10 - 20 m) were coded as "C".
- Tanzania: All species were assumed to be characteristic species ("C").
- Uganda: Those species that were mentioned in the main text or were indicated in the appendix to be dominant species were coded "C".
- Zambia: All species were assumed to be characteristic species ("C").
- Coastal areas of Kenya and Tanzania: All species were assumed to be characteristic species ("C").

Within the information on assemblages, coding "f" indicates that there is information that the species **potentially** occurs in the vegetation type since it occurs in the focal country and in the same woodland (or wooded grassland) type in other countries (see section 2.3).

Table 13. Species composition of edaphic wooded grassland on drainage-impeded or seasonally flooded soils (wd)

Species	Regional status (see section 2.3)	(Ethiopia)	(Kenya)	(Malawi)	wdeT (Tanzania subtype)	wdnT (Tanzania subtype)	(Uganda)	(Zambia)	(coast)
Abutilon hirtum		f	xn		f	f	f		f
Acacia amythethophylla		f	f	f	f	f	x56	f	
Acacia brevispica		f	x		f	f	f		f
Acacia drepanolobium	Somalia-Masai edaphic grassland	Cv	Ct		C	C	C68		
Acacia elatior			x				f		f
Acacia etbaica		f	x		f	f	f		f
Acacia gerrardii		f	C	f	f	f	x568	f	f
Acacia hockii		f	f	f	f	f	x456	f	f
Acacia kirkii			x		f	f	f	f	
Acacia malacocephala	Somalia-Masai edaphic grassland		x		C	f			
Acacia mellifera	Somalia-Masai edaphic grassland; scattered bushes in edaphic grassland of the Serengeti plains; Pleistocene clays of the Nile valley	Cv	C		f	C	f	f	f
Acacia nilotica		C	x	f	f	f	f	C	f
Acacia oerfota		f	x		f	f	f		f
Acacia paolii		Cv	x						
Acacia polyacantha		f	C	f	f	f	C4 x5	C	f
Acacia pseudofistula	Somalia-Masai edaphic grassland		x		C	f			
Acacia robusta		f	x		f	f		f	f
Acacia senegal		Cv	f		f	f	x6	f	f
Acacia seyal	Somalia-Masai edaphic grassland; Pleistocene clays of the Nile Basin	C	Cn	f	C	f	C7 x8	C	
Acacia sieberiana		f	C	f	f	f	C57 x6	C	f
Acacia stuhlmannii			x		f	f			f
Acacia tanganyikensis	Somalia-Masai edaphic grassland		x		f	C			
Acacia tortilis	Somalia-Masai edaphic grassland	f	x		f	C	f	f	f
Acacia xanthophloea			x	C	f	f			f
Acacia zanzibarica	Zanzibar-Inhambane edaphic grassland	f	f		f	f			C
Aeschynomene abyssinica		f	x	f	f	f	f	f	
Albizia amara	Somalia-Masai edaphic grassland	f	x	f	f	C	x6	f	
Albizia harveyi	Somalia-Masai edaphic grassland		x	f	f	C	f	f	f
Alloteropsis cimicina			f	x	f	f	f		

Species	Regional status (see section 2.3)	(Ethiopia)	(Kenya)	(Malawi)	wdeT (Tanzania subtype)	wdnT (Tanzania subtype)	(Uganda)	(Zambia)	(coast)
Andropogon kelleri	seasonally waterlogged grassland in Somalia with scattered *Acacia tortilis*		x						
Aristida adscensionis	seasonally waterlogged grassland in Somalia		x						
Aspilia mossambicensis		f	xn		f	f	f		
Balanites aegyptiaca	Sudanian grassland on shallow soil over ironstone	x	x		f	f	C67 x58	f	
Balanites glabra		f	x		f	f			f
Balanites rotundifolia		f	x				x68		f
Barleria acanthoides		f	xn		f	f	f		
Bauhinia petersiana				f	f	f		C	
Blepharis acanthodioides	Somalia-Masai edaphic grassland		x						
Blepharis linariifolia			xn						
Borassus aethiopum	*Sudanian valley and floodplain edaphic grassland; Sudanian wooded edaphic grassland on pleistocene clays; palm species*	C	f	f	f	f	f	f	f
Bothriochloa bladhii			f	x	f	f	g6		
Bothriochloa insculpta			f		f	f	g6		
Brachiaria decumbens			f		f	f	g4		
Bridelia scleroneura		f	f		f	f	x5		
Cadaba glandulosa		f	x		f	f	f		f
Cadaba rotundifolia		f	x						
Caesalpinia trothae		f	x		f	f			
Cenchrus ciliaris	seasonally waterlogged grassland in Somalia		x		f	f	f		
Chloris gayana			x	x	f	f	f		
Chloris roxburghiana	seasonally waterlogged grassland in Somalia with scattered *Acacia tortilis*		x		f	f	f		
Chloris virgata			x		f	f	f		
Chrysopogon plumulosus	seasonally waterlogged grassland in Somalia		x		f	f			
Combretum adenogonium		f	f	f	f	f	C56 x4	C	
Combretum collinum		f	f	f	f	f	x456	f	f
Commiphora schimperi	Somalia-Masai edaphic grassland	f	x		f	C	f		
Cynodon dactylon	seasonally waterlogged grassland in Somalia		x		f	f	f		
Cynodon plectostachyus			x		f	f	f		
Dactyloctenium aegyptium			x	x	f	f	f		

Species	Regional status (see section 2.3)	(Ethiopia)	(Kenya)	(Malawi)	wdeT (Tanzania subtype)	wdnT (Tanzania subtype)	(Uganda)	(Zambia)	(coast)
Dalbergia melanoxylon	Somalia-Masai edaphic grassland	f	x	f	f	C	f	f	f
Dichanthium annulatum			f		f	f	g8		
Dichrostachys cinerea		f	f	f	f	f	x8	f	f
Diospyros kirkii				f	f	f	f	C	
Duosperma eremophilum			xn						
Echinochloa haploclada			f		f	f	f		x
Echinochloa pyramidalis			f	x	f	f	f		
Enteropogon macrostachyus			x						f
Eragrostis atrovirens			f	x	f	f			
Eriochloa fatmensis							g8		
Erythrina abyssinica		f	f	f	f	f	x6	f	f
Faidherbia albida		f	f	f	f	f	f	C	f
Flueggea virosa		f	x	f	f	f	f	f	f
Gardenia ternifolia	Sudanian grassland on shallow soil over ironstone	f	f		f	f	x5		f
Harrisonia abyssinica		x	f	f	f	f	x8	f	f
Hymenocardia acida		f	f	f	f	f	x5	f	
Hyparrhenia filipendula			f		f	f	g56		
Hyparrhenia rufa			f	x	f	f	g6		
Hyphaene compressa	Zanzibar-Inhambane edaphic grassland (palm species)	f	f		f	f			C
Hyphaene petersiana	(palm species)			C	f	f		f	
Hyphaene thebaica	Sudanian edaphic wooded grassland on pleistocene clays; palm species	C							
Imperata cylindrica			f		f	f	g4		
Jasminum streptopus		x	f	f				f	f
Kigelia africana		f	f	f	f	f	x46	f	f
Kyllinga alba	Somalia-Masai edaphic grassland		x						
Lannea humilis	Somalia-Masai edaphic grassland	f	x		f	C	x6	f	
Leersia hexandra			f	x	f	f	g4		
Leptochloa fusca			f	x	f	f	f		
Maytenus senegalensis		f	f	f	f	f	x5	f	f
Microchloa indica	Somalia-Masai edaphic grassland		x		f	C			
Microchloa kunthii			f		f	f	g5		

Species	Regional status (see section 2.3)	(Ethiopia)	(Kenya)	(Malawi)	wdeT (Tanzania subtype)	wdnT (Tanzania subtype)	(Uganda)	(Zambia)	(coast)
Mimosa pigra		f	f	f	f	f	x4	f	
Ocimum basilicum			x		f	f			
Oryza barthii				x	f	f			
Oryza longistaminata		C							
Panicum coloratum	seasonally waterlogged grassland in Somalia		x		f	f	f		
Panicum maximum			f		f	f	g4		
Panicum repens			f	x	f	f	f		
Parinari curatellifolia			f	f	f	f	f	f	x
Pavetta crassipes		f	f		f	f	x6		
Pennisetum purpureum			f	x	f	f	f		
Phoenix reclinata	(palm species)	f	f	f	f	f	x4	f	f
Piliostigma thonningii		x	f	f	f	f	C45 x6	C	f
Pluchea ovalis			x		f	f	f		
Pseudocedrela kotschyi	Sudanian grassland on shallow soil over ironstone	f					x456		
Salvadora persica		f	xn	f	f	f	f	f	f
Sclerocarya birrea	Somalia-Masai edaphic grassland	f	x	f	f	C	f	f	f
Sesbania rostrata		x			f	f			
Setaria incrassata	Somalia-Masai edaphic grassland; Pleistocene clays of the Nile Basin		x	x	x	f	g8		
Setaria pumila			f	x	f	f	f		
Setaria sphacelata			f		f	f	g45		x
Solanum incanum			x	f	f	f	f	f	
Sorghastrum bipennatum				x	f	f			
Sorghum arundinaceum									x
Sorghum bicolor				x					
Sorghum purpureo-sericeum	Pleistocene clays of the Nile basin		f		f	f	g8		
Sporobolus festivus			f		f	f	g5		
Sporobolus helvolus			xn		f	f	f		
Sporobolus ioclados			f	x	f	f	f		
Sporobolus pyramidalis			f	x	f	f	g46		

Species	Regional status (see section 2.3)	(Ethiopia)	(Kenya)	(Malawi)	wdeT (Tanzania subtype)	wdnT (Tanzania subtype)	(Uganda)	(Zambia)	(coast)
Stereospermum kunthianum		f	f	f	f	f	x45	f	f
Strychnos innocua		f	f	f	f	f	x4	f	f
Terminalia spinosa	Zanzibar-Inhambane edaphic grassland	f	f		f	f	f		C
Terminalia stenostachya				f	f	f		C	
Terminalia stuhlmannii	Somalia-Masai edaphic grassland		x		f	C		f	
Tetrapogon cenchriformis			x		f	f	f		
Thalia geniculata		C							
Themeda triandra	Somalia-Masai edaphic grassland; edaphic grasslands of the Serengeti plains; Zambezian edaphic grassland		x		x	f	g78		
Thespesia danis	Zanzibar-Inhambane edaphic grassland	f	f		f	f			C
Tribulus cistoides			xn		f	f			
Turraea nilotica		x	f	f	f	f		f	f
Uapaca nitida				f	f	f		f	x

14. Riverine woodland (edaphic vegetation type, wr)

14.1. Description

It is not always easy to discriminate between riverine wooded grasslands and edaphic wooded grasslands (there is a similar problem in differentiating riverine forest from swamp forests, see Volume 2). We were probably not consistent in allocating mapping units from national maps to riverine or edaphic wooded grasslands, but where proximity to a river was obvious, we preferred the classification of riverine wooded grasslands.

In Marsabit district, some woodlands occur at low elevations (< 1000 m) on sandy alluvial soils along the larger seasonal streams where periodic stream flow and the increased moisture storage-capacity of the sandy soils compensate for low rainfall and high potential evaporation. ***Acacia tortilis*** is the dominant species of these woodlands. Other low elevation woodlands that are dominated by ***Acacia tortilis*** occur in Marsabit district on alluvial and colluvial soils a the base of Mt. Nyiru, Ol Doinyou Mara and the Ndoto Mts. (White 1983 p. 121).

One of the variants described for Undifferentiated woodland (Wn) is "riparian woodland" (White 1983 p. 95). We described this vegetation type in the general treatment of Undifferentiated woodland (Wn). An alternative mapping system could be to map "riparian woodland" as riverine woodland.

Figure 14.1. Riverine *Acacia tortilis* woodland in Turkana District (Kenya). This vegetation type extends for several kilometers. Photograph by F. Gachathi (2010).

Figure 14.2. Riverine *Acacia elatior* woodland along a seasonal river in Isiolo District (Kenya) during the dry season. Photograph by F. Gachathi (2008)

14.2. VECEA region

Within the VECEA region (Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda and Zambia), riverine woodland was only described for Kenya. Within the VECEA map, we have not distinguished riverine forest from other riverine wooded vegetation types (see Volume 1). One of the reasons for not making such distinction is that differences exist in classification systems whether a specific type of riverine wooded vegetation type is classified as "riverine forest" (classified as "fr" in VECEA), "riverine woodland" (classified as "wr" in VECEA) or "riverine thicket" (classified as "br" in VECEA).

The original map of the Kenyan highlands by Trapnell *et al.* (1966, 1969, 1976, 1986) contained various "upland *Acacia*" vegetation subtypes that occur on recent alluvium[39]:

(i) *Acacia xanthophloea* (original mapping unit 30 on vegetation sheets 2 and 4)
(ii) mixtures of *Acacia xanthophloea* and *Acacia kirkii* (original mapping unit 30 on vegetation sheet 3)
(iii)Acacia kirkii (original mapping unit 30a)
(iv) Acacia polyacantha (original mapping unit 30b); and
(v) Acacia gerrardii (original mapping unit 30c)

We reclassified these vegetation types are riverine woodland because, besides the reference to recent alluvium in the original legend for all these vegetation types, the shape of various polygons (such as the *Acacia xanthophloea* polygons north of Nyeri, the *Acacia xanthophloea* polygons within Nairobi National Park and the *Acacia xanthophloea* and *Acacia kirkii* polygons south and east of Narok) also suggest that these are riparian. *Acacia xanthophloea* and *Acacia polyacantha* are typical riparian species (White 1983 p. 129). The original upland *Acacia* areas surrounding the Rift Valley lakes of Elmenteita, Naivasha and Nakuru are also of the *Acacia xanthophloea* type.

The Range Management Handbook of Kenya (RMHK; Schwartz *et al.* 1991; Shaabani *et al.* 1992abc; Herlocker *et al.* 1993, Herlocker *et al.* 1994abcd) described "riverine woodland" for Marsabit district (original mapping type 10). In a harmonized GIS map that was later developed by Dennis Herlocker (he was the main botanist involved in the RMHK project), mapping type 10 from Marsabit was changed to "*Acacia tortilis* semi-deciduous woodland" [40] (newer mapping unit 5.1; 5 indicates the physiognomy of semi-deciduous woodland), "*Acacia tortilis - Acacia elatior* semi-deciduous woodland" (newer mapping unit 5.2) or "*Sporobolus - Duosperma - Acacia tortilis* deciduous wooded grassland" (newer mapping unit 8.1; 8 indicates the physiognomy of deciduous wooded grassland).

For other districts of the Range Management Handbook of Kenya (RMHK), riverine wooded vegetation types were not classified separately from deciduous wooded grassland (Wd) or *Combretum* wooded grassland (Wc). Based on information from species descriptions and landscape positions, we classified the following mapping units as riverine woodland:

39: Trapnell and Langdale-Brown (1972 p. 132) describe that closed stands (*i.e.* woodland physiognomical types) of species like *Acacia polyacantha*, *Acacia xanthophloea* and *Acacia tortilis* are found under progressively drier regimes on alluvial flats.

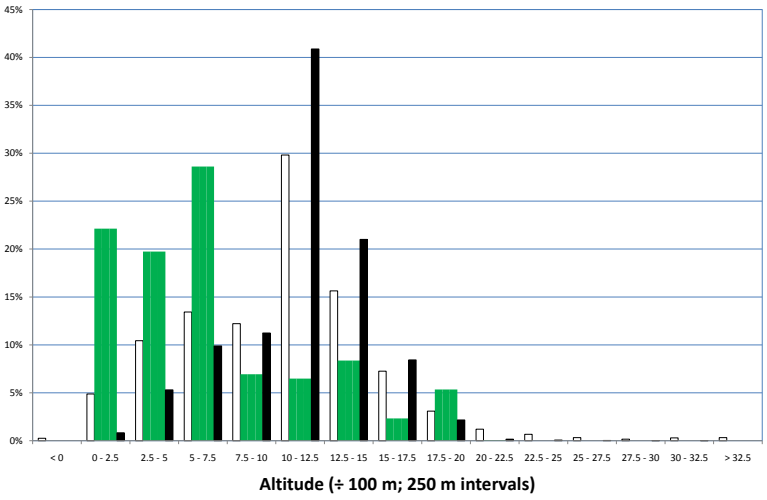
40: In the RMHK, "woodland" is defined as vegetation of trees with canopy cover over 20%, whereas "wooded grassland" is defined as vegetation of trees with canopy cover between 2 and 20%. Note that the regional definition of wooded grasslands specifies cover percentages of 10% and 40% (see section 1).

(i) *Hyphaene* evergreen woodland (mapping unit 2.1, Mandera District);
(ii) *Acacia tortilis - Acacia elatior - Hyphaene* evergreen and semi-deciduous woodland (4.2, Isiolo District);
(iii) *Hyphaene - Acacia tortilis* evergreen and semi-deciduous woodland (4.4, Turkana District);
(iv) *Acacia tortilis - Acacia elatior* semi-deciduous woodland (5.2, Baringo, Elgeyo-Marakwet, Marsabit and Turkana districts); and
(v) *Sporobolus - Duosperma - Acacia tortilis* deciduous wooded grassland (8.1, Isiolo and Marsabit districts).

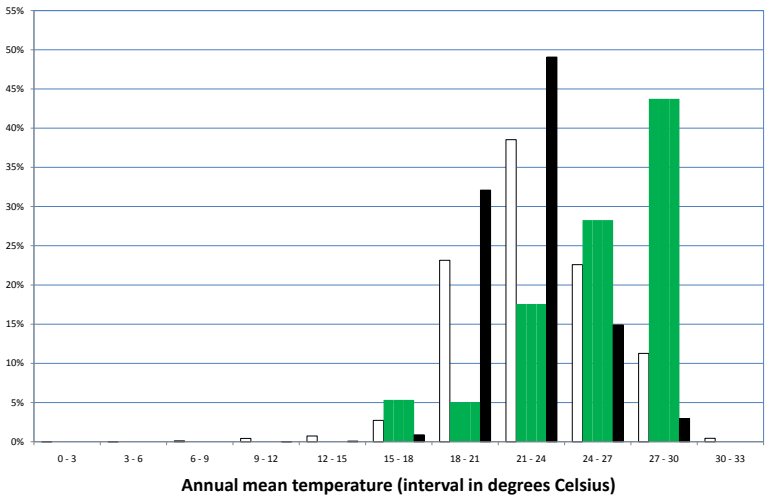
We also classified "*Sporobolus - forbs - Acacia seyal* deciduous shrub grassland" (mapping unit 21.1, occurring in Wajir district) as riverine based on its shape, the description of seasonal water flow and the mention of (unidentified) *Sesbania* species. In a stricter classification system, this vegetation type should probably have been classified as "riverine bushland".

Investigation of environmental distribution of riverine woodland in the VECEA region (Figure 14.3; limits are for areas of the VECEA map where this vegetation type is not mapped as mosaic) shows that more than 90% of the samples occur in an interval from 0 – 1500 m. The altitude interval of 500 – 750 m contains the highest number of samples (28.6%), whereas a considerable proportion of samples occur at lower altitudes (showing that this is clearly the woodlands and wooded grasslands vegetation type that occur at the lowest altitudes). Riverine wooded grassland generally has the lowest rainfall of all woodlands and wooded grasslands with more than 95% of samples receiving between 0 and 1000 mm. Among all woodlands and wooded grasslands, this vegetation type has the lowest rainfall interval where most samples occur (200 – 400 mm; 38.9%).

(a)



(b)



(c)

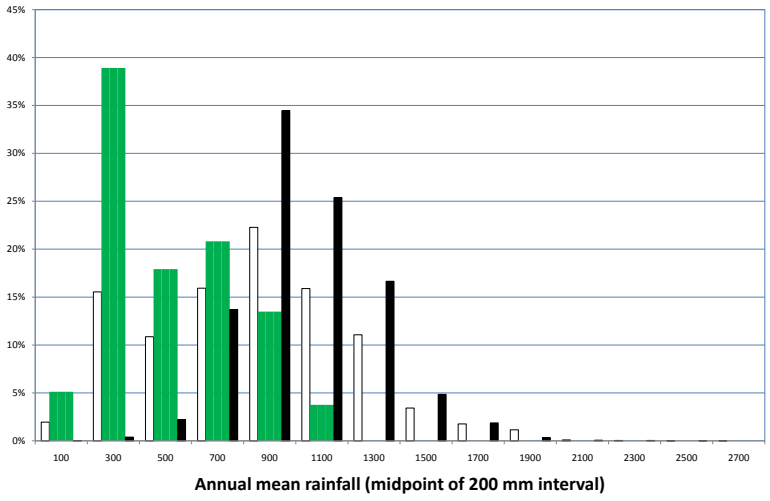


Figure 14.3. Histograms of the distribution of altitude (a), mean annual temperature (b) and mean annual rainfall (c). Bars at the centre of each interval show the percentage of samples within riverine woodland (wr), *n* = 1,758). Bars on left (open) show the overall percentage of samples (*n* = 740,047). Bars on the right (black) show the percentages of samples within woodland or wooded grassland (*n* =355,078).

14.3. Species composition

Species assemblages were obtained from the following references:

- Kenya: Species associated with mapping units that we reclassified as riverine woodland from the Range Management Handbook of Kenya (RMHK; Schwartz *et al.* 1991; Shaabani *et al.* 1992abc; Herlocker *et al.* 1993, Herlocker *et al.* 1994abcd) were coded "C", with a suffix (2, 4, 5, 8, a) indicating the main physiognomic mapping unit in the RMHK (suffix "a" indicating physiognomic unit 21).

Characteristic species were determined as:

- Kenya: all species were assumed to be characteristic.

Species assemblage information was provided in a separate column ("wrK") in the species assemblage table for riverine forest (fr, volume 2).

15. Palm wooded grassland (physiognomically easily recognized type, P)

15.1. Description

White (1983) did not describe palm wooded grasslands as a separate vegetation type in his main treatment of floristic regions. However, he describes ***Hyphaene coriacea*** palm stands that occur on sites with permanent ground water at the edge of the Chalbi desert and at the base of Mt. Kulal (White 1983 p. 123). ***Borassus aethiopum*** and ***Hyphaene petersiana*** (synonym: *Hyphaene ventricosa*) are among the characteristic species of the riparian woodland subtype of Undifferentiated woodland and wooded grassland (Wn, White 1983 p. 95). ***Borassus aethiopum*** is listed to occur in seasonally inundated flood plains in the Sudanian floristic region (White 1983 p. 107). ***Borassus aethiopum*** and ***Hyphaene thebaica*** occur on transition zones between swamp grassland and better drained areas with *Acacia seyal* in the flood region of the Nile (White 1983 p. 108). ***Hyphaene compressa*** occurs in Zanzibar-Inhambane edaphic wooded grassland (White 1983 p. 189). ***Phoenix reclinata*** and ***Raphia farifera*** are palm species that are listed among the more important species of swamp forests that are widespread in the Lake Victoria region and elsewhere (White 1983 p. 181). ***Phoenix reclinata*** occurs in swamp forests in the Zanzibar-Inhambane region (White 1983 p. 188).

Lind and Morrison (1974 p. 94) mention that palm wooded grassland is limited in area, but so noticeable that it needed to be included in descriptions of East African vegetation types. The main species is ***Borassus aethiopum***. In Uganda, it is found on sands and sandy loams with mobile ground water. In Kenya, it is scattered through the coastal belt and is noticeable on the Shimba Hills. In Tanzania, extensive stands occur in the flood plains of the Igombe and Ugala rivers and other riverine communities where it is sometimes accompanied by *Hyphaene* doum palm species. ***Hyphaene coriacea*** is the dominant palm species on the Ruaha - Usangu plain complex and in the Warmi and Mkata flood plains. *Borassus* stands are more common than *Hyphaene* in parts of the coastal plain, but small trees (up to 3 m) of *Hyphaene* form extensive stands in grassland on poorly drained sands.
From the descriptions above it is clear that the palm stands that were described often occur in areas with drainage impediments or riverine locations. It would therefore be perfectly acceptable to classify and map these vegetation types as "edaphic wooded grassland" (wd) or "riverine wooded grassland" (wr), which we have done in several situations. We think that discrimination between these types is more a question of the scale of mapping since palm trees can easily be identified in the field.

Figure 15.1 *Borassus - Hyperthelia dissoluta* [a grass species, synonym: *Hyparrhenia dissoluta*,] palm wooded grassland (original mapping unit M2) from Uganda. Photograph by J. Kalema.

Figure 15.2 Stand of *Phoenix reclinata* in waterlogged area within Afromontane rain forest (Fa). Photograph by I. Friis and Sebsebe Demissew. Reproduced from Biologiske Skrifter of the Royal Danish Academy of Sciences and letters, Vol. 58, Fig 25G. 2010.

Figure 15.3 *Hyphaene petersiana* wooded grassland next to the Shire River marsh and lagoons (Liwonde National Park, Malawi). An alternative classification method for this vegetation type would have been as "edaphic wooded grassland on drainage-impeded or seasonally flooded soils". Photograph by C. Dudley.

15.2. VECEA region

Within the VECEA region, palm wooded grassland was originally mapped in Kenya, Malawi, Uganda and Zambia (Figure 15.7, see also Volume 6). Palm wooded grassland also occurs in the other VECEA countries where it was described to occur in mosaic with other vegetation types. Also within those countries where palm wooded grassland was mapped separately, we expect it to occur more widely in vegetation mosaics.

Figure 15.7. Mapped distribution of palm wooded grassland in the VECEA region (Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda and Zambia). Where this vegetation type does not occur in mosaic, it is depicted by green polygons. This vegetation is also mapped as part of different vegetation mosaics (shown in greyish-brown). This vegetation type is distributed more widely than shown in the map. It occurs in each VECEA country.

In Ethiopia, palm species (***Borassus aethiopum, Hyphaene compressa, Hyphaene thebaica*** and *Phoenix reclinata*) were mapped within other vegetation types (Friis *et al.* 2010 p. 236).

In Kenya, Palm wooded grassland was originally mapped as "Palm savanna with *Hyphaene coriacea*" [class 11] in the Del Sol vegetation map; see Volume 6).

In Malawi, Palm wooded grassland was originally mapped as *Hyphaene petersiana* wooded grassland.

Gillman (1949 pp. 24-25) indicates that palm stands occur as "intrazonals" (defined as vegetation types that occur as a result of rapid alterations of geological, edaphic or anthropogenic conditions under a uniform climate, but that could not be represented on the map) in wooded grasslands and semi-desert vegetation in Tanzania. He also refers to Borassus palm stands that occur within the "central plateau catena" (*i.e.* a catena of miombo woodland, Undifferentiated woodland (Wn) and edaphic grassland) where shallow ground water is present (Gillman 1949 p. 28).

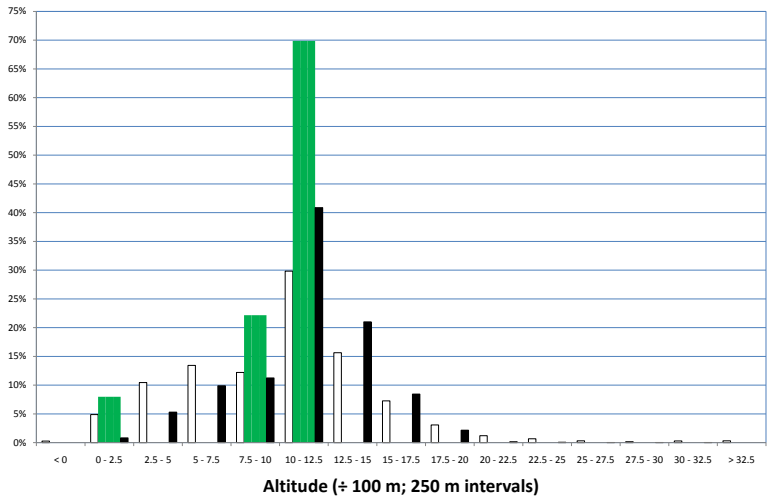
For Uganda, Langdale-Brown *et al.* (1964 p. 59) distinguish a wetter "Borassus - *Hyparrhenia rufa* palm savanna" (original mapping unit M1) and a drier "*Borassus - Hyperthelia dissoluta* [synonym: *Hyparrhenia dissoluta*] palm savanna" (original mapping unit M2). These two wooded grassland types mainly differ in their grass layers. The distinction between wetter and drier types - including the dominance of the *Hyparrhenia rufa* grass in wetter types and the dominance of the *Hyperthelia dissoluta* grass in drier types - is similar as in *Vitellaria* wooded grasslands (Wb) and *Combretum* wooded grasslands (Wc). Both palm communities are usually found on lower hillsides or other positions with mobile ground water.

In Zambia, palm wooded grassland was originally mapped as "*Hyphaene* palm country" (SK1; see Volume 6). As indicated on the legend of the Fanshawe vegetation map (Edmonds and Fanshawe 1976) where the correspondence between the classification systems for Zambia of Fanshawe (1970) and Trapnell *et al.* (1950) is indicated, Fanshawe included the Trapnell *et al.* "*Hyphaene* palm country on marginal Transitional (Kalahari) Sands (SK1)" into mapping unit 4 (originally classified as Munga woodland, classified as Undifferentiated woodland [Wn] by the VECEA project). Trapnell *et al.* (1950 p. 20) describe "Hyphaene palm country" as belts of scattered *Hyphaene ventricosa* (now: *Hyphaene petersiana*) with associated *Acacia giraffae* (now: *Acacia erioloba*), *Burkea africana*, *Combretum* spp. and *Terminalia sericea*. Based on the Trapnell *et al.* (1950) map, we separated the *Hyphaene* areas from other areas mapped as Undifferentiated woodland (Wn).

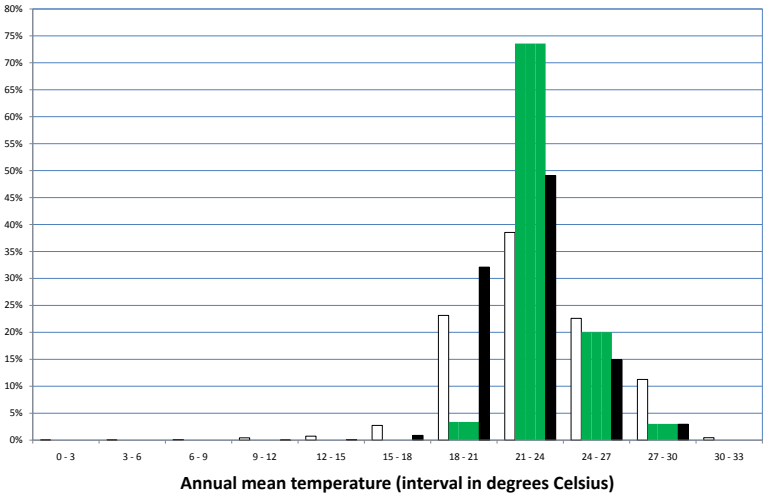
Investigation of environmental distribution of palm wooded grassland in the VECEA region (Figure 15.9; limits are for areas of the VECEA map where this vegetation type is not mapped as mosaic) shows that more than 90% of the samples occur in an interval from 750 – 1250 m. The altitude interval where most of samples occur is the same for this vegetation type (1000 – 1250 m; 69.9% of samples) as for all woodlands and wooded grass-

lands combined (40.9%). Palm wooded grassland generally receives between 800 and 1600 mm annual rainfall (> 90% samples). The rainfall interval of 1200 – 1400 mm contains the highest number of samples (51.2%); *Terminalia glaucescens* woodland (Wvt) is the only woodland and wooded grassland type that has a higher rainfall interval where the most samples occur.

(a)



(b)



(c)

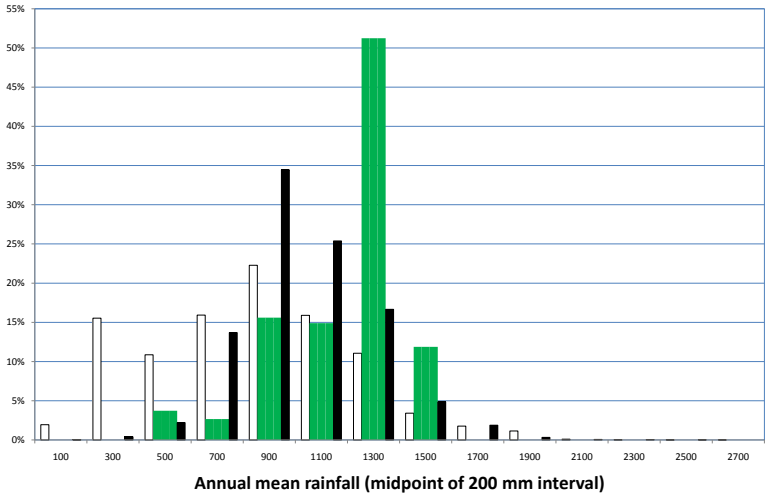


Figure 15.9. Histograms of the distribution of altitude (a), mean annual temperature (b) and mean annual rainfall (c). Bars at the centre of each interval show the percentage of samples within Palm wooded grassland (P, *n* = 564). Bars on left (open) show the overall percentage of samples (*n* = 740,047). Bars on the right (black) show the percentages of samples within woodland or wooded grassland (*n* =354,078).

15.3. Species composition

Species assemblages were obtained from the following references:

- Ethiopia: Friis *et al.* (2010 p. 236). All species listed for the Arecaceae family were coded "C".
- Kenya): Beentje (1994). All indigenous species from the Arecaceae (synonym: Palmae) family were coded "C".
- Malawi: Kabwazi & Kanjo (1999). Species mentioned in the reference for "*Hyphaene petersiana* wooded grassland " were coded "x" (unless they were characteristic species)
- Rwanda: Bloesch *et al.* (2009). Species listed for the Arecaceae family were coded "C".
- Tanzania: Species were assigned based on floristic similarity only.
- Uganda (columns "P1U" and "P2U"): Langdale-Brown *et al.* (1964). All species that were listed to occur in (wetter) "Borassus - *Hyparrhenia rufa* palm savanna" (M1) in the main text were coded "x" (unless they were characteristic species). In a separate column ("P2U"), all species that were listed to occur in (drier) "Borassus - *Hyperthelia dissoluta* [synonym: *Hyparrhenia dissoluta*] palm savanna" (M2) in the main text were coded "x" (unless they were characteristic species).
- Zambia: Trapnell *et al.* (1950 p. 20). The typical species for mapping unit SK1 was coded "C".
- Coastal areas of Kenya and Tanzania: Beentje (1994). All indigenous species from the Palmae species that were listed for floristic region K7 were coded "C".

Characteristic species were determined as:

- Ethiopia: All species were assumed to be characteristic ("C")
- Kenya: All species were assumed to be characteristic ("C")
- Malawi: Those species that were characterized as medium sized trees (10 - 20 m) were coded as "C", unless they were dominant species. Dominant species were coded as "D".
- Rwanda: All species were assumed to be characteristic.
- Tanzania: Characteristic species were not determined.
- Uganda: The palm species that were mentioned in the main text were identified as dominant species and were coded "D".
- Zambia: All species were assumed to be characteristic.
- Coastal areas of Kenya and Tanzania: All species were assumed to be characteristic.

Within the information on assemblages, coding "f" indicates that there is information that the species **potentially** occurs in the vegetation type since it occurs in the focal country and in the same woodland (or wooded grassland) type in other countries (see section 2.3).

Table 15. Species composition of Palm wooded grassland (physiognomically easy type, P)

Species	Regional status (see section 2.3)	(Ethiopia)	(Kenya)	(Malawi)	(Rwanda)	(Tanzania)	P1U (Uganda)	P2U (Uganda)	(Zambia)	(Coast)
Borassus aethiopum	Palm species (north Zambezian undifferentiated woodland: riparian woodland subtype, Sudanian edaphic grassland on Pleistocene clays, Zanzibar-Inhambane secondary grassland and wooded grassland)	C	C	f		f	D	D	f	C
Cocos nucifera	Palm species (Zanzibar-Inhambane edaphic grassland and secondary grassland)		C			f				C
Elaeis guineensis	Palm species (associated species in swamp forest on Pemba island)		C	f		f	f	f		C
Hyphaene compressa	Palm species (Zanzibar-Inhambane edaphic grassland and secondary grassland)	C	C			f				C
Hyphaene coriacea	Palm species (small stands with permanent ground water at the edge of the Chalbi desert and at the base of Mt. Kulal)		C			f				C
Hyphaene petersiana	Palm species (north Zambezian undiffertiated woodland: riparian woodland subtype)			D		f			C	
Hyphaene thebaica	Palm species (Sudanian undifferentiated woodland, Sudanian edaphic grassland on Pleistocene clays)	C								
Phoenix reclinata	Palm species (small communities in areas with frequent landslides on Mt. Kulal, Lake Victoria swamp forest, Zanzibar-Inhambane swamp forest	C	C	f	C	f	f	f	f	C
Raphia farinifera	Palm species (Lake Victoria swamp forest)		C	f		f	f	f	f	C
Acacia erioloba									C	
Acacia gerrardii				f				x	f	
Acacia nigrescens				C					f	
Acacia nilotica				x			f	f	f	
Acacia polyacantha				f			x	x	f	
Acacia senegal								x	f	
Acacia sieberiana				C			x	x	f	
Acacia xanthophloea				C						
Adansonia digitata				C					f	
Albizia adianthifolia				x			f	f	f	
Albizia amara				x			f	f	f	
Albizia coriaria								x	f	

Species	Regional status (see section 2.3)	(Ethiopia)	(Kenya)	(Malawi)	(Rwanda)	(Tanzania)	P1U (Uganda)	P2U (Uganda)	(Zambia)	(Coast)
Albizia versicolor				C			f	f	f	
Albizia zygia								x		
Antidesma venosum				x			f	f	f	
Balanites aegyptiaca								x	f	
Bridelia scleroneura							x			
Burkea africana				f			f	f	C	
Combretum collinum				f			x	x	f	
Combretum molle				f				x	f	
Commiphora africana				x			f	f	f	
Dalbergia melanoxylon				x			f	f	f	
Dichrostachys cinerea				x			f	f	f	
Diospyros mespiliformis				C			f	f	f	
Erythrina abyssinica				f			x		f	
Faidherbia albida				C			f	f	f	
Grewia bicolor				x			f	f	f	
Kigelia africana				C				x	f	
Lannea schweinfurthii				C			f	f	f	
Lecaniodiscus fraxinifolius				x			f	f	f	
Lonchocarpus capassa				C					f	
Markhamia obtusifolia				x					f	
Maytenus senegalensis				x			f	f	f	
Ozoroa insignis				f				x	f	
Piliostigma thonningii				C			x	x	f	
Salvadora persica				x			f	f	f	
Sterculia africana				C					f	
Stereospermum kunthianum				f			x		f	
Tamarindus indica				f				x	f	
Terminalia glaucescens								x		
Terminalia sericea				f					C	
Trichilia emetica				C			f	f	f	
Ziziphus mucronata				x			f	f	f	

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Appendices

Appendix 1. Information on useful tree species

Information on useful tree species was obtained from the following references listing "useful trees and shrub species" for one of the seven VECEA countries: Bekele-Tesemma (2007), Fanshawe (1982), Katende *et al.* (1995), Maundu and Tengnas (2005), Mbuya *et al.* (1994), Nduwayezu *et al.* (2009), Simute *et al.* (1998) and Williamson (1975). From the Williamson (1975) reference, only species were included for which it was mentioned that their wood was used for timber or other purposes.

Table A1. Information on useful tree species that occur in at least one of the woodland or wooded grassland potential natural vegetation types. x = species was listed in the reference on useful tree species in the country; f = there is floristic information that the species occurs in the country; w = the only floristic information is from the UNEP-WCMC species database

Species	Ethiopia	Kenya	Malawi	Rwanda	Tanzania	Uganda	Zambia
Abutilon angulatum	f		f	x		f	f
Acacia abyssinica	x	x	f	x	f	x	
Acacia brevispica	x	x		x	f	f	
Acacia bussei	x	f			f		
Acacia drepanolobium	f	x			f	f	
Acacia elatior		x				f	
Acacia erioloba							x
Acacia gerrardii	f	x	f	x	f	x	f
Acacia hockii	f	f	f	x	x	x	f
Acacia kirkii		x		x	f	f	f
Acacia lahai	x	x			f	x	
Acacia mellifera	f	x			x	x	f
Acacia nigrescens			x		f		f
Acacia nilotica	x	x	f		x	x	f
Acacia oerfota	x	f			f	f	
Acacia paolii	f	x					
Acacia polyacantha	x	x	x	x	x	f	x
Acacia senegal	x	x		x	x	x	f
Acacia seyal	x	x	f		x	x	f
Acacia sieberiana	x	f	f	x	f	x	x
Acacia tortilis	x	x			x	x	f
Acacia xanthophloea		x	f		x		
Acokanthera oppositifolia		x	f				f
Acokanthera schimperi	x	x		x	x	f	
Adansonia digitata	x	x	f		x		x
Adenium obesum	f	x				x	
Afzelia africana						x	
Afzelia quanzensis		x	x		x	w	x
Albizia adianthifolia		f	f	x	f	x	x

Species	Ethiopia	Kenya	Malawi	Rwanda	Tanzania	Uganda	Zambia
Albizia amara	f	x	f	x	x	f	x
Albizia anthelmintica	f	x	f		f	f	f
Albizia antunesiana			f	f	f		x
Albizia coriaria	f	x			f	x	f
Albizia gummifera	x	f	x	x	x	x	
Albizia malacophylla	x					f	
Albizia petersiana		f	f	x	f	f	
Albizia versicolor		f	x	x	x	x	x
Albizia zygia		f			f	x	
Allophylus africanus	f	f	f	x	f	f	f
Allophylus rubifolius	f	f	f	x	f	f	f
Amblygonocarpus andongensis			f		f	f	x
Anisophyllea boehmii					f		x
Annona senegalensis	x	f	f	x	x	x	x
Anogeissus leiocarpa	x						
Antiaris toxicaria	x	x		f	f	x	f
Antidesma venosum	f	x	f		f	f	f
Apodytes dimidiata	x	x	x	x	f	f	f
Baikiaea plurijuga							x
Balanites aegyptiaca	x	x		f	x	x	x
Balanites glabra	f	x			f		
Balanites rotundifolia	f	x				x	
Baphia massaiensis					f		x
Bauhinia petersiana			f		x		x
Beilschmiedia ugandensis					f	x	f
Berberis holstii	x	f	f		f	f	
Berchemia discolor	x	x	x		x	f	x
Bersama abyssinica	x	x	f	x	x	x	f
Bobgunnia madagascariensis			x		x		x
Borassus aethiopum	x	x	x		x	x	x
Boscia angustifolia	f	f	w	x	f	f	w
Boscia coriacea	f	x			f	f	
Boscia salicifolia	f	f	f		x	f	f
Boswellia papyrifera	x	f				f	
Brachystegia boehmii			f		f		x
Brachystegia bussei			x		x		x
Brachystegia glaucescens			x				w
Brachystegia longifolia			f		f		x
Brachystegia spiciformis		x	x		x		x
Breonadia salicina	x	f	x		x	w	w
Bridelia micrantha	x	x	x	x	x	x	x
Bridelia scleroneura	f	f		x	f	f	
Buddleja polystachya	x	x			f	f	
Burkea africana		w	x		x	f	x
Caesalpinia decapetala	x	x	f	x	x	x	x
Caesalpinia volkensii		x			f	f	
Calotropis procera	x	f			f	f	
Canthium lactescens	f	f		x	f	f	f
Capparis tomentosa	x	x	f	x	f	f	f
Carissa spinarum	x	x	f	x	x	x	f
Cassia abbreviata		x	f		f		x

Species	Ethiopia	Kenya	Malawi	Rwanda	Tanzania	Uganda	Zambia
Catha edulis	x	f	f	w	x	x	f
Chrysophyllum albidum		f	w			x	
Clausena anisata	f	x	f	x	w	f	f
Clerodendrum myricoides	f	x		f	f	f	
Cocos nucifera		x				x	
Colophospermum mopane			x				x
Combretum aculeatum	x	x			f	f	
Combretum adenogonium	f	f	f		x	f	f
Combretum collinum	x	x	f	x	f	x	f
Combretum imberbe			x		f		x
Combretum molle	x	x	f	x	x	x	x
Combretum schumannii		x	f		x		f
Combretum zeyheri		f	x		f		f
Commiphora africana	x	x	f	x	x	x	x
Commiphora habessinica	x	f		f	f	f	f
Cordia africana	x	x	x	f	x	x	f
Cordia monoica	f	x			x	x	
Cordia sinensis	f	x			x	x	f
Cordyla africana		x	x		x		x
Crossopteryx febrifuga	f	f	x	f	f	f	
Crotalaria agatiflora	f	x	f	f	f	f	
Croton macrostachyus	x	x	f	f	x	x	f
Croton sylvaticus	f	f	f		f	x	f
Cryptosepalum exfoliatum			f		f		x
Cussonia arborea	f	f	f	x	x	f	x
Cussonia holstii	f	x		f	f	f	
Cussonia spicata		f	x		f	f	f
Dalbergia melanoxylon	x	x	x		x	x	f
Dalbergia nitidula			f	x	x	f	f
Daniellia oliveri						x	
Dialium englerianum							x
Dichrostachys cinerea	x	x	x	x	x	x	x
Diospyros kirkii			f		f	f	x
Diospyros mespiliformis	x	x	x		x	x	x
Diplorhynchus condylocarpon			f				x
Dobera glabra	x	x				f	
Dodonaea viscosa	x	x	f	x	x	x	f
Dombeya buettneri	f			f		x	
Dombeya kirkii	f	f	f	f	f	x	f
Dombeya rotundifolia	f	x	x	x	x	f	x
Dovyalis abyssinica	x	x	w		f	x	
Dovyalis macrocalyx		x	f	f	f	x	f
Ehretia cymosa	x	x	f	f		x	
Ekebergia benguelensis		f	x		f		f
Ekebergia capensis	x	x	f	x	x	x	f
Elaeis guineensis		f	w	x	f	x	
Elaeodendron buchananii	f	x	f	x	f	f	f
Entada abyssinica	x	x	f	x	x	x	f
Entandrophragma angolense		f			w	x	
Erythrina abyssinica	x	x	x	x	x	x	x

Species	Ethiopia	Kenya	Malawi	Rwanda	Tanzania	Uganda	Zambia
Erythrina burttii		x			f		
Erythrina excelsa		f			f	x	f
Erythrina melanacantha	f	x			f		
Erythrophleum africanum		w			f	w	x
Erythroxylum fischeri	x	f			f	f	
Euclea divinorum	f	x	f	f	x	f	f
Euclea racemosa	x	f	f	x	f	f	f
Eugenia capensis	f	f	f	f	f	x	f
Euphorbia abyssinica	x	f	w		f	f	
Euphorbia candelabrum	x	x	w	x	f	x	w
Euphorbia tirucalli	x	x	f	x	x	x	x
Faidherbia albida	x	x	x		x	x	x
Faurea rochetiana	f	f	x	f	f	f	
Faurea saligna		x	x	x	f	x	x
Ficus glumosa	f	f	f	f	f	x	f
Ficus natalensis		f	f	x	f	f	f
Ficus ovata	f	f	f	x	f	x	f
Ficus platyphylla	f					x	
Ficus sycomorus	x	x	f	x	x	x	x
Ficus thonningii	f	x	f	x	x	f	f
Ficus vallis-choudae	f	f	f	x	f	x	f
Flacourtia indica	x	x	f	x	x	x	x
Flueggea virosa	x	x	f	x	f	f	f
Galiniera saxifraga	x	f	w	x	f	f	
Garcinia buchananii	f	f	w	f	f	x	x
Garcinia livingstonei	f	x	f		x	f	f
Gardenia ternifolia	x	f		x	f	f	
Gardenia volkensii	x	x			f	f	
Grewia bicolor	x	x	f	x	x	x	f
Grewia mollis	f	f		f	f	x	f
Grewia similis	f	f		x	x	f	
Grewia tembensis	f	x					
Grewia villosa	x	x			x	f	
Guibourtia coleosperma							x
Hallea stipulosa						x	w
Harrisonia abyssinica	f	x	f	f	f	f	f
Harungana madagascariensis		x	f	x	f	x	f
Hexalobus monopetalus			f		f	f	x
Hymenaea verrucosa		x			x		
Hypericum quartinianum	x	f	f		f	f	f
Hypericum roeperanum	x	f			f	f	f
Hyphaene compressa	f	x			f		
Hyphaene petersiana					f		x
Hyphaene thebaica	x						
Indigofera swaziensis		f			x	f	
Isoberlinia angolensis			f		f		x
Isoberlinia doka						x	
Jatropha curcas	x	x	f	x	f	x	f
Julbernardia globiflora			x		x		x
Julbernardia paniculata			f		f		x

Species	Ethiopia	Kenya	Malawi	Rwanda	Tanzania	Uganda	Zambia
Kedrostis gijef		x			f		
Khaya senegalensis						x	
Kigelia africana	x	x	x	x	x	x	x
Kigelia moosa		f		x	f	f	
Kirkia acuminata			x		f		x
Landolphia kirkii		x	f		f		f
Lannea alata		x			f		
Lannea barteri	f					x	
Lannea discolor			x				x
Lannea fulva		x		x	f	x	
Lannea humilis	f	f		x	f	f	f
Lannea rivae	f	x			f		
Lannea schimperi	f	x	f	x	f	f	f
Lannea schweinfurthii	f	x	x	x	x	x	x
Lannea triphylla	f	x			f	f	
Lecaniodiscus fraxinifolius	f	x	f		f	f	f
Lippia kituiensis		x			f		
Lonchocarpus capassa			x		x		x
Lophira alata						x	
Maerua decumbens	f	x			f	f	
Maesopsis eminii		x		x	f	x	w
Mangifera indica	x	x				x	x
Manilkara mochisia		x	f		f		f
Manilkara sansibarensis		x			f		
Margaritaria discoidea	f	x	f		f	x	f
Markhamia lutea	x	x		x	f	x	
Markhamia obtusifolia		f	x	x	f		x
Markhamia zanzibarica		f	x		f	f	f
Maytenus arbutifolia	x	f		f	f	f	
Maytenus senegalensis	x	x	x	x	f	f	f
Maytenus undata	f	f	f	f	f	x	f
Melia volkensii	f	x			f		
Meyna tetraphylla	f	x			f	f	
Milicia excelsa	f	x	x	x	f	f	
Millettia dura		x	f	f	f	x	
Monotes africana			f		f		x
Morus mesozygia	x	f	f		f	x	f
Mussaenda arcuata	f	f	x		f	f	
Myrsine africana	f	x	f	f	f	f	f
Newtonia buchananii		x	x	x	f	x	f
Newtonia hildebrandtii		x			f		f
Oncoba spinosa	x	x	x		f	f	f
Opilia campestris	f	x			f		
Oreobambos buchwaldii		f	x		f	f	f
Ormocarpum kirkii		x	f		f		f
Ormocarpum trachycarpum	f	f			x	f	
Ormocarpum trichocarpum	f	f	f	x	f	f	
Osyris lanceolata	f	x		x	x	f	
Oxytenanthera abyssinica	x		x		x	x	x
Ozoroa insignis	f	x	x	x	x	x	f

Species	Ethiopia	Kenya	Malawi	Rwanda	Tanzania	Uganda	Zambia
Pappea capensis	f	x	f	x	x	f	f
Parinari curatellifolia		x	x	x	x	x	x
Pavetta crassipes	f	x			f	f	
Pavetta oliveriana	x	f		f	f	f	
Pericopsis angolensis			x	f	x		x
Philenoptera laxiflora	x					f	
Phoenix reclinata	x	x	w	x	x	x	x
Phytolacca dodecandra	x	f	f	f	f	x	f
Piliostigma thonningii	x	x	x	f	x	x	x
Pistacia aethiopica	f	x			f	f	
Pittosporum viridiflorum	x	f	f	f	f	x	f
Plectranthus barbatus	f	x			f	f	
Pleurostylia africana		f	f	x	f	f	f
Pouteria altissima	x	f		f	f	x	f
Premna resinosa	f	x			f	f	
Prosopis africana						x	
Pseudocedrela kotschyi	f					x	
Pseudolachnostylis maprouneifolia			f		x		x
Pseudospondias microcarpa		f		f	f	x	f
Psydrax parviflora	f	f	f	x	f	f	f
Psydrax schimperiana	x	f	f	x	f	f	f
Pterocarpus angolensis			x		x		x
Pterolobium stellatum	f	f	f	x	f	f	f
Raphia farinifera		x	x		f	x	
Rauvolfia caffra		x	x		x	x	f
Rhamnus prinoides	x	f	f	x	f	f	f
Rhamnus staddo	x	x		f	f	f	
Rhoicissus revoilii	x	f	f	f	f	f	f
Rhoicissus tridentata	x	x	f	f	f	f	f
Rhus longipes	f	f	f	x	f	f	f
Rhus natalensis	x	x	f	x	f	f	f
Rhus tenuinervis	f	x	f		f		f
Rhus vulgaris	x	x	f	f	f	f	f
Rothmannia urcelliformis	f	f	w		f	x	w
Rubus apetalus	f	x	f	f	f	f	f
Rubus volkensii	f	x			f	f	
Saba comorensis	f	x					
Salvadora persica	x	x	f		x	f	f
Sarcocephalus latifolius	x	f				x	
Schinziophyton rautanenii			x		f		x
Schrebera alata	f	x	f	f	f	x	f
Sclerocarya birrea	x	x	x		x	x	x
Scutia myrtina	f	x	f	x	f	f	f
Securidaca longipedunculata	x	f	f	f	x	x	f
Senna didymobotrya	x	f	f	x	f	x	f
Senna septemtrionalis		f	f	x	f	f	f
Senna singueana	f	x	f	x	f	f	x
Sesbania sesban	x	x	f	x	x	x	x
Shirakiopsis elliptica	x	x	f	x	f	x	f

Species	Ethiopia	Kenya	Malawi	Rwanda	Tanzania	Uganda	Zambia
Smilax anceps	f	f		f	f	x	
Solanecio cydoniifolius		f		f	f	x	
Solanecio mannii	f	x	w	f	f	x	w
Solanum aculeastrum		f	f	f	f	x	
Spathodea campanulata	x	x		x	x	x	x
Spirostachys venenifera		x			f		
Steganotaenia araliacea	x	f	f	f	f	x	f
Sterculia africana	x	x	f		x		x
Sterculia quinqueloba			x	f	x		x
Stereospermum kunthianum	x	x	f		x	x	f
Strychnos cocculoides		f	f		x		x
Strychnos henningsii	x	x	f		f	f	f
Strychnos innocua	x	f	f	x	x	x	x
Strychnos spinosa	x	x	f	x	x	x	x
Synsepalum brevipes		x	x		f	x	f
Syzygium guineense	x	x	x	x	x	x	x
Tamarindus indica	x	x	x		x	x	x
Tamarix nilotica	f	x			f		
Tarenna graveolens	f	f		x	f	f	
Tecomaria capensis		f	f	x	f	f	f
Tephrosia vogelii		f	f	x	f	f	x
Terminalia brownii	x	x			x	x	
Terminalia glaucescens	w				f	x	
Terminalia laxiflora	x					f	
Terminalia mollis		x		f	f	f	f
Terminalia prunioides	f	x			f		f
Terminalia sericea			x		x		x
Terminalia spinosa	f	x			x	f	
Tetradenia riparia	f	x		f			
Thespesia garckeana		f	f		x		x
Trema orientalis	f	f	f	x	x	f	f
Trichilia emetica	x	x	x		x	f	x
Uapaca kirkiana			x		x		x
Uapaca nitida			x		f		x
Uapaca sansibarica			f		f	f	x
Uvaria scheffleri		x			f	f	
Vangueria apiculata	f	x	f	x	f	f	f
Vangueria infausta		x	f	x	x	f	f
Vangueria madagascariensis	f	x	f		x	f	
Vangueriopsis lanciflora			f		x		f
Vepris nobilis	x	x	f	x	x	x	f
Vernonia amygdalina	x	x	f	x	f	f	f
Vernonia auriculifera	f	f		f	f	x	
Vernonia myriantha	f	f	f	f	x	f	f
Vitellaria paradoxa	x					x	
Vitex doniana	x	x	x	f	f	x	x
Vitex madiensis					f	x	
Vitex mombassae		x			x		
Vitex payos		x			f		
Warburgia ugandensis	x	x	f		x	x	

Species	Ethiopia	Kenya	Malawi	Rwanda	Tanzania	Uganda	Zambia
Xeroderris stuhlmannii		f	x		x		x
Ximenia americana	x	x	x	x	x	x	x
Xylopia parviflora	f	x	w		f	f	w
Xymalos monospora		f	x	x	f	f	
Zanthoxylum chalybeum	f	x	f	x	x	x	f
Zanthoxylum usambarense	f	x		f	f		
Ziziphus abyssinica	f	x	f	f	f	x	x
Ziziphus mauritiana	x	x	f		x	f	x
Ziziphus mucronata	x	x	f	x	x	f	f
Ziziphus pubescens	x	f	f		f	f	f

Appendix 2. Information on synonyms

We used a consistent naming system for all the species that were listed in this volume. The table immediately below shows how we reclassified some of the species that we encountered in national references. Note that we did not always use the most current name (mainly as a result of trying to use the same names of species listed in the Plant Resources of Tropical Africa (PROTA) database (URL *http://www.prota4u.org/*).

Table A2. Correspondence between species names as listed in the VECEA documentation and some synonyms of these species

Synonym	Species in VECEA
Acacia albida	*Faidherbia albida*
Acacia giraffae	*Acacia erioloba*
Acacia macrothyrsa	*Acacia amythethophylla*
Acacia nubica	*Acacia oerfota*
Acacia oliveri	*Acacia senegal*
Adina microcephala	*Breonadia salicina*
Aframomum biauriculatum	*Aframomum alboviolaceum*
Afrormosia angolensis	*Pericopsis angolensis*
Albizia fastigiata	*Albizia adianthifolia*
Aningeria altissima	*Pouteria altissima*
Annona chrysophylla	*Annona senegalensis*
Antiaris usambarensis	*Antiaris toxicaria*
Azanza garckeana	*Thespesia garckeana*
Balanites orbicularis	*Balanites rotundifolia*
Bauhinia macrantha	*Bauhinia petersiana*
Bauhinia thonningii	*Piliostigma thonningii*
Blepharis acanthoides	*Blepharis acanthodioides*
Boscia patens	*Boscia angustifolia*
Bothriochloa glabra	*Bothriochloa bladhii*
Breonadia microcephala	*Breonadia salicina*
Bridelia scleeroneuroides	*Bridelia scleroneura*
Caesalpinia erlangeri	*Caesalpinia trothae*
Canthium rubrocostatum	*Psydrax parviflora*
Canthium schimperanum	*Psydrax schimperiana*
Canthium vulgare	*Psydrax parviflora*
Carissa edulis	*Carissa spinarum*
Cassia didymobotrya	*Senna didymobotrya*
Cassia floribunda	*Senna septemtrionalis*
Cassia singueana	*Senna singueana*
Cassine buchananii	*Elaeodendron buchananii*
Chlorophora excelsa	*Milicia excelsa*
Chrysopogon aucheri	*Chrysopogon plumulosus*
Coleus barbatus	*Plectranthus barbatus*
Combretum binderianum	*Combretum collinum*
Combretum fragrans	*Combretum adenogonium*
Combretum ghasalense	*Combretum adenogonium*
Combretum mechowianum	*Combretum collinum*
Commiphora madagascariensis	*Commiphora habessinica*

Synonym	Species in VECEA
Commiphora tubuk	*Commiphora africana*
Cordia ovalis	*Cordia monoica*
Cordia rothii	*Cordia sinensis*
Crassocephalum mannii	*Solanecio mannii*
Cryptosepalum pseudotaxus	*Cryptosepalum exfoliatum*
Cussonia kirkii	*Cussonia arborea*
Dialiopsis africana	*Zanha africana*
Dichanthium papillosum	*Dichanthium annulatum*
Diplachne fusca	*Leptochloa fusca*
Dodonaea angustifolia	*Dodonaea viscosa*
Dombeya bagshawei	*Dombeya buettneri*
Dombeya mukole	*Dombeya kirkii*
Dovyalis engleri	*Dovyalis abyssinica*
Echinochloa holubi	*Echinochloa pyramidalis*
Ekebergia rueppelliana	*Ekebergia capensis*
Ekebergia senegalensis	*Ekebergia capensis*
Eriochloa nubica	*Eriochloa fatmensis*
Erythrina tomentosa	*Erythrina abyssinica*
Euclea latidens	*Euclea racemosa*
Euclea schimperi	*Euclea racemosa*
Eugenia bukobensis	*Eugenia capensis*
Euphorbia obovalifolia	*Euphorbia abyssinica*
Excoecaria venenifera	*Spirostachys venenifera*
Fagara chalybea	*Zanthoxylum chalybeum*
Faurea speciosa	*Faurea rochetiana*
Ficus burkei	*Ficus thonningii*
Ficus dekdekana	*Ficus thonningii*
Gardenia jovis-tonantis	*Gardenia ternifolia*
Gardenia spatulifolia	*Gardenia volkensii*
Harrisonia occidentalis	*Harrisonia abyssinica*
Heeria reticulata	*Ozoroa insignis*
Hexalobus monopetalanthus	*Hexalobus monopetalus*
Hyphaene parvula	*Hyphaene coriacea*
Hyphaene ventricosa	*Hyphaene petersiana*
Iboza riparia	*Tetradenia riparia*
Kigelia aethiopum	*Kigelia africana*
Lannea stuhlmannii	*Lannea schweinfurthii*
Lonchocarpus laxiflorus	*Philenoptera laxiflora*
Markhamia acuminata	*Markhamia zanzibarica*
Markhamia platycalyx	*Markhamia lutea*
Mitragyna stipulosa	*Hallea stipulosa*
Morus excelsa	*Milicia excelsa*
Nauclea latifolia	*Sarcocephalus latifolius*
Ostryoderris stuhlmannii	*Xeroderris stuhlmannii*
Osyris abyssinica	*Osyris lanceolata*
Osyris compressa	*Osyris lanceolata*
Ozoroa reticulata	*Ozoroa insignis*
Pachystela brevipes	*Synsepalum brevipes*
Phyllanthus discoideus	*Margaritaria discoidea*
Piptadeniastrum buchananii	*Newtonia buchananii*

Synonym	Species in VECEA
Pittosporum malosanum	*Pittosporum viridiflorum*
Pittosporum mildbraedii	*Pittosporum viridiflorum*
Pittosporum rhodesicum	*Pittosporum viridiflorum*
Pittosporum spathicalyx	*Pittosporum viridiflorum*
Plectronia schimperiana	*Psydrax schimperiana*
Pterocarpus antunesii	*Pterocarpus lucens*
Pterolobium lacerans	*Pterolobium stellatum*
Rauvolfia inebriens	*Rauvolfia caffra*
Rauvolfia obliquinervis	*Rauvolfia caffra*
Rauvolfia oxyphylla	*Rauvolfia caffra*
Rhoicissus erythrodes	*Rhoicissus tridentata*
Ricinodendron rautanenii	*Schinziophyton rautanenii*
Rubus rigidus	*Rubus apetalus*
Sapium ellipticum	*Shirakiopsis elliptica*
Sclerocarya caffra	*Sclerocarya birrea*
Scutia commersonii	*Scutia myrtina*
Securinega virosa	*Flueggea virosa*
Senecio mannii	*Solanecio mannii*
Setaria angustifolia	*Setaria sphacelata*
Setaria holsti	*Setaria incrassata*
Setaria homblei	*Setaria sphacelata*
Setaria pallide-fusca	*Setaria pumila*
Setaria phragmitoides	*Setaria incrassata*
Setaria trinervia	*Setaria sphacelata*
Smilax kraussiana	*Smilax anceps*
Sorghum sudanense	*Sorghum bicolor*
Sorghum verticilliflorum	*Sorghum arundinaceum*
Sporobolus kentrophyllus	*Sporobolus ioclados*
Sporobolus marginatus	*Sporobolus ioclados*
Swartzia madagascariensis	*Bobgunnia madagascariensis*
Syzygium parvifolium	*Syzygium guineense*
Teclea nobilis	*Vepris nobilis*
Trema guineensis	*Trema orientalis*
Vangueria acutiloba	*Vangueria madagascariensis*
Vernonia ampla	*Vernonia myriantha*
Ximenia caffra	*Ximenia americana*

Appendix 3. Information on botanical families

Table A3. Species arranged by family or subfamily (species from the Fabaceae family were listed separately for the *Caesalpinioideae, Mimosoideae* and *Papilionoideae* subfamilies)

Family	Species
Acanthaceae	*Barleria acanthoides*
	Blepharis acanthodioides
	Blepharis linariifolia
	Duosperma eremophilum
Anacardiaceae	*Lannea alata*
	Lannea barteri
	Lannea discolor
	Lannea fulva
	Lannea humilis
	Lannea rivae
	Lannea schimperi
	Lannea schweinfurthii
	Lannea triphylla
	Mangifera indica
	Ozoroa insignis
	Pistacia aethiopica
	Pseudospondias microcarpa
	Rhus longipes
	Rhus natalensis
	Rhus tenuinervis
	Rhus vulgaris
	Sclerocarya birrea
Annonaceae	*Annona senegalensis*
	Hexalobus monopetalus
	Uvaria scheffleri
	Xylopia odoratissima
	Xylopia parviflora
Apiaceae	*Steganotaenia araliacea*
Apocynaceae	*Acokanthera oppositifolia*
	Acokanthera schimperi
	Adenium obesum
	Carissa spinarum
	Diplorhynchus condylocarpon
	Landolphia kirkii
	Rauvolfia caffra
	Saba comorensis
Araliaceae	*Cussonia arborea*
	Cussonia holstii
	Cussonia spicata
Arecaceae	*Borassus aethiopum*
	Cocos nucifera
	Elaeis guineensis
	Hyphaene compressa
	Hyphaene coriacea
	Hyphaene petersiana

Family	Species
Arecaceae	*Hyphaene thebaica*
	Phoenix reclinata
	Raphia farinifera
Asclepiadaceae	*Calotropis procera*
Asteraceae	*Aspilia mossambicensis*
	Pluchea ovalis
	Solanecio cydoniifolius
	Solanecio mannii
	Vernonia amygdalina
	Vernonia auriculifera
	Vernonia myriantha
Balanitaceae	*Balanites aegyptiaca*
	Balanites glabra
	Balanites rotundifolia
Berberidaceae	*Berberis holstii*
Bignoniaceae	*Kigelia africana*
	Kigelia moosa
	Markhamia lutea
	Markhamia obtusifolia
	Markhamia zanzibarica
	Spathodea campanulata
	Stereospermum kunthianum
	Tecomaria capensis
Bombacaceae	*Adansonia digitata*
Boraginaceae	*Cordia africana*
	Cordia monoica
	Cordia sinensis
	Ehretia cymosa
Burseraceae	*Boswellia papyrifera*
	Commiphora africana
	Commiphora habessinica
	Commiphora schimperi
Canellaceae	*Warburgia ugandensis*
Capparidaceae	*Boscia angustifolia*
	Boscia coriacea
	Boscia salicifolia
	Cadaba glandulosa
	Cadaba rotundifolia
	Capparis tomentosa
	Maerua decumbens
Celastraceae	*Catha edulis*
	Elaeodendron buchananii
	Maytenus arbutifolia
	Maytenus senegalensis
	Maytenus undata
	Pleurostylia africana
Chrysobalanaceae	*Parinari capensis*
	Parinari curatellifolia
Clusiaceae	*Garcinia buchananii*
	Garcinia livingstonei

Family	Species
Clusiaceae	*Harungana madagascariensis*
	Hypericum quartinianum
	Hypericum roeperanum
Combretaceae	*Anogeissus leiocarpa*
	Combretum aculeatum
	Combretum adenogonium
	Combretum celastroides
	Combretum collinum
	Combretum hartmannianum
	Combretum imberbe
	Combretum molle
	Combretum psidioides
	Combretum schumannii
	Combretum zeyheri
	Terminalia brownii
	Terminalia glaucescens
	Terminalia laxiflora
	Terminalia mollis
	Terminalia prunioides
	Terminalia sericea
	Terminalia spinosa
	Terminalia stenostachya
	Terminalia stuhlmannii
Cucurbitaceae	*Kedrostis gijef*
Cyperaceae	*Kyllinga alba*
Dipterocarpaceae	*Marquesia macroura*
	Monotes africana
Ebenaceae	*Diospyros kirkii*
	Diospyros mespiliformis
	Euclea divinorum
	Euclea racemosa
Erythroxylaceae	*Erythroxylum fischeri*
Euphorbiaceae	*Antidesma venosum*
	Bridelia micrantha
	Bridelia scleroneura
	Croton dichogamus
	Croton macrostachyus
	Croton megalobotrys
	Croton sylvaticus
	Euphorbia abyssinica
	Euphorbia candelabrum
	Euphorbia tirucalli
	Flueggea virosa
	Hymenocardia acida
	Jatropha curcas
	Margaritaria discoidea
	Oldfieldia dactylophylla
	Pseudolachnostylis maprouneifolia
	Schinziophyton rautanenii
	Shirakiopsis elliptica

Family	Species
Euphorbiaceae	*Spirostachys venenifera*
	Uapaca kirkiana
	Uapaca nitida
	Uapaca sansibarica
Flacourtiaceae	*Dovyalis abyssinica*
	Dovyalis macrocalyx
	Flacourtia indica
	Oncoba spinosa
Icacinaceae	*Apodytes dimidiata*
Lamiaceae	*Ocimum basilicum*
	Plectranthus barbatus
	Tetradenia riparia
Lauraceae	*Beilschmiedia ugandensis*
Leguminosae: Caesalpinioideae	*Afzelia africana*
	Afzelia quanzensis
	Baikiaea plurijuga
	Bauhinia petersiana
	Brachystegia allenii
	Brachystegia bakeriana
	Brachystegia boehmii
	Brachystegia bussei
	Brachystegia floribunda
	Brachystegia glaberrima
	Brachystegia glaucescens
	Brachystegia longifolia
	Brachystegia manga
	Brachystegia microphylla
	Brachystegia puberula
	Brachystegia spiciformis
	Brachystegia stipulata
	Brachystegia taxifolia
	Brachystegia utilis
	Brachystegia wangermeeana
	Burkea africana
	Caesalpinia decapetala
	Caesalpinia trothae
	Caesalpinia volkensii
	Cassia abbreviata
	Colophospermum mopane
	Cordyla africana
	Cryptosepalum exfoliatum
	Daniellia oliveri
	Dialium englerianum
	Erythrophleum africanum
	Guibourtia coleosperma
	Hymenaea verrucosa
	Isoberlinia angolensis
	Isoberlinia doka
	Julbernardia globiflora
	Julbernardia paniculata

Family	Species
Leguminosae: Caesalpinioideae	*Peltophorum africanum*
	Piliostigma thonningii
	Pterolobium stellatum
	Senna didymobotrya
	Senna septemtrionalis
	Senna singueana
	Tamarindus indica
	Bauhinia petersiana
Leguminosae: Mimosoideae	*Abutilon hirtum*
	Acacia abyssinica
	Acacia amythethophylla
	Acacia brevispica
	Acacia bussei
	Acacia drepanolobium
	Acacia elatior
	Acacia erioloba
	Acacia etbaica
	Acacia gerrardii
	Acacia hockii
	Acacia kirkii
	Acacia lahai
	Acacia malacocephala
	Acacia mellifera
	Acacia nigrescens
	Acacia nilotica
	Acacia oerfota
	Acacia paolii
	Acacia polyacantha
	Acacia pseudofistula
	Acacia reficiens
	Acacia robusta
	Acacia senegal
	Acacia seyal
	Acacia sieberiana
	Acacia stuhlmannii
	Acacia tanganyikensis
	Acacia tortilis
	Acacia xanthophloea
	Acacia zanzibarica
	Albizia adianthifolia
	Albizia amara
	Albizia anthelmintica
	Albizia antunesiana
	Albizia coriaria
	Albizia gummifera
	Albizia harveyi
	Albizia malacophylla
	Albizia petersiana
	Albizia versicolor
	Albizia zygia

Family	Species
Leguminosae: Mimosoideae	*Amblygonocarpus andongensis*
	Dichrostachys cinerea
	Entada abyssinica
	Faidherbia albida
	Mimosa pigra
	Newtonia buchananii
	Newtonia hildebrandtii
	Prosopis africana
Leguminosae:Papilionoideae	*Aeschynomene abyssinica*
	Baphia massaiensis
	Bobgunnia madagascariensis
	Crotalaria agatiflora
	Dalbergia boehmii
	Dalbergia melanoxylon
	Dalbergia nitidula
	Erythrina abyssinica
	Erythrina burttii
	Erythrina excelsa
	Erythrina melanacantha
	Indigofera swaziensis
	Lonchocarpus capassa
	Millettia dura
	Ormocarpum kirkii
	Ormocarpum trachycarpum
	Ormocarpum trichocarpum
	Pericopsis angolensis
	Philenoptera laxiflora
	Pterocarpus angolensis
	Pterocarpus lucens
	Pterocarpus rotundifolius
	Sesbania rostrata
	Sesbania sesban
	Tephrosia vogelii
	Xeroderris stuhlmannii
Loganiaceae	*Buddleja polystachya*
	Strychnos cocculoides
	Strychnos henningsii
	Strychnos innocua
	Strychnos potatorum
	Strychnos pungens
	Strychnos spinosa
Malvaceae	*Abutilon angulatum*
	Thespesia danis
	Thespesia garckeana
Marantaceae	*Thalia geniculata*
Meliaceae	*Ekebergia benguelensis*
	Ekebergia capensis
	Entandrophragma angolense
	Khaya senegalensis
	Melia volkensii

Family	Species
Meliaceae	*Pseudocedrela kotschyi*
	Trichilia emetica
	Turraea nilotica
Melianthaceae	*Bersama abyssinica*
Monimiaceae	*Xymalos monospora*
	Antiaris toxicaria
	Ficus glumosa
	Ficus natalensis
	Ficus ovata
	Ficus platyphylla
	Ficus sycomorus
	Ficus thonningii
	Ficus vallis-choudae
	Milicia excelsa
	Morus mesozygia
Myrsinaceae	*Myrsine africana*
Myrtaceae	*Eugenia capensis*
	Syzygium guineense
Ochnaceae	*Lophira alata*
	Lophira lanceolata
	Ochna pulchra
Olacaceae	*Ximenia americana*
	Jasminum streptopus
	Schrebera alata
Opiliaceae	*Opilia campestris*
Palmaceae	*Hyphaene compressa*
	Hyphaene petersiana
	Hyphaene thebaica
Phytolaccaceae	*Phytolacca dodecandra*
Pittosporaceae	*Pittosporum viridiflorum*
Poaceae	*Alloteropsis cimicina*
	Andropogon kelleri
	Aristida adscensionis
	Bothriochloa bladhii
	Bothriochloa insculpta
	Brachiaria decumbens
	Cenchrus ciliaris
	Chloris gayana
	Chloris roxburghiana
	Chloris virgata
	Chrysopogon plumulosus
	Cynodon dactylon
	Cynodon plectostachyus
	Dactyloctenium aegyptium
	Dichanthium annulatum
	Echinochloa haploclada
	Echinochloa pyramidalis
	Enteropogon macrostachyus
	Eragrostis atrovirens
	Eriochloa fatmensis

Family	Species
Poaceae	*Hyparrhenia filipendula*
	Hyparrhenia rufa
	Imperata cylindrica
	Leersia hexandra
	Leptochloa fusca
	Microchloa indica
	Microchloa kunthii
	Oreobambos buchwaldii
	Oryza barthii
	Oryza longistaminata
	Oxytenanthera abyssinica
	Panicum coloratum
	Panicum maximum
	Panicum repens
	Pennisetum purpureum
	Setaria incrassata
	Setaria pumila
	Setaria sphacelata
	Sorghastrum bipennatum
	Sorghum arundinaceum
	Sorghum bicolor
	Sorghum purpureo-sericeum
	Sporobolus festivus
	Sporobolus helvolus
	Sporobolus ioclados
	Sporobolus pyramidalis
	Tetrapogon cenchriformis
	Themeda triandra
Polygalaceae	*Securidaca longipedunculata*
Proteaceae	*Faurea rochetiana*
	Faurea saligna
Pteridiaceae	*Pteridium aquilinum*
Rhamnaceae	*Berchemia discolor*
	Rhamnus prinoides
	Rhamnus staddo
	Scutia myrtina
	Ziziphus abyssinica
	Ziziphus mauritiana
	Ziziphus mucronata
	Ziziphus pubescens
Rharnnaceae	*Maesopsis eminii*
Rhizophoraceae	*Anisophyllea boehmii*
	Anisophyllea pomifera
Rosaceae	*Rubus apetalus*
	Rubus volkensii
Rubiaceae	*Breonadia salicina*
	Canthium lactescens
	Crossopteryx febrifuga
	Galiniera saxifraga
	Gardenia ternifolia

Family	Species
Rubiaceae	*Gardenia volkensii*
	Hallea stipulosa
	Meyna tetraphylla
	Mussaenda arcuata
	Pavetta crassipes
	Pavetta oliveriana
	Psydrax parviflora
	Psydrax schimperiana
	Rothmannia urcelliformis
	Sarcocephalus latifolius
	Tarenna graveolens
	Vangueria apiculata
	Vangueria infausta
	Vangueria madagascariensis
	Vangueriopsis lanciflora
Rutaceae	*Clausena anisata*
	Vepris nobilis
	Zanthoxylum chalybeum
Rutaceae	*Zanthoxylum usambarense*
Salvadoraceae	*Dobera glabra*
	Salvadora persica
Santalaceae	*Osyris lanceolata*
Sapindaceae	*Allophylus africanus*
	Allophylus rubifolius
	Dodonaea viscosa
	Lecaniodiscus fraxinifolius
	Pappea capensis
	Zanha africana
Sapotaceae	*Chrysophyllum albidum*
	Manilkara mochisia
	Manilkara sansibarensis
	Pouteria altissima
	Synsepalum brevipes
	Vitellaria paradoxa
Simaroubaceae	*Harrisonia abyssinica*
	Kirkia acuminata
Solanaceae	*Solanum aculeastrum*
	Solanum incanum
Srnilacaceae	*Smilax anceps*
Sterculiaceae	*Dombeya buettneri*
	Dombeya kirkii
	Dombeya rotundifolia
	Sterculia africana
	Sterculia quinqueloba
Tamaricaceae	*Tamarix nilotica*
Tiliaceae	*Grewia bicolor*
	Grewia fallax
	Grewia mollis
	Grewia similis
	Grewia tembensis

Family	Species
Tiliaceae	*Grewia villosa*
Ulmaceae	*Trema orientalis*
Verbenaceae	*Clerodendrum myricoides*
	Lippia kituiensis
	Premna resinosa
	Vitex doniana
	Vitex madiensis
	Vitex mombassae
	Vitex payos
Vitaceae	*Rhoicissus revoilii*
	Rhoicissus tridentata
Zingiberaceae	*Aframomum alboviolaceum*
Zygophyllaceae	*Tribulus cistoides*

FOREST & LANDSCAPE

FOREST & LANDSCAPE WORKING PAPERS 63 / 2011

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Volume 3

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National centre for research, education and advisory services within the fields of forest and forest products, landscape architecture and landscape management, urban planning and urban design