



# 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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# 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

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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](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 <i>Acacia-Commiphora</i> 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 <i>Ericaceous</i> 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 <i>Juniperus procera</i> forest (Fbj)
Fc	Afromontane single-dominant <i>Widdringtonia whytei</i> forest
fc (no capital)	Zanzibar-Inhambane scrub forest on coral rag (edaphic forest type)
Fd	Afromontane single-dominant <i>Hagenia abyssinica</i> forest
Fe	Afromontane moist transitional forest
fe (no capital)	Lake Victoria <i>Euphorbia dawei</i> 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 <a href="http://sl.life.ku.dk/English.aspx">http://sl.life.ku.dk/English.aspx</a> )
Fm	Zambeziian dry evergreen forest
Fn	Zambeziian 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 <a href="http://www.worldagroforestry.org/">http://www.worldagroforestry.org/</a> )
L	Lowland bamboo
M	Mangrove
P	Palm wooded grassland (physiognomically easily recognized type)
PROTA	Plant Resources of Tropical Africa (URL <a href="http://www.prota.org/">http://www.prota.org/</a> )
S	Somalia-Masai semi-desert grassland and shrubland
s (no capital)	Vegetation of sands (edaphic type)

T	<i>Termitaria</i> vegetation (easily identifiable and edaphic type, including bush groups around <i>termitaria</i> within grassy drainage zones)
UNEP	United Nations Environment Programme (URL <a href="http://www.unep.org/">http://www.unep.org/</a> )
VECEA	Vegetation and Climate Change in Eastern Africa project (funded by the Rockefeller Foundation)
Wb	<i>Vitellaria</i> wooded grassland
Wc	<i>Combretum</i> wooded grassland
Wcd	dry <i>Combretum</i> wooded grassland subtype
Wcm	moist <i>Combretum</i> wooded grassland subtype
WCMC	World Conservation Monitoring Centre (URL <a href="http://www.unep-wcmc.org/">http://www.unep-wcmc.org/</a> )
wd (no capital)	Edaphic wooded grassland on drainage-impeded or seasonally flooded soils (edaphic vegetation type)
We	Biotic <i>Acacia</i> 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 Zambesian 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	<i>Terminalia sericea</i> woodland
Wvs	<i>Vitex</i> - <i>Phyllanthus</i> - <i>Shikariopsis (Sapium)</i> - <i>Terminalia</i> woodland (not described regionally)
Wvt	<i>Terminalia glaucescens</i> 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)

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# 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<sup>(1)</sup>, but never with interlocking crowns and usually with a field layer of heliophilous ('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)<sup>(2)</sup>. **Wooded grasslands** are lands covered with grasses and other herbs with woody plants (trees  $\geq 7$  m tall], bushes [3 - 7 m], dwarf trees, palm trees or shrubs  $\leq 2$  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 extent. 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 Zambezi 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<sup>(3)</sup> (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)

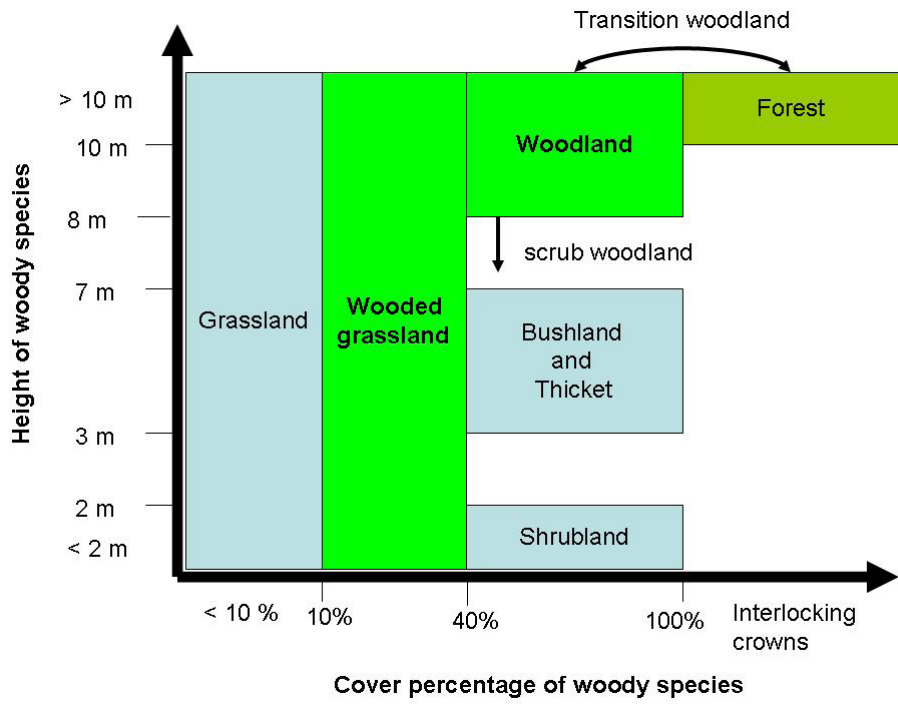


Figure 1. Height and cover percentage limits for major physiognomic types. Transition woodland is woodland that reverts to forest under certain conditions. Scrub woodland is a stunted variant of typical woodland formations such as “scrub miombo woodland”.

## 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 <sup>(4)</sup> 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 Africa 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<sup>5</sup>. 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 [ $\sim 925$  m]). Information on altitude was obtained from CGIAR-CSI (2008; resolution of 3 arc seconds [ $\sim 90$  m]). We created a layer of sample points at a density of approximately one point per 5 km<sup>2</sup> 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* - *Sapinum 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).

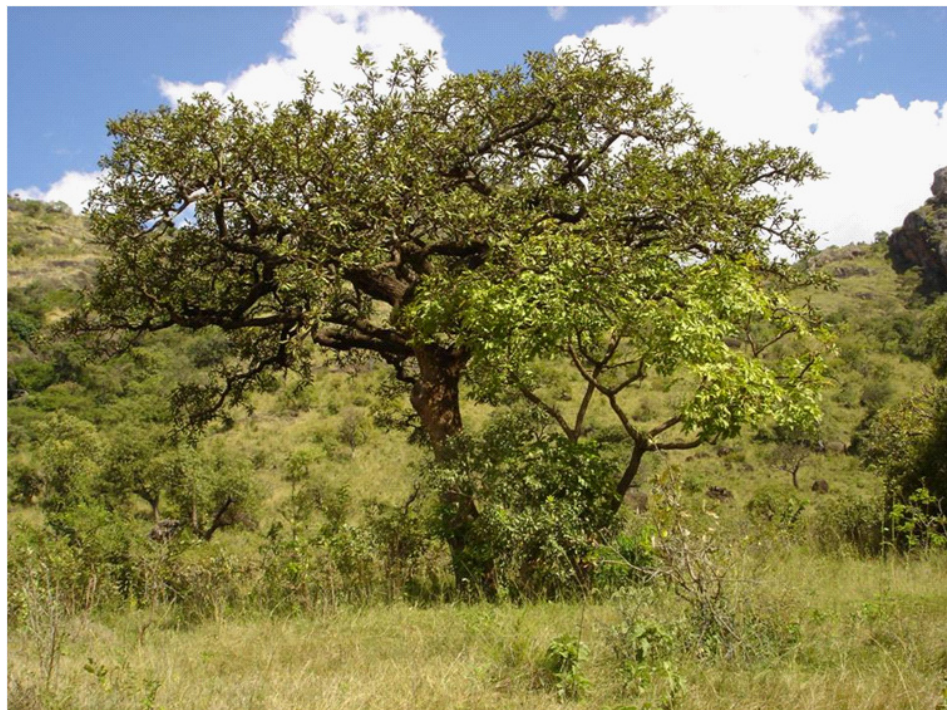
Trapnell and Langdale-Brown (1972 p. 133) mention that *Combretum* is replaced as a dominant species from *Combretum* wooded grassland (Wc) by ***Vitellaria paradoxa*** in wooded grasslands similar to west African wooded grasslands. They mention that *Combretum* species and *Terminalia mollis* still 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).

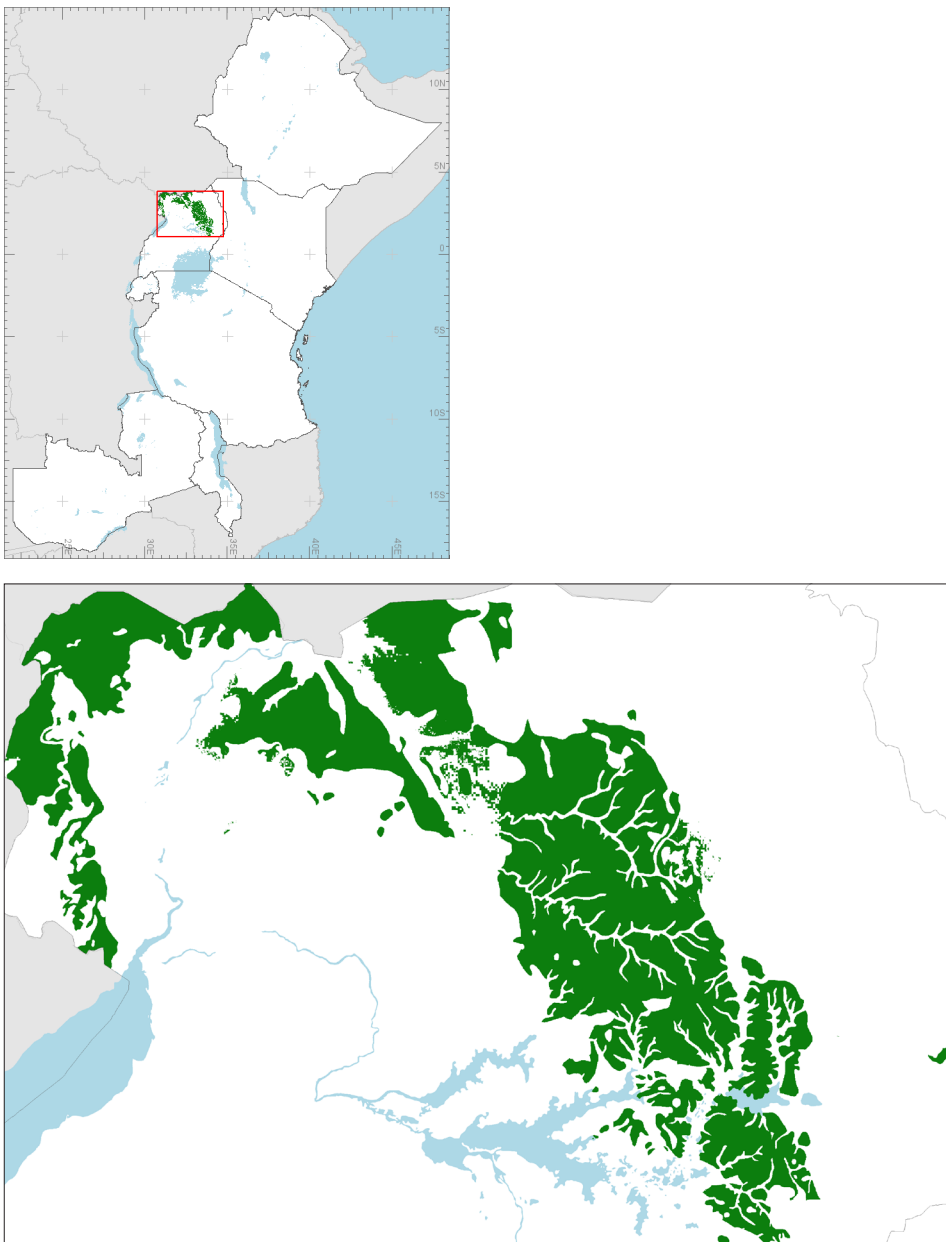


Figure 3.3. Mapped distribution of *Vitellaria* wooded grassland in the VECEA region (Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda and Zambia). Areas where we mapped this vegetation type are depicted by green polygons.

*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/Hypertelia*]) 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* - *Hypertelia dissoluta*) is a drier plant community where, similar as in drier *Combretum* and *Borassus* wooded grasslands, the grass layer is dominated by *Hypertelia 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%).

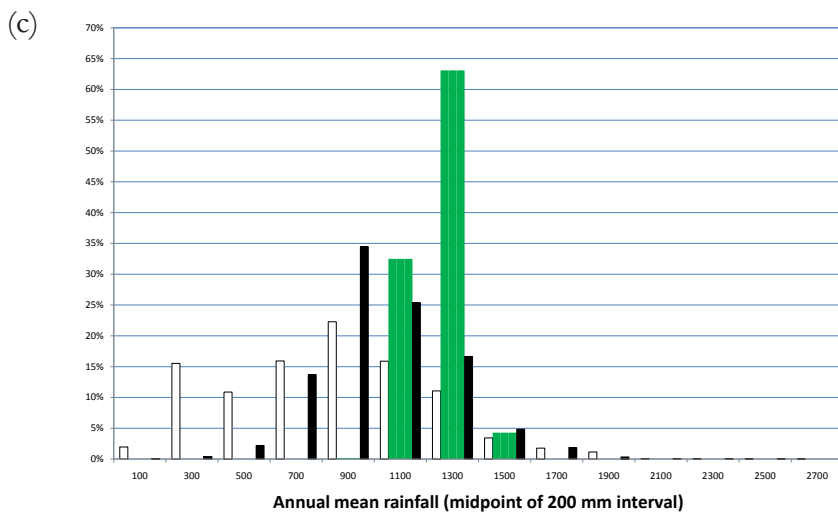
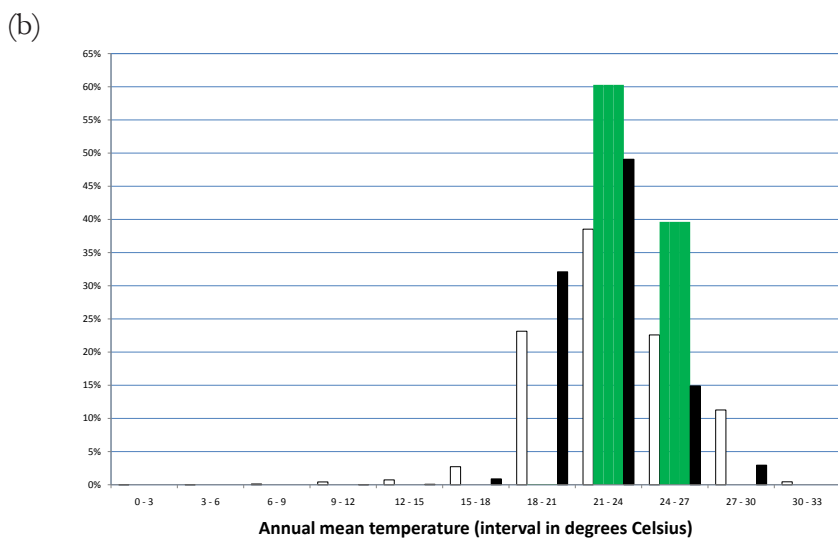
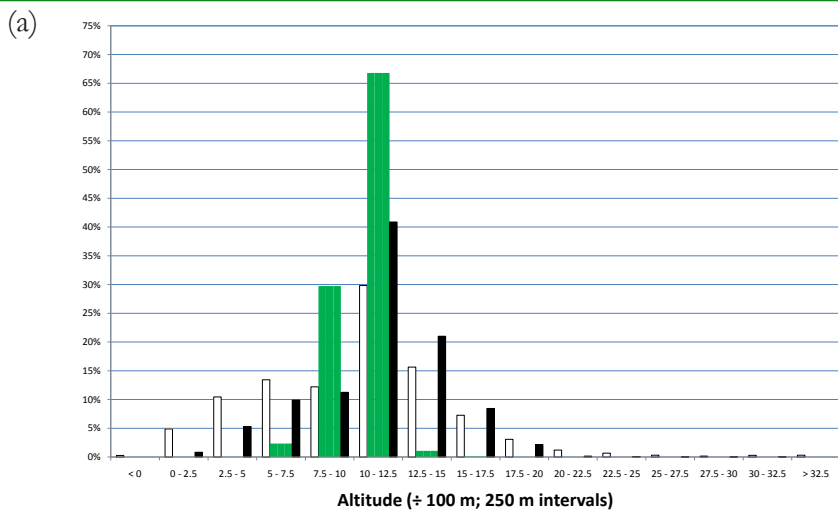


Figure 3.4. Histograms of the distribution of altitude (a), mean annual temperature (b) and mean annual rainfall (c). Bars at the centre of each interval show the percentage of samples within *Vitellaria* (synonym: *Butyrospermum*) wooded grassland (Wb,  $n = 6,287$ ). Bars on left (open) show the overall 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)
<i>Vitellaria paradoxa</i>	characteristic	D	D	D
<i>Acacia gerrardii</i>				x
<i>Acacia hockii</i>	indicator for (Sudanian woodland)	x		x
<i>Acacia polyacantha</i>	indicator for (Sudanian woodland)		x	
<i>Albizia amara</i>				x
<i>Albizia coriaria</i>			x	
<i>Albizia zygia</i>			x	
<i>Annona senegalensis</i>	characteristic		x	C
<i>Boscia salicifolia</i>	indicator for (Sudanian woodland)			x
<i>Bridelia scleroneura</i>			x	x
<i>Burkea africana</i>	characteristic			x
<i>Combretum adenogonium</i>				C
<i>Combretum collinum</i>	characteristic		x	x
<i>Combretum molle</i>	indicator for (Sudanian woodland)	x	x	x
<i>Commiphora africana</i>	indicator for (Sudanian woodland)			x
<i>Daniellia oliveri</i>	characteristic	C		
<i>Dombeya rotundifolia</i>			x	
<i>Erythrina abyssinica</i>			x	
<i>Kigelia africana</i>			x	
<i>Lannea barteri</i>		x	x	
<i>Lannea humilis</i>				x
<i>Lannea schimperi</i>	indicator for (Sudanian woodland)			C
<i>Lophira alata</i>		f	f	f
<i>Lophira lanceolata</i>	characteristic	x	x	x
<i>Pappea capensis</i>				x
<i>Philenoptera laxiflora</i>	indicator for (Sudanian woodland)			x
<i>Piliostigma thonningii</i>	characteristic	x	x	x
<i>Sclerocarya birrea</i>	indicator for (Sudanian woodland)			x
<i>Strychnos innocua</i>	not characteristic (indicator for Guineo-Congolian secondary wooded grassland)		x	
<i>Tamarindus indica</i>	indicator for (Sudanian woodland)	x	x	
<i>Terminalia glaucescens</i>	Characteristic	x	x	
<i>Terminalia mollis</i>		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 <sup>(6)</sup>) 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<sup>(7)</sup>. 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.

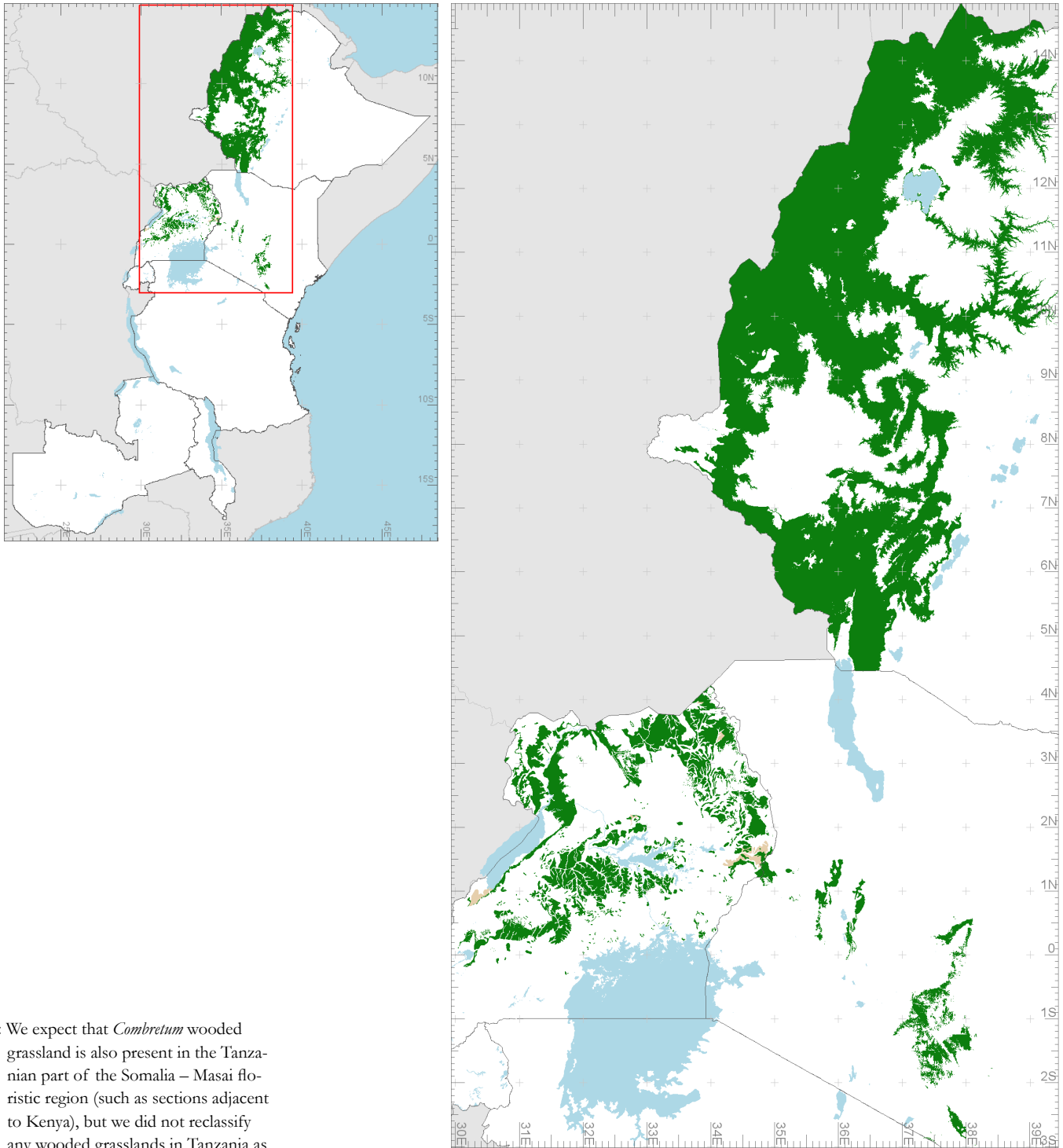


Figure 4.3 *Combretum* – *Terminalia* woodland and wooded grassland with tall underground of grasses (mainly *Hyparrhenia* species) on rocky outcrops east of Kurmuk (Ethiopia). Altitude approximately 1100 m. Photograph by I. Friis and Sebsebe Demissew (October 1998). Reproduced from Biologiske Skrifter 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<sup>(8)</sup>, Uganda and Zambia), *Combretum* wooded grassland was mapped in Ethiopia, Kenya and Uganda (Figure 4.4, see Volume 6).



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 4.4. 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 Zambezan region.

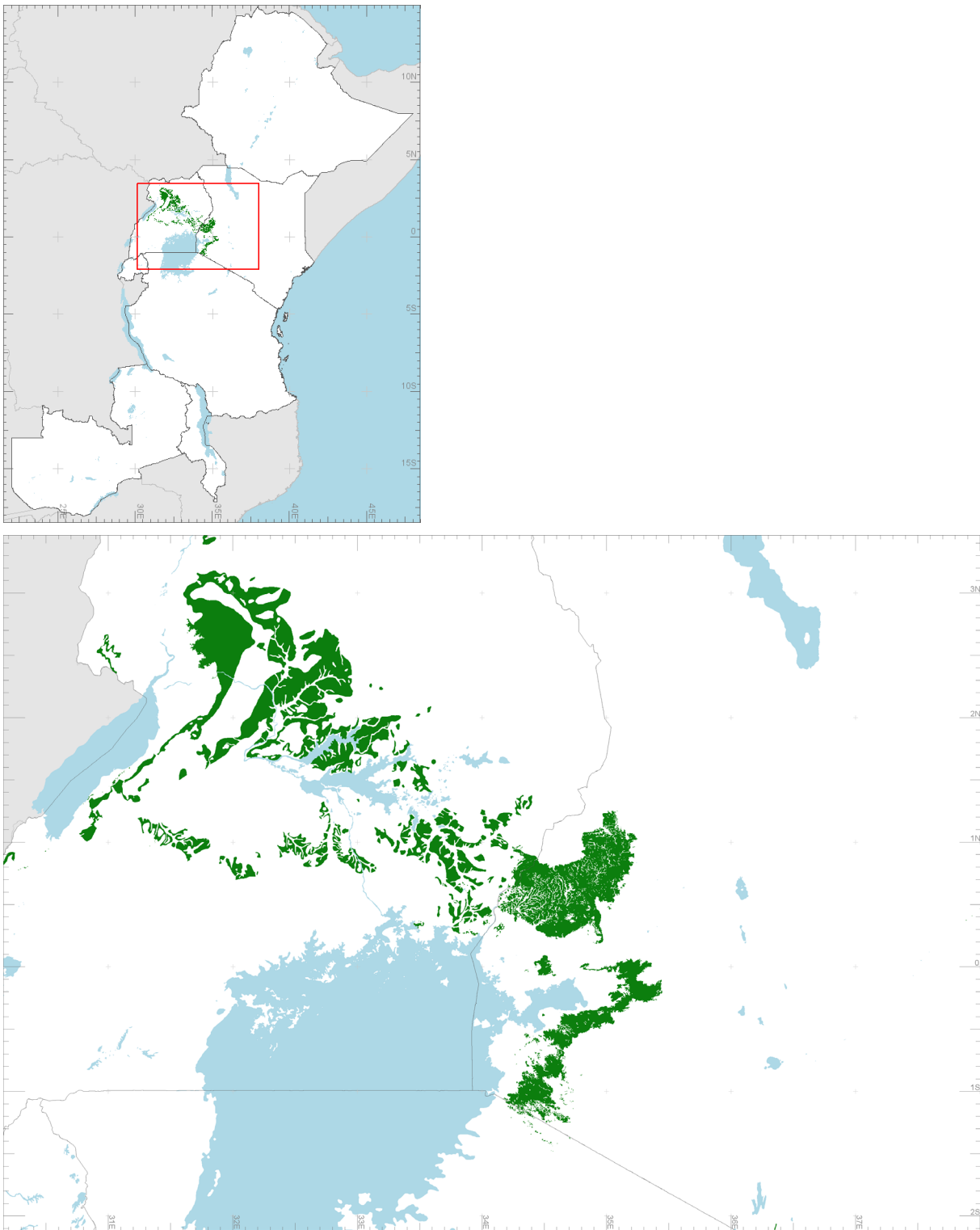


Figure 4.5. Distribution of moist *Combretum* wooded grassland in the VECEA region (Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda and Zambia). The distribution of this vegetation subtype is depicted by green polygons. Various areas that are mapped as moist *Combretum* wooded grassland are possibly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

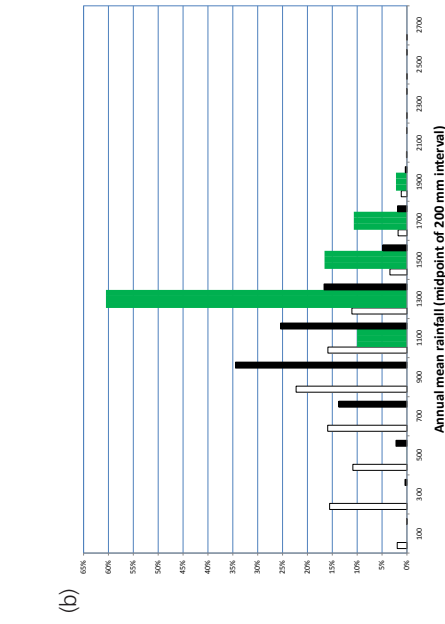
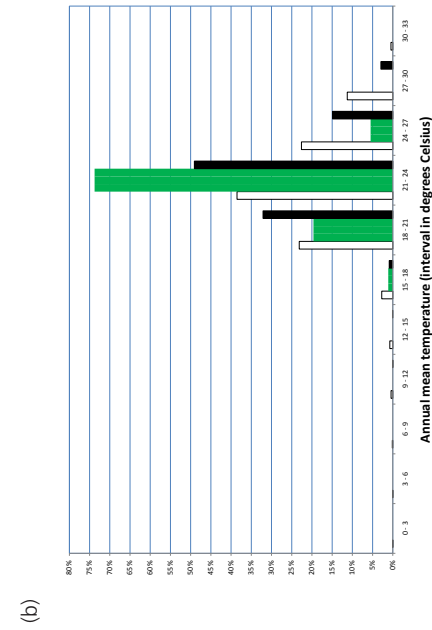
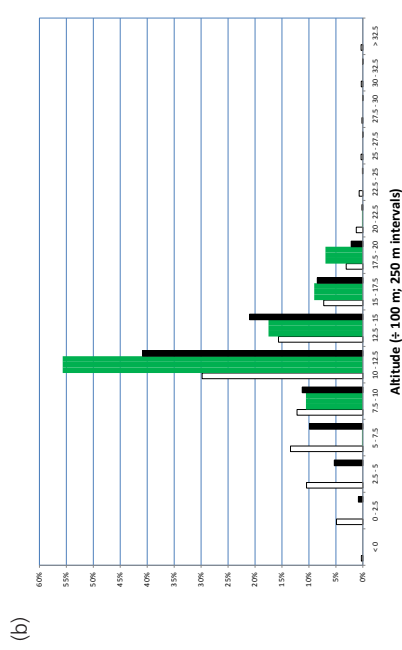
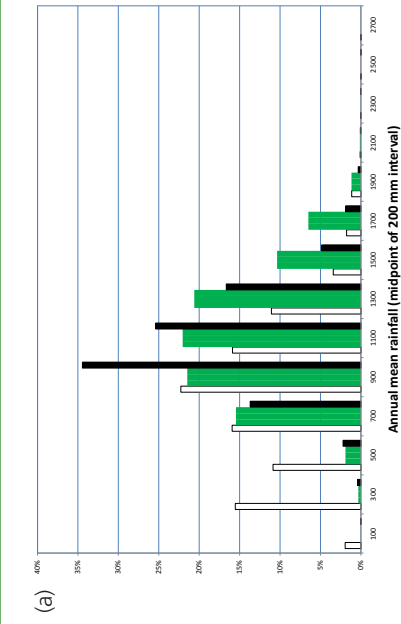
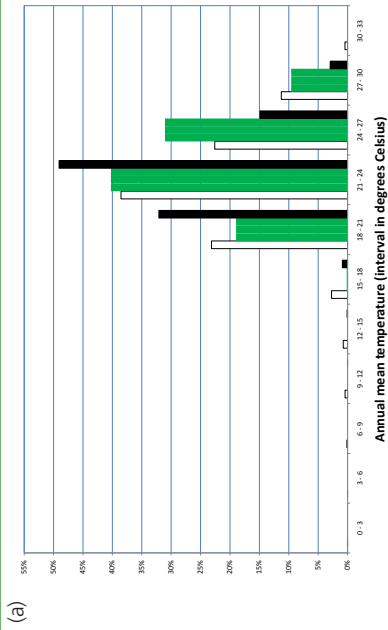
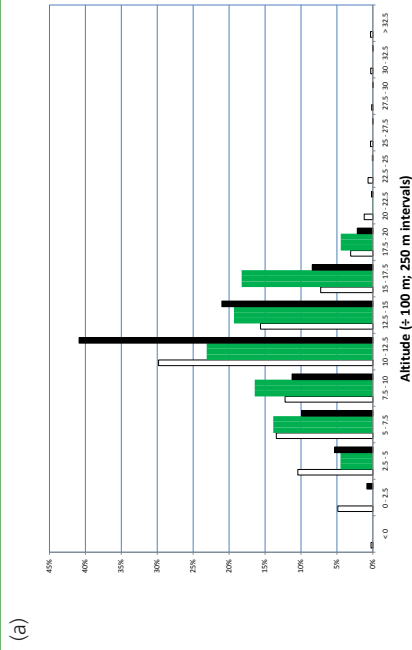


Figure 4.6.1. Histograms of the distribution of altitude for dry *Combretum* wooded grassland (a,  $n = 74,173$ ) and moist *Combretum* wooded grassland (b,  $n = 6,403$ ). Bars at the centre of each interval show the percentage of samples within dry or moist *Combretum* wooded grassland. Bars on left (open) show the overall percentage of samples within woodland or wooded grassland (n = 354,078). 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 <sup>9)</sup> 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)	WcmK (Kenya subtype)	WcmU (Uganda subtype)	WacU (Uganda subtype)
<i>Combretum aculeatum</i>		f	x	f			
<i>Combretum adenogonium</i>	characteristic	C	x	C3d	C	f	
<i>Combretum collinum</i>	characteristic	C	C	C23 J2	C	x	C
<i>Combretum hartmannianum</i>	indicator for (Ethiopian undifferentiated woodland)	C					
<i>Combretum molle</i>	characteristic	C	C	C123abd J2	C	C	C
<i>Combretum schumannii</i>			x				
<i>Combretum zeyheri</i>			C		x		
<i>Terminalia brownii</i>	indicator for (Ethiopian undifferentiated woodland)	C	C	Cc	x	f	
<i>Terminalia glaucescens</i>	characteristic	f		C1 j2		C	x
<i>Terminalia laxiflora</i>	characteristic	C		f			
<i>Terminalia mollis</i>			x	x j2	C	f	
<i>Terminalia prunoides</i>		f	x				
<i>Terminalia spinosa</i>		f	x	Cc			
<i>Abutilon angulatum</i>		x		f			
<i>Acacia abyssinica</i>					x	f	
<i>Acacia brevispica</i>		f	x	f	x	f	
<i>Acacia bussei</i>		f	x				
<i>Acacia drepanolobium</i>		x	x	f	x	f	
<i>Acacia elatior</i>			x	f			
<i>Acacia gerrardii</i>	not characteristic (listed for biotic Acacia wooded grassland)	x	x	x	x	f	
<i>Acacia hockii</i>	characteristic	C	x	Cabc j2	x	f	x
<i>Acacia lahai</i>					x	f	
<i>Acacia mellifera</i>		f	x	f			
<i>Acacia nilotica</i>	characteristic	f	x	x			
<i>Acacia oerfota</i>		f	x	f			
<i>Acacia polyacantha</i>	characteristic	x	x	x j2	x	x s2 J1	x
<i>Acacia senegal</i>	characteristic	x	x	x			
<i>Acacia seyal</i>	characteristic	x	x	Cb	x	f	
<i>Acacia sieberiana</i>	characteristic	x	f	x j2	x	J1	x
<i>Acacia tortilis</i>		x	x	f			
<i>Acacia xanthophloea</i>			x				
<i>Acokanthera oppositifolia</i>			x				



Species	Regional status (see section 2.3)	(Ethiopia)	WcdK (Kenya subtype)	WcdU (Uganda subtype)	WcmK (Kenya subtype)	WcmU (Uganda subtype)	WacU (Uganda subtype)
<i>Acokanthera schimperi</i>		f	x	f	x	f	
<i>Adansonia digitata</i>		C	x				
<i>Adenium obesum</i>		f	x				
<i>Albizia amara</i>					x	f	
<i>Albizia anthelminitica</i>		x	x	C			
<i>Albizia coriaria</i>		x	f	C j2	x	x s12 J1	x
<i>Albizia gummifera</i>					x	s1 j1	
<i>Albizia malacophylla</i>		x		x			
<i>Albizia zygia</i>			f	C23 j2	x	C s2	C
<i>Allophylus africanus</i>		x	f	f	x	f	
<i>Allophylus rubifolius</i>		x	x	f	x		
<i>Annona senegalensis</i>	characteristic	x	x	C	C	x	x
<i>Anogeissus leiocarpa</i>	characteristic for Ethiopian undifferentiated woodland and Sudanain woodland	C					
<i>Antiaris toxicaria</i>					x	s2	
<i>Antidesma venosum</i>		f	x	f	x	f	
<i>Apodytes dimidiata</i>		f	x	f	x	f	
<i>Balanites aegyptiaca</i>	characteristic for Ethiopian undifferentiated woodland and Sudanain woodland	C	x	C	x	f	
<i>Balanites glabra</i>		f	x				
<i>Balanites rotundifolia</i>		f	f	x			
<i>Beilschmiedia ugandensis</i>					x	f	
<i>Berchemia discolor</i>		f	x	f			
<i>Borassus aethiopum</i>	(palm species)	x	f	f	x	f	
<i>Boscia angustifolia</i>		f	x	f			
<i>Boscia coriacea</i>		f	x	f			
<i>Boscia salicifolia</i>	characteristic	f	x	x			
<i>Boswellia papyrifera</i>	indicator for Ethiopian undifferentiated woodland	C	f	Ca j2			
<i>Breonadia salicina</i>		f	x	f			
<i>Bridelia micrantha</i>		f	x	f	x	f	
<i>Bridelia scleroneura</i>		x	x	C j2	x	x	x
<i>Buddleja polystachya</i>					x	f	
<i>Caesalpinia decapetala</i>					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)
<i>Calotropis procera</i>		f	x	f	x	f	
<i>Capparis tomentosa</i>		f	x	f	x	f	
<i>Carissa spinarum</i>		f	x	f	x	f	
<i>Cassia abbreviata</i>			x				
<i>Catha edulis</i>		f	x	f	x	f	
<i>Chrysophyllum albidum</i>							
<i>Clausena anisata</i>		f	x	f	x	f	
<i>Clerodendrum myricoides</i>		x	x	f	x	f	
<i>Commiphora africana</i>	characteristic for Ethiopian undifferentiated woodland and Sudanian woodland	f	x	C			
<i>Commiphora habessinica</i>		f	x	x			
<i>Cordia africana</i>		x	x	f			
<i>Cordia monoica</i>		f	x	f	x	f	
<i>Cordia sinensis</i>		f	x	f			
<i>Crossopteryx febrifuga</i>	characteristic	x	f	f			
<i>Crotalaria agatiflora</i>					x	f	
<i>Croton macrostachyus</i>		x	x	x	x	s1	
<i>Cussonia arborea</i>	characteristic	x	x	x	x	f	
<i>Cussonia holstii</i>		f	x	f	x	f	
<i>Cussonia spicata</i>			x	f		s1	
<i>Dalbergia melanoxylon</i>	characteristic for Ethiopian undifferentiated woodland and Sudanian woodland	C	x	C			
<i>Dichrostachys cinerea</i>	characteristic	x	x	f	x	f	
<i>Diospyros mespiliformis</i>	characteristic	x	x	f			
<i>Dobera glabra</i>		f	x	f			
<i>Dodonaea viscosa</i>		f	x	f	x	f	
<i>Dombeya buettneri</i>		x					
<i>Dombeya rotundifolia</i>		f	x	C8	x	f	
<i>Dovyalis abyssinica</i>					x	f	
<i>Dovyalis macrocalyx</i>					x	f	
<i>Ehretia gymosa</i>					x	f	
<i>Ekebergia benguelensis</i>			x				
<i>Ekebergia capensis</i>	characteristic	f	f	x		s1	

Species	Regional status (see section 2.3)	(Ethiopia)	WcdK (Kenya subtype)	WcdU (Uganda subtype)	WcmK (Kenya subtype)	WcmU (Uganda subtype)	WacU (Uganda subtype)
<i>Elaeodendron buchananii</i>		f	x	f	x	f	
<i>Entada abyssinica</i>		x	f	x	x	f	
<i>Entandrophragma angolense</i>					x	f	
<i>Erythrina abyssinica</i>	indicator for Ethiopian undifferentiated woodland	x	x	xj2	x	x s12 j1	x
<i>Erythrina burttii</i>			x				
<i>Erythrina excelsa</i>					x	f	
<i>Erythrina melanacantha</i>		f	x				
<i>Erythroxylum fischeri</i>					x	f	
<i>Euclea divinorum</i>		f	x	f	x	s1	
<i>Euclea racemosa</i>		f	x	x	C	f	
<i>Eugenia capensis</i>					x	f	
<i>Euphorbia candelabrum</i>		x	x	f	x	f	
<i>Euphorbia tirucalli</i>		f	x	f	x	f	
<i>Faurea rochetiana</i>		x	f	f	C	f	
<i>Faurea saligna</i>	characteristic		C	f	x	s1	
<i>Ficus glumosa</i>	characteristic	x	x	f	x	f	
<i>Ficus natalensis</i>			x	f	x	f	
<i>Ficus ovata</i>					x	f	
<i>Ficus platyphylla</i>		f		x			
<i>Ficus sycomorus</i>	characteristic	f	x	f	x	f	
<i>Ficus thonningii</i>					x	f	
<i>Ficus vallis-choudae</i>					x	f	
<i>Flacourtia indica</i>		f	x	f	x	f	
<i>Flueggea virosa</i>		x	x	f	x	f	
<i>Garcinia buchananii</i>					x	s1	
<i>Gardenia ternifolia</i>	characteristic	x	x	x	x	f	
<i>Gardenia volkensii</i>		x	x	f	x	f	
<i>Grewia bicolor</i>		x	x	f	x	f	
<i>Grewia mollis</i>		x	x	f	x	f	
<i>Grewia similis</i>		f	x	f	x	f	
<i>Grewia tembensis</i>		f	x		x		
<i>Grewia villosa</i>		f	x	f	x	f	
<i>Harrisonia abyssinica</i>		x	x	C	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)
<i>Harungana madagascariensis</i>					x	f	
<i>Hyphaene thebaica</i>	(palm species)	x					
<i>Indigofera swaziensis</i>			x	f	x	f	
<i>Jatropha curcas</i>			x	f	x	f	
<i>Kedrostis gijef</i>			x				
<i>Kigelia africana</i>		f	x	xj2	x	f	
<i>Kigelia moosa</i>					x	f	
<i>Lannea alata</i>			x				
<i>Lannea barteri</i>		C		x			C
<i>Lannea fulva</i>					x	f	
<i>Lannea humilis</i>	characteristic	f	f	C			
<i>Lannea riva</i>		f	x				
<i>Lannea schimperi</i>	characteristic for Ethiopian undifferentiated woodland and Sudanian woodland	x	x	C	x	f	
<i>Lannea schweinfurthii</i>		x	x	f	x	f	
<i>Lannea triphylla</i>		f	x	C			
<i>Lecaniodiscus fraxinifolius</i>		f	x	f	x	f	
<i>Lippia kituiensis</i>			x		x		
<i>Maerua decumbens</i>		f	x	f	x	f	
<i>Maesopsis eminii</i>					x	s2	
<i>Mangifera indica</i>	(introduced species)					x s2	
<i>Manilkara mochisia</i>			x				
<i>Markhamia lutea</i>					x	x s12	
<i>Markhamia obtusifolia</i>					x		
<i>Maytenus arbutifolia</i>		f	x	f	x	f	
<i>Maytenus senegalensis</i>	not characteristic (indicator for Guineo-Congolian secondary wooded grassland)	x	x	C j2	C	f	
<i>Maytenus undata</i>		f	x	f	x	f	
<i>Melia volkensii</i>		f	x				
<i>Meyna tetraphylla</i>		x	x	f			
<i>Milicia excelsa</i>		f	x	f	x	x s2	
<i>Millettia dura</i>			x	f			
<i>Morus mesozygia</i>					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)
<i>Mussaenda arcuata</i>					x	f	
<i>Newtonia buchananii</i>			x		x	s2	
<i>Newtonia hildebrandtii</i>							
<i>Oncoba spinosa</i>		x	x	f	x	f	
<i>Opilia campestris</i>		f	x				
<i>Oreobambos buchwaldii</i>	(bamboo species indigenous to Africa)				x	f	
<i>Ormocarpum kirkii</i>			x				
<i>Ormocarpum trichocarpum</i>		f	x	x	x	f	
<i>Oxytenanthera abyssinica</i>	(lowland bamboo species)	C		C4			
<i>Ozoroa insignis</i>		x	x	Cac	x	x	
<i>Papea capensis</i>		x	x	x	x	f	
<i>Parinari curatellifolia</i>	characteristic		x	f	C	f	
<i>Pavetta crassipes</i>		x	x	x	x	f	
<i>Pavetta oliveriana</i>		x	f	f	x	f	
<i>Philenoptera laxiflora</i>	characteristic for Ethiopian undifferentiated woodland and Sudanian woodland	C		Cd			
<i>Phytolacca dodecandra</i>		f	x	f	x	f	
<i>Piliostigma thonningii</i>	characteristic	C	x	C,j2	C	x	
<i>Pitosporum viridiflorum</i>		f	x	f	x	f	
<i>Plectranthus barbatus</i>		f	x	f	x	f	
<i>Pouteria altissima</i>					x	f	
<i>Premna resinosa</i>		f	x	f	x	f	
<i>Pseudoedreia kotschy</i>	characteristic	x		C			
<i>Pseudospondias microcarpa</i>					x	s2	
<i>Psychax parviflora</i>		x	f	f			
<i>Psychax schimperiana</i>		x	x	f	x	f	
<i>Pterolobium stellatum</i>		f	x	f	x	f	
<i>Rauvolfia caffra</i>			x	f	x	f	
<i>Rhamnus staddo</i>		f	x	f	x	f	
<i>Rhoicissus revouillii</i>		x	x	f	x	f	
<i>Rhoicissus tridentata</i>		x	x	f	x	f	
<i>Rhus longipes</i>		x	x	f	x	f	
<i>Rhus natalensis</i>		x	x	C	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)
<i>Rhus tenuinervis</i>		x	x				
<i>Rhus vulgaris</i>		x	x	f	x	f	
<i>Rothmannia urcelliformis</i>					x	f	
<i>Rubus volkensii</i>		f	x	f	x	f	
<i>Saba comorensis</i>		x	f				
<i>Salvadora persica</i>		f	x	f	x	f	
<i>Sarcocephalus latifolius</i>	not characteristic (indicator for Guineo-Congolian secondary wooded grassland)	x	f	f	x	f	
<i>Sclerocarya birrea</i>	characteristic	C	x	C			
<i>Scutia myrtina</i>		f	x	f	x	f	
<i>Securidaca longipedunculata</i>	not characteristic (indicator for Guineo-Congolian secondary wooded grassland)	x	x	x	x	f	
<i>Senna didymobotrya</i>		f	x	f	x	s1	
<i>Senna septemtrionalis</i>			x	f	x	f	
<i>Senna singueana</i>		f	x	x	x	f	
<i>Sesbania sesban</i>		x	f	f			
<i>Solanecio cydoniifolius</i>			x	f			
<i>Solanecio manii</i>					x	f	
<i>Solanum aculeastrum</i>					x		
<i>Spathodea campanulata</i>		f			f	x s12	
<i>Spirostachys venenifera</i>			x				
<i>Steganotaenia araliacea</i>	characteristic	x	x	x	x	f	
<i>Sterculia africana</i>		x	x				
<i>Stereospermum kunthianum</i>	characteristic	C	x	C j2	x	x	
<i>Strychnos henningsii</i>		x	x	f	x	f	
<i>Strychnos innocua</i>	not characteristic (indicator for Guineo-Congolian secondary wooded grassland)	x	f	C			x
<i>Strychnos spinosa</i>	not characteristic (indicator for Guineo-Congolian secondary wooded grassland)	x	x	f	x	f	
<i>Synsepalum brevipes</i>					x	f	
<i>Syzygium guineense</i>	characteristic	x	f	x	x	s1	
<i>Tamarindus indica</i>	characteristic	f	x	x j2	x	x	
<i>Tamarix nilotica</i>		f	x				
<i>Tarenna graveolens</i>		f	x	f	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)
<i>Tephrosia vogelii</i>			x	f	x	f	
<i>Tetradenia riparia</i>		f	x		x		
<i>Thespesia garckeana</i>			x				
<i>Trichilia emetica</i>	characteristic	f	x	f	x	f	
<i>Uvaria scheffleri</i>			x	f			
<i>Vangueria apiculata</i>		f	x	f	x	f	
<i>Vangueria infausta</i>			x	f	x	f	
<i>Vangueria madagascariensis</i>		f	x	f	x	f	
<i>Vepris nobilis</i>		f	x	f	x	j1	
<i>Vernonia amygdalina</i>			x		x	s1	
<i>Vernonia auriculifera</i>			x		x	f	
<i>Vernonia myriantha</i>			x		x	f	
<i>Vitellaria paradoxa</i>	characteristic (dominant species of <i>Vitellaria</i> wooded grassland [Wb])	x		x			
<i>Vitex doniana</i>	characteristic	C	f	f	C	f	
<i>Vitex payos</i>			x				
<i>Warburgia ugandensis</i>		f	x	f	x	f	
<i>Ximenesia americana</i>		x	x	x	x	f	
<i>Xymalos monospora</i>			x		x	f	
<i>Zanthoxylum chalybeum</i>		f	x	f	x	f	
<i>Zanthoxylum usambarense</i>		f	x		x		
<i>Ziziphus abyssinica</i>	characteristic	x	x	C	x	f	
<i>Ziziphus mauritiana</i>	characteristic	f	x	f			
<i>Ziziphus mucronata</i>	characteristic	x	x	f	x	f	
<i>Ziziphus pubescens</i>		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).

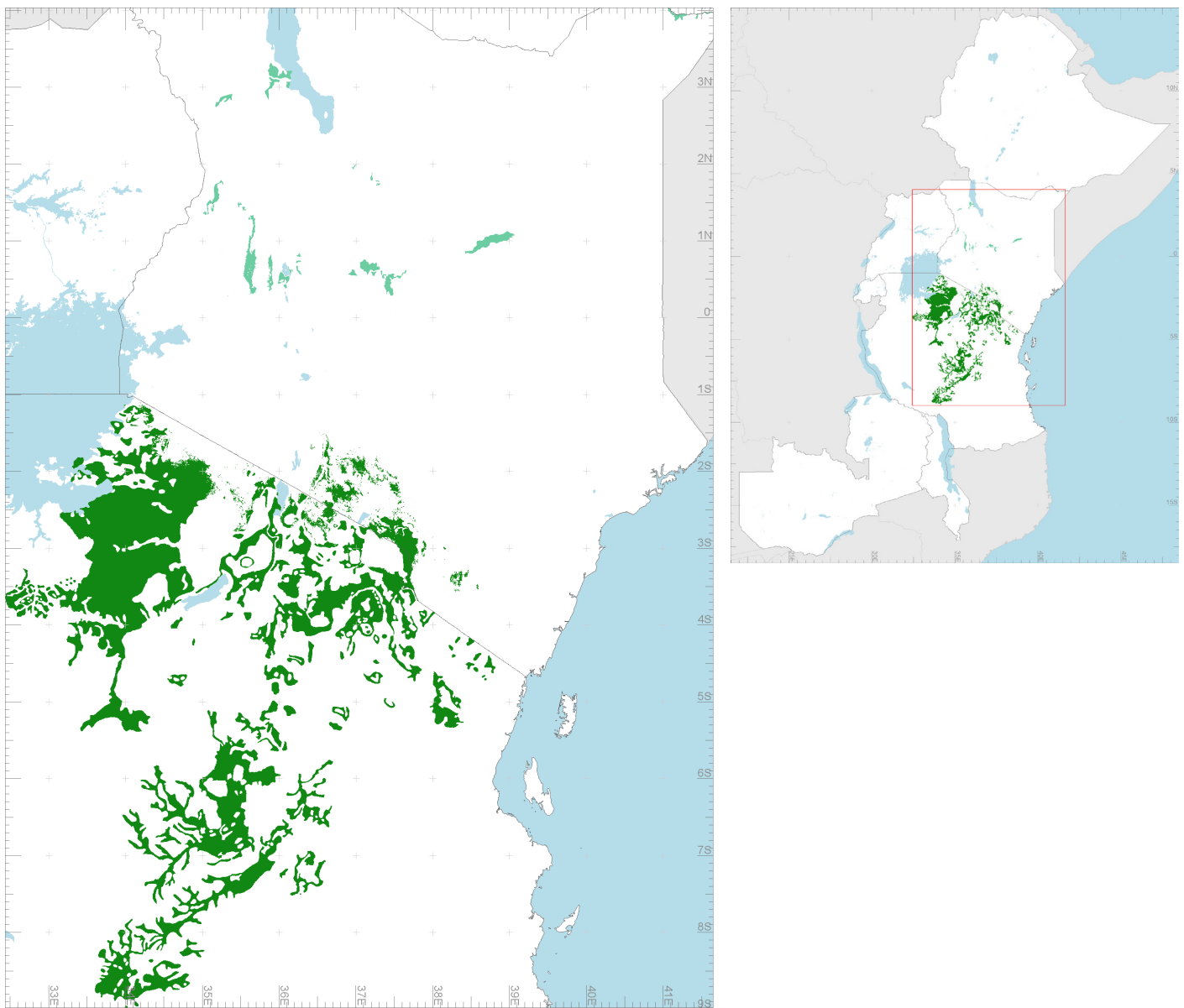


Figure 5.2. Mapped distribution of *Acacia-Commiphora* deciduous wooded grassland in the VECEA region (Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda and Zambia). Areas in light green (south of the equator) depict where we mapped this vegetation type after excluding the WdK subtype. Areas in olive 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 <sup>(10)</sup> (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.

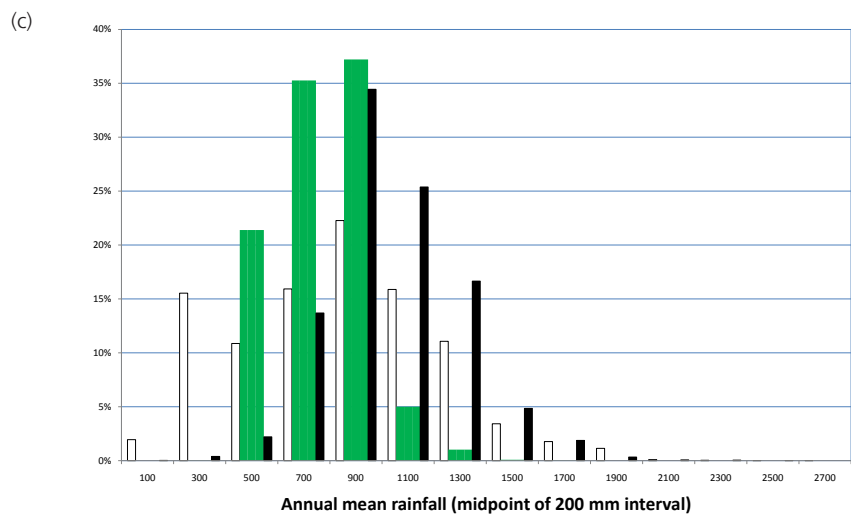
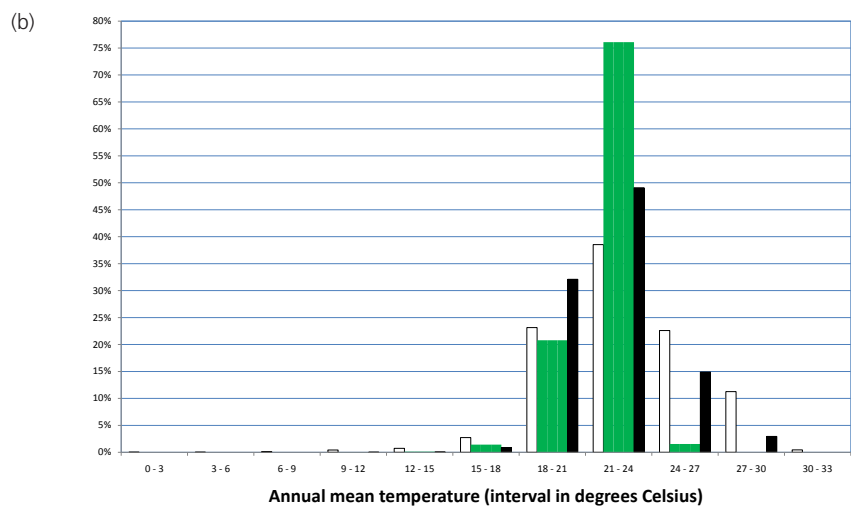
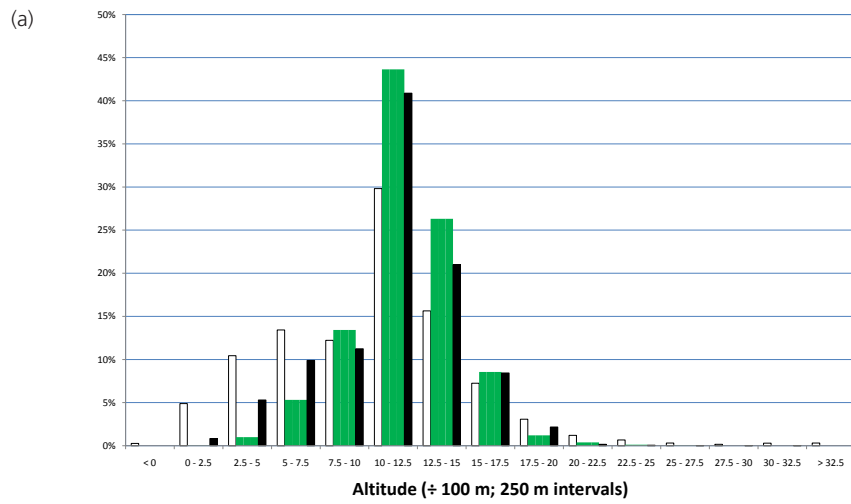


Figure 5.3. Histograms of the distribution of altitude (a), mean annual temperature (b) and mean annual rainfall (c). Bars at the centre of each interval show the percentage of samples within *Acacia-Commiphora* deciduous wooded grassland (Wd,  $n = 23,286$ ). Samples within the northern Kenyan subtype (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)
<i>Acacia drepanolobium</i>	not characteristic (characteristic for biotic <i>Acacia</i> wooded grassland and Somalia-Masai edaphic grassland)	f	C
<i>Acacia gerrardii</i>	not characteristic (characteristic for biotic <i>Acacia</i> wooded grassland)	f	C
<i>Acacia hockii</i>	not characteristic (characteristic for biotic <i>Acacia</i> wooded grassland)	f	C
<i>Acacia mellifera</i>	indicator (main canopy)	C45	f
<i>Acacia nilotica</i>	indicator (main canopy)	C46	C
<i>Acacia oerfota</i>		C4	f
<i>Acacia polyacantha</i>	riparian species in the Serengeti ecosystem	f	C
<i>Acacia reficiens</i>	indicator (main canopy)	C45	
<i>Acacia senegal</i>	not characteristic (indicator for biotic <i>Acacia</i> wooded grassland)	C9	C
<i>Acacia seyal</i>	not characteristic (indicator for biotic <i>Acacia</i> wooded grassland)	f	C
<i>Acacia sieberiana</i>	riparian species in the Serengeti ecosystem	f	C
<i>Acacia tortilis</i>	indicator (one of few species with well-defined trunk)	C456789	C
<i>Acacia xanthophloea</i>	riparian species	f	C
<i>Albizia amara</i>	not characteristic (characteristic for Somalia-Masai edaphic grassland)	C4	f
<i>Balanites aegyptiaca</i>		C46	f
<i>Commiphora schimperi</i>	indicator (main canopy)	f	C
<i>Cordia monoica</i>	indicator (main canopy)	f	x
<i>Croton dichogamus</i>	not characteristic (characteristic for East African evergreen and semi-evergreen bushland and thicket)	C4	f
<i>Grewia fallax</i>	indicator (smaller bush or shrub)	f	x
<i>Salvadora persica</i>	indicator (main canopy, evergreen)	C79	f
<i>Terminalia brownii</i>		C6	f

## 6. Biotic *Acacia* wooded grassland (We)

### 6.1. Description

Where domestic animals <sup>(11)</sup> 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]<sup>(12)</sup>) 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).

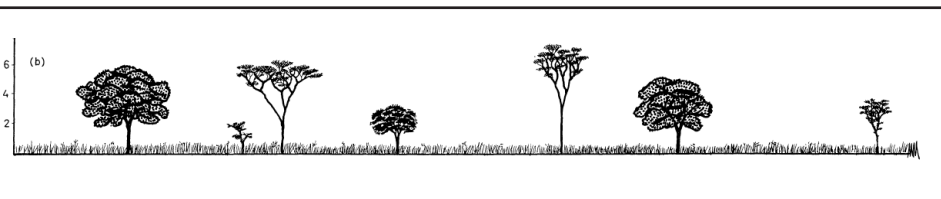


Figure 6.5 *Acacia gerrardii* – *Acacia seyal* wooded grassland with *Themeda* grass understorey. Height of vegetation in meter. Pratt *et al.* (1966, Fig 3b). Image obtained from URL: <http://www.jstor.org/stable/2401259>

## 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<sup>(13)</sup>. 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”<sup>(14)</sup> 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-imposed 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 boeckii* [involved in the most extensive areas that were former evergreen bushland (Be) types], *Acacia abyssinica* [Kenya], *Acacia labai* [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<sup>15</sup>. *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 than 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).

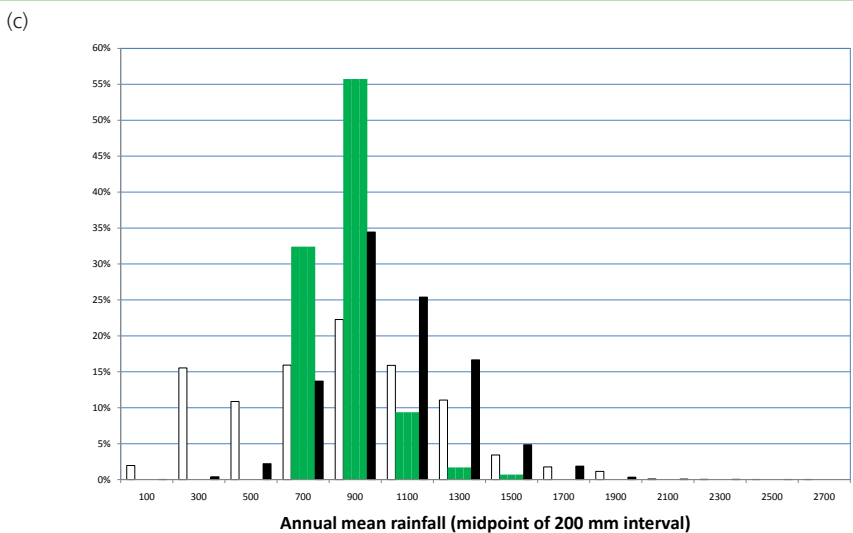
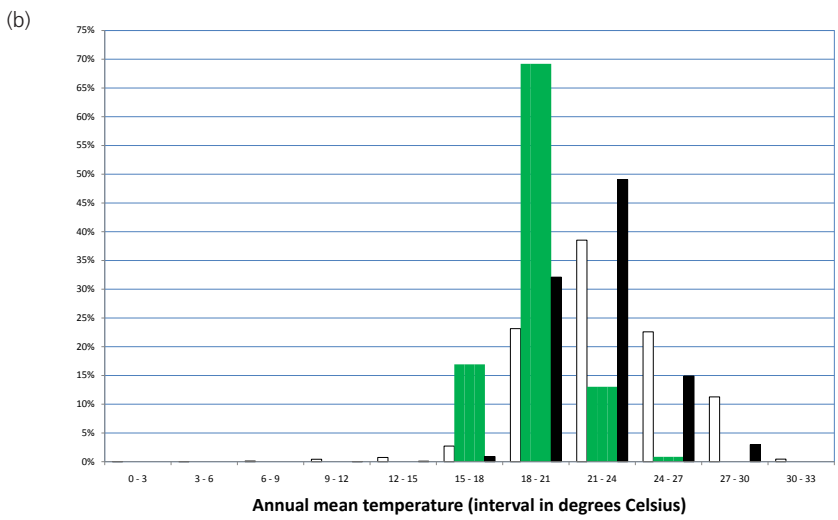
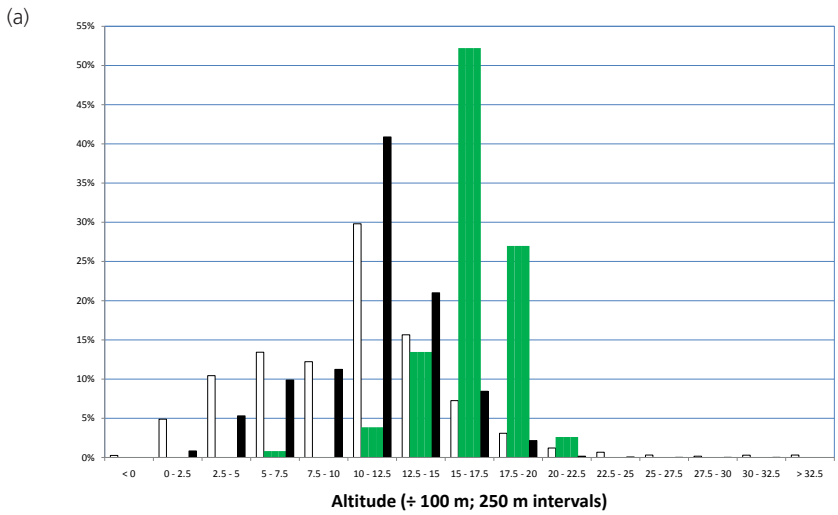


Figure 6.7 Histograms of the distribution of altitude (a), mean annual temperature (b) and mean annual rainfall (c). Bars at the centre of each interval show the percentage of samples within biotic *Acacia* wooded grassland (We,  $n = 4,769$ ). Bars on left (open) show the overall percentage of samples ( $n = 740,047$ ). 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 Zambesian 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”<sup>(16)</sup>. 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 identified
- 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)
<i>Abutilon angulatum</i>		f		xe		f	f
<i>Acacia abyssinica</i>		f	x	f	f	f	f
<i>Acacia brevispica</i>		f	Ceu	f	f	f	f
<i>Acacia drepanolobium</i>	characteristic	f	Ceu		f	f	x
<i>Acacia gerrardii</i>	indicator	f	Ca	C	f	C	C
<i>Acacia hockii</i>	indicator	f	Ce	x	f	x	x
<i>Acacia kirkii</i>	indicator		Ca	C	f	f	f
<i>Acacia lahai</i>		f	x		f	f	f
<i>Acacia mellifera</i>	not characteristic (indicator for deciduous bushland)	f	Cu		f	f	f
<i>Acacia nilotica</i>	not characteristic (indicator for deciduous bushland)	f	x		f	f	f
<i>Acacia polyacantha</i>		f	Ca	C	f	f	f
<i>Acacia senegal</i>	indicator	C	x	C	f	x	f
<i>Acacia seyal</i>	characteristic	C	Ce	C	f	f	x
<i>Acacia sieberiana</i>		f	x	C	f	x	f
<i>Acacia tortilis</i>	not characteristic (indicator for deciduous bushland)	C	Ccu		f	f	f
<i>Acacia xanthophloea</i>			Ca		f		
<i>Acokanthera schimperi</i>	characteristic (indicator for evergreen bushland)	f	x	f	f	f	f
<i>Albizia adianthifolia</i>			f	C	f	x	f
<i>Albizia amara</i>	not characteristic (indicator for Somalia-Masai edaphic grassland)	f	Cc	C	f	f	f
<i>Albizia antunesiana</i>				x	f		
<i>Albizia petersiana</i>			f	xb	f	f	f
<i>Albizia versicolor</i>			f	x	f	f	f
<i>Allophylus rubifolius</i>		f	x	xb	f	f	f
<i>Annona senegalensis</i>		f	f	x	f	f	f
<i>Balanites aegyptiaca</i>		f	f	f	f	f	x
<i>Berberis holstii</i>		f	x		f	f	f
<i>Bersama abyssinica</i>		f	x	x	f	f	f
<i>Boscia angustifolia</i>		f	x	xb	f	f	f
<i>Boscia salicifolia</i>		f	x		f	f	x
<i>Bridelia scleroneura</i>		f	f		f	x	f



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

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

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

Species	Regional status	(Ethiopia)	(Kenya)	(Rwanda)	(Tanzania)	WecU (Uganda subtype)	WesU (Uganda subtype)
<i>Schrebera alata</i>	characteristic (indicator for evergreen bushland, transition to forest)	f	f	xbe	f	f	f
<i>Scutia myrtina</i>	characteristic (indicator for evergreen bushland)	f	x	f	f	f	f
<i>Securidaca longipedunculata</i>		f	f	x	f	f	f
<i>Senna didymobotrya</i>		f	x	x	f	f	f
<i>Senna septemtrionalis</i>			x	f	f	f	f
<i>Senna singueana</i>		f	f	x	f	f	f
<i>Strychnos hemingsii</i>		f	x		f	f	f
<i>Strychnos innocua</i>		f	f	xb	f	f	f
<i>Strychnos spinosa</i>		f	f	xbe	f	f	f
<i>Syzygium guineense</i>		f	x	f	f	f	f
<i>Tarennia graveolens</i>	characteristic (indicator for evergreen bushland)	f	x	xb	f	f	f
<i>Terminalia brownii</i>		x	x		f	f	f
<i>Terminalia mollis</i>			f	x	f	f	f
<i>Uvaria scheffleri</i>			x		f	f	f
<i>Vangueria apiculata</i>		f	x	f	f	f	f
<i>Vangueria infausta</i>			x	x	f	f	f
<i>Vangueria madagascariensis</i>		f	x		f	f	f
<i>Vepris nobilis</i>		f	x	f	f	f	f
<i>Vernonia auriculifera</i>		f	x	f	f	f	f
<i>Vitex doniana</i>		f	f	xbz	f	f	f
<i>Warburgia ugandensis</i>		f	x		f	f	f
<i>Ximenia americana</i>		f	x	x	f	f	f
<i>Xymalos monospora</i>			x	f	f	f	f
<i>Zanthoxylum chalybeum</i>		f	f	xb	f	f	f
<i>Zanthoxylum usambarense</i>		f	x	f	f		
<i>Ziziphus abyssinica</i>		f	x	f	f	f	x
<i>Ziziphus mauritiana</i>		f	x		f	f	f
<i>Ziziphus mucronata</i>		f	x	x	f	f	f
<i>Ziziphus pubescens</i>		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,<sup>(17)</sup> with evergreen *Cryptosepalum exfoliatum* ssp. *pseudotaxus* forest (mapped in VECEA as Zambebian dry evergreen forest [Fm]) in the north and deciduous *Baikiaea plurijuga* forest (mapped in VECEA as Zambebian 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 water-logged 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 Zambebian 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).

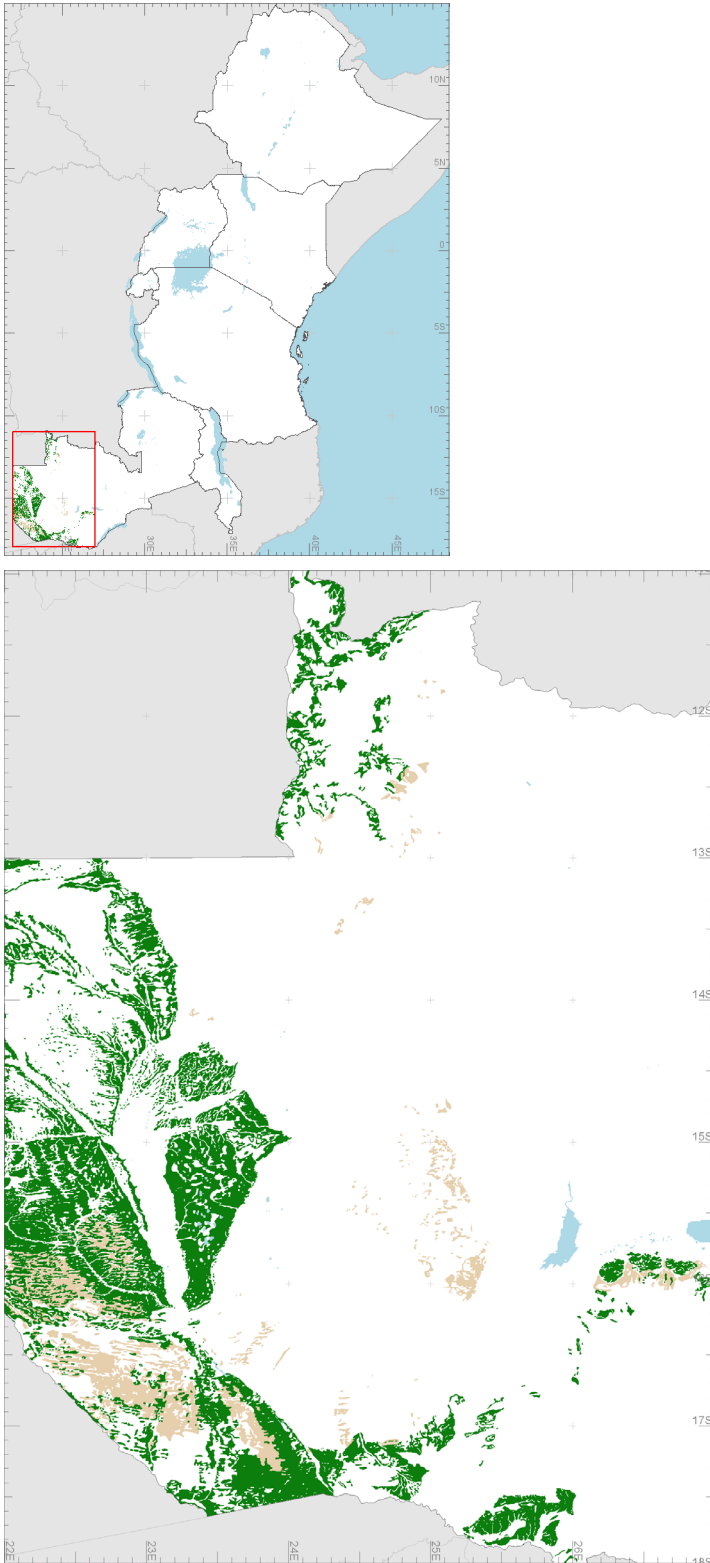


Figure 7.1. Mapped distribution of Kalahari woodland in the VECEA region (Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda and Zambia). Where this vegetation type does not occur in mosaic, it is depicted by green polygons. This vegetation type is also mapped in mosaic with edaphic grassland (Wk/g; shown 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 <sup>(16)</sup> 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%).

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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:

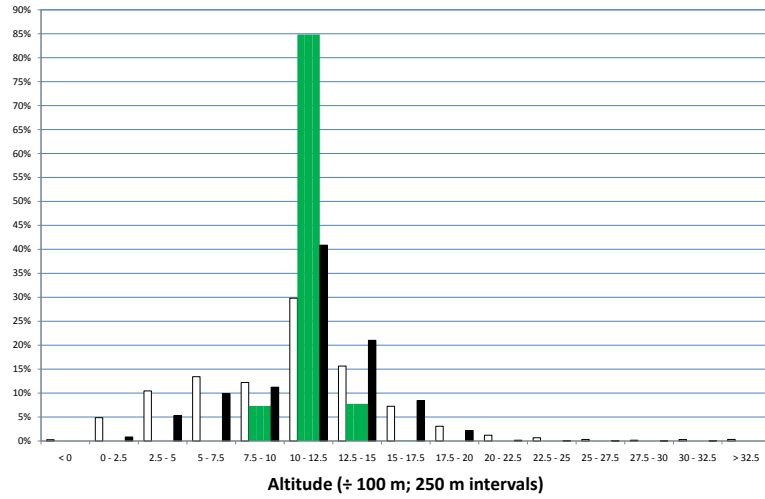
- Zambia: Fanshawe (1971). Species listed for the species composition table for “Kalahari woodland” provided on pages 46 to 47 were coded “x” (unless they were characteristic species).

Characteristic species were determined as:

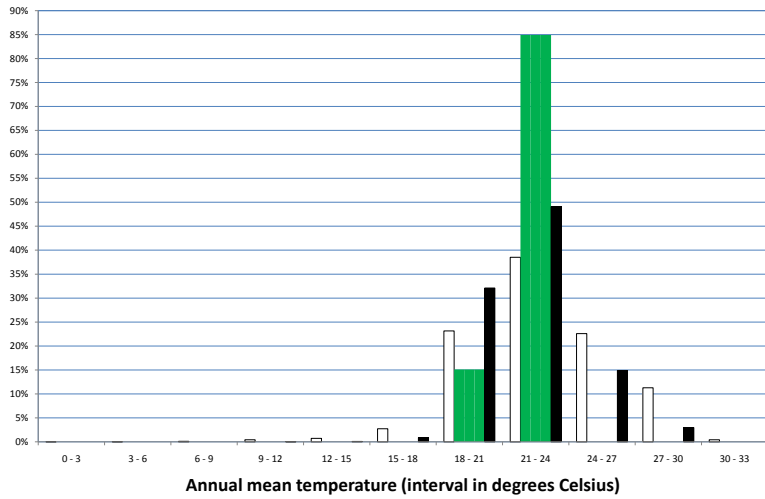
- Zambia: Canopy species were coded “C”.



(a)



(b)



(c)

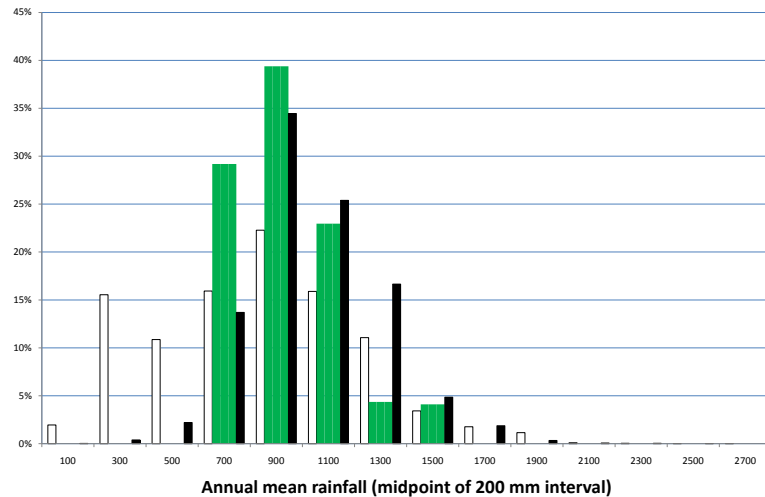


Figure 7.2. Histograms of the distribution of altitude (a), mean annual temperature (b) and mean annual rainfall (c). Bars at the centre of each interval show the percentage of samples within Kalahari woodland (Wk,  $n = 9,030$ ). Bars on left (open) show the overall percentage of samples ( $n = 740,047$ ). 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)
<i>Acacia erioloba</i>	characteristic for Kalahari Sands	C
<i>Albizia antunesiana</i>	characteristic	x
<i>Allophylus africanus</i>		x
<i>Amblygonocarpus andongensis</i>	characteristic	C
<i>Baikiaea plurijuga</i>	indicator (forest remnant of southern Kalahari Sands)	C
<i>Baphia massaiensis</i>		x
<i>Bauhinia petersiana</i>		x
<i>Bobgunnia madagascariensis</i>	characteristic	x
<i>Brachystegia bakeriana</i>		x
<i>Brachystegia floribunda</i>		C
<i>Brachystegia longifolia</i>	characteristic for northern Kalahari Sands	C
<i>Brachystegia spiciformis</i>	characteristic	C
<i>Burkea africana</i>	characteristic (also occurs in Kalahari scrub woodland)	C
<i>Combretum collinum</i>	not characteristic (characteristic for undifferentiated woodland and Chipya woodland)	C
<i>Combretum psidioides</i>	indicator	x
<i>Combretum zeyheri</i>	characteristic	x
<i>Cryptosepalum exfoliatum</i>	indicator (forest remnant of northern Kalahari Sands [ <i>Cryptosepalum exfoliatum</i> ssp. <i>pseudotaxus</i> ])	C
<i>Dialium englerianum</i>	indicator	C
<i>Dichrostachys cinerea</i>		x
<i>Diplorhynchus condylocarpon</i>	characteristic (also main species in Kalahari scrub woodland)	x
<i>Erythrophleum africanum</i>	characteristic	C
<i>Guibourtia coleosperma</i>		C
<i>Hymenocardia acida</i>	characteristic for Kalahari scrub woodland	x
<i>Isoberlinia angolensis</i>		C
<i>Julbernardia globiflora</i>		C
<i>Julbernardia paniculata</i>	characteristic for northern Kalahari Sands	C
<i>Markhamia obtusifolia</i>	not characteristic (indicator for undifferentiated woodland)	x
<i>Myrsine africana</i>		x
<i>Ochna pulchra</i>	indicator	x
<i>Parinari capensis</i>	characteristic for Kalahari suffrutex grassland	x
<i>Parinari curatellifolia</i>	characteristic (also characteristic for Kalahaari scrub woodland)	C
<i>Pseudolachnostylis maprouneifolia</i>	characteristic	x
<i>Rhus tenuinervis</i>		x
<i>Schinziophyton rautanenii</i>	indicator (characteristic for southern Kalahari Sands)	C
<i>Smilax anceps</i>		x
<i>Strychnos cocculoides</i>		x
<i>Strychnos pungens</i>	indicator	x
<i>Syzygium guineense</i>	not characteristic (indicator for Chipya woodland [ <i>Syzygium guineense</i> ssp. <i>guineense</i> ])	C
<i>Terminalia sericea</i>	characteristic	C
<i>Uapaca kirkiana</i>		x
<i>Uapaca nitida</i>		x
<i>Vitex madiensis</i>		x
<i>Vitex mombassae</i>		x
<i>Ximenia americana</i>		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 be 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 (Burt *et al.* 1942; Lind and Morrison 1974 p. 83).

18: This statement is very often not true 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 Zambezi floristic region that have deeper soils would only have Zambezi 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 Zambezi dry evergreen forest (P. Smith and J. Timberlake, pers. comm.; see also comments for Zambezi 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 VE-CEA map) is part of that succession (P. Smith, personal communication).

Miombo woodland is the prevalent vegetation throughout the greater part of the Zambezi region, especially on the main plateau and its flanking escarpments where the soils are freely drained but the rooting environment is restricted. Miombo soils often have a restricted rooting environment<sup>(18)</sup> since they are shallow and stony, or since a laterite or gley horizon<sup>(19)</sup> occurs near the surface. On moister and deeper soils in higher rainfall areas, miombo has probably replaced Zambezi dry evergreen forest (Fm)<sup>(20)</sup> or Zambezi transition woodland (an ecotone in between Zambezi dry evergreen forest, see description of Zambezi 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 Zambezi dry evergreen forest<sup>(21)</sup> or Zambezi 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 Zambezi dry evergreen forest and thicket (Fm), Zambezi swamp forest (fs), Zambezi evergreen riparian forest (fr) and wet dambos. Annual

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***<sup>(22)</sup>, ***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 Zambebian 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.

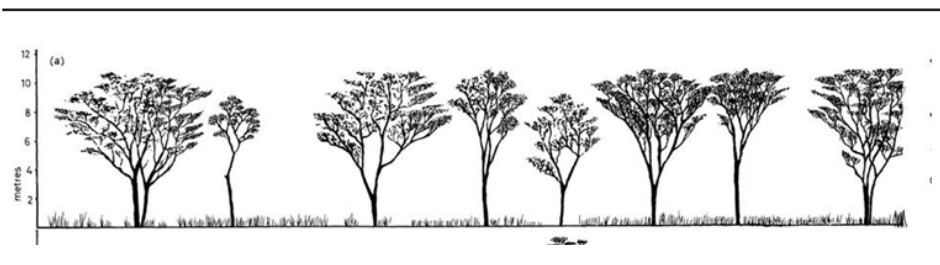


Figure 8.7. Profile diagram of Miombo woodland. Pratt et al. (1966, Fig 3a). Image obtained from URL: <http://www.jstor.org/stable/2401259>



## 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.

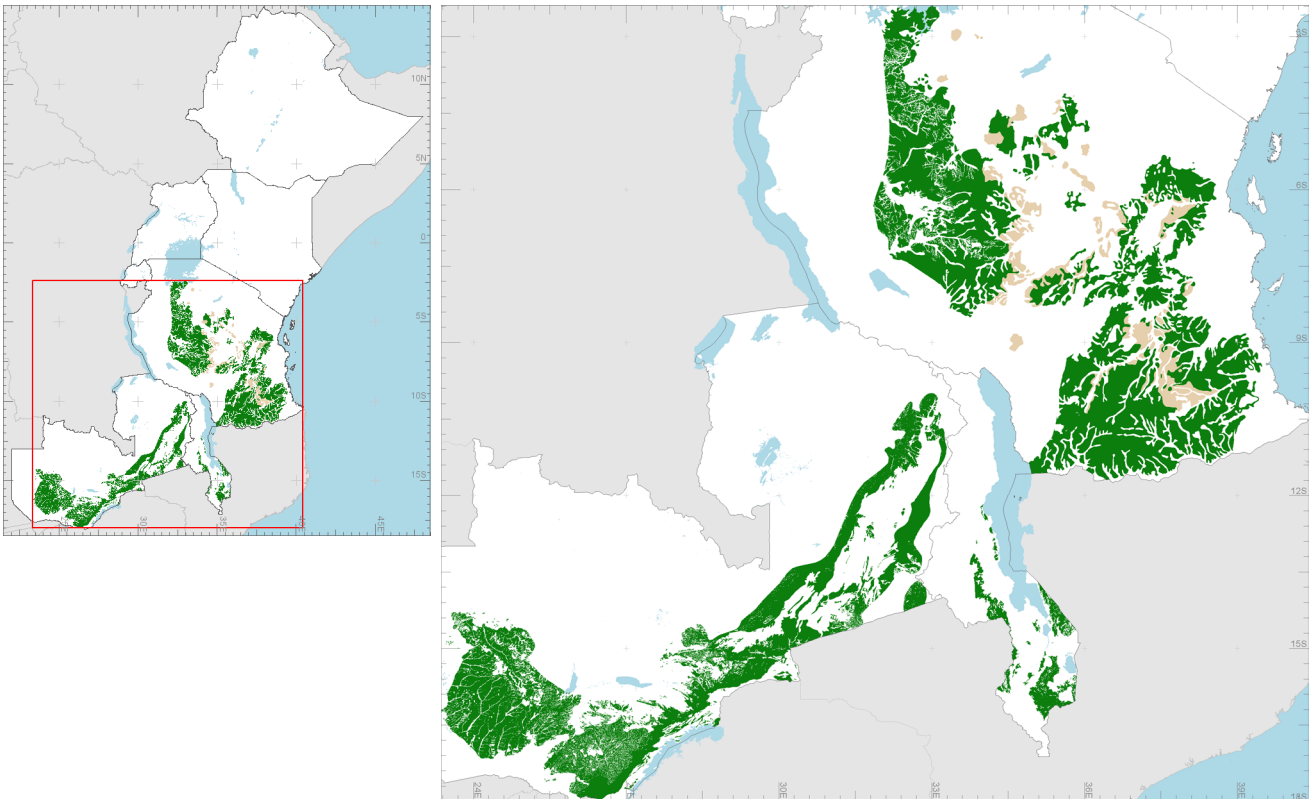


Figure 8.8. Mapped distribution of drier miombo woodland in the VECEA region (Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda and Zambia). Where this vegetation subtype does not occur in mosaic, it is depicted by green polygons. In Tanzania, it is also mapped as part of different vegetation mosaics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

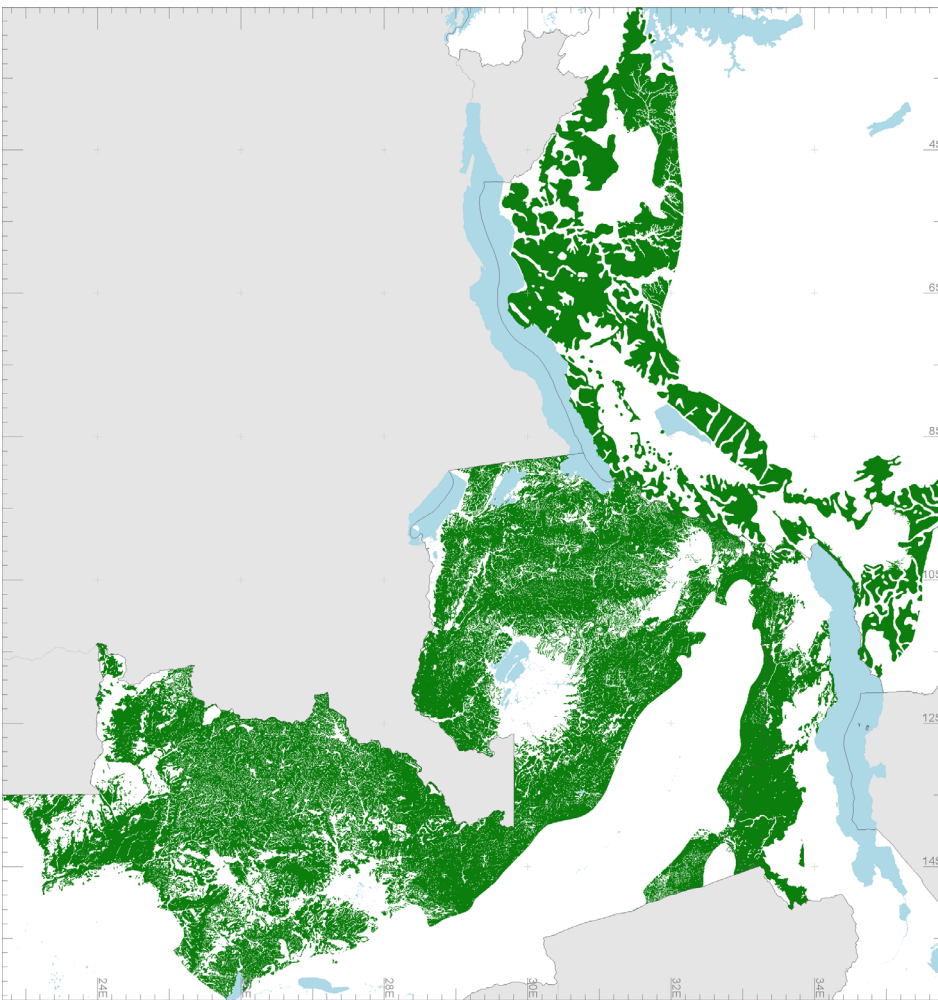
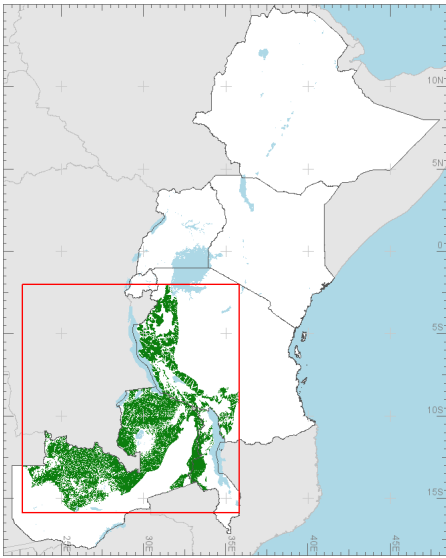


Figure 8.9. Mapped distribution of wetter Miombo woodland in the VECEA region (Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda and Zambia). Green polygons depict where we mapped this vegetation subtype.

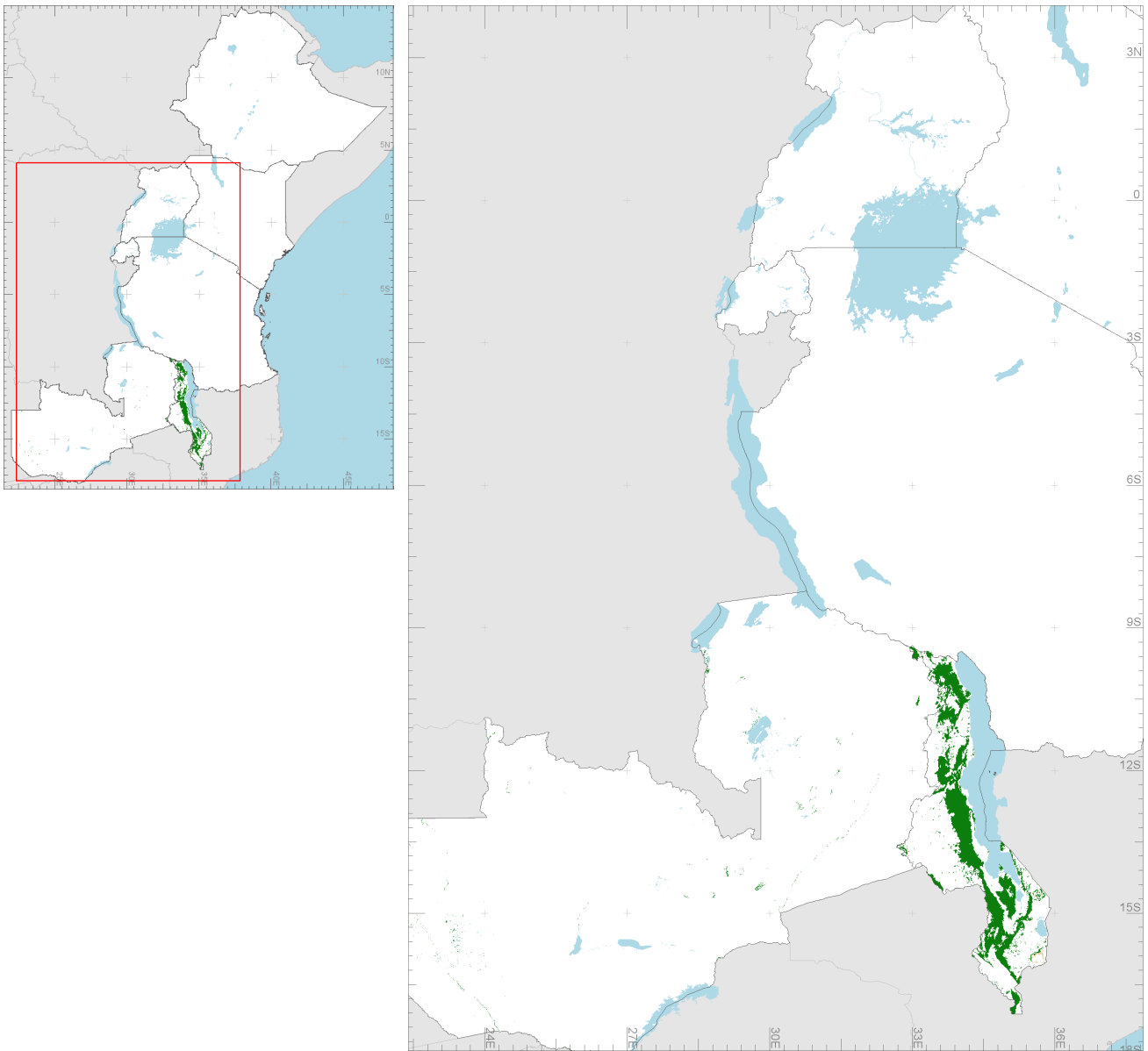


Figure 8.10. Distribution of miombo woodland on rocks and woody outcrops in the VECEA region (Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda and Zambia). Green polygons show where we mapped this vegetation subtype. We expect that this vegetation subtype also exists in Tanzania. The distribution of 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 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.

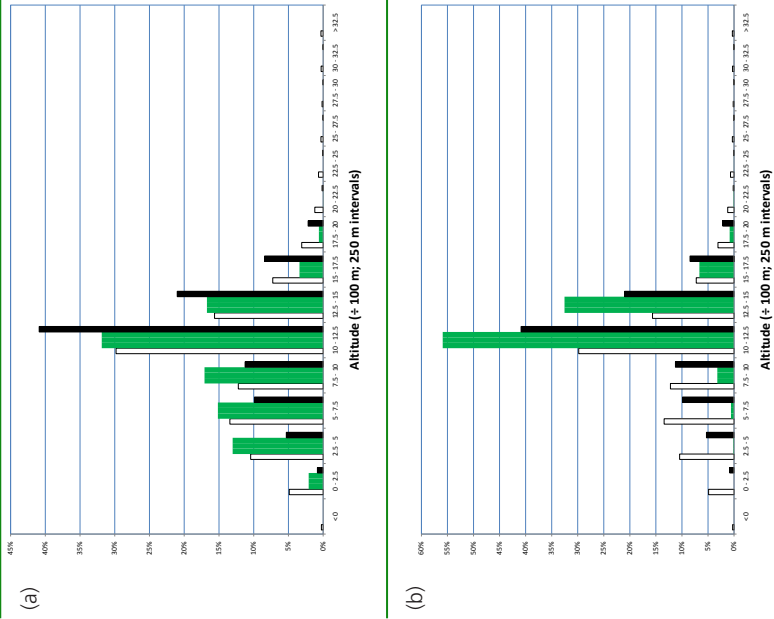


Figure 8.11. Histograms of the distribution of altitude within drier miombo woodland (a,  $n = 68,524$ ) and wetter miombo woodland (b,  $n = 116,907$ ). Bars at the centre of each interval show the percentage of samples within drier or wetter miombo woodland. Bars on left (open) show the overall percentage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

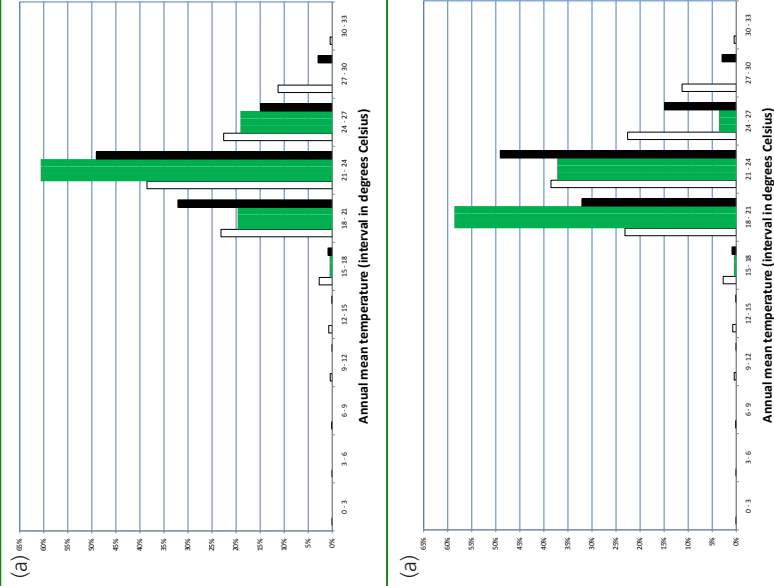


Figure 8.12. Histograms of the distribution of mean annual temperature within drier miombo woodland (a,  $n = 75,101$ ) and wetter miombo woodland (b,  $n = 110,319$ ). Bars at the centre of each interval show the percentage of samples within drier or wetter miombo woodland. Bars on left (open) show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

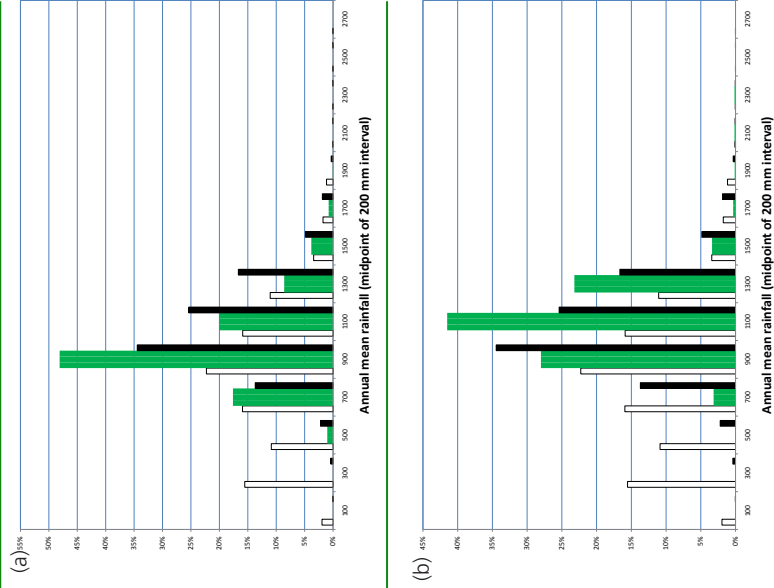


Figure 8.13. Histograms of the distribution of mean annual rainfall within drier miombo woodland (a,  $n = 75,101$ ) and wetter miombo woodland (b,  $n = 110,319$ ). Bars at the centre of each interval show the percentage of samples within drier or wetter miombo woodland. Bars on left (open) show the 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 - Julbernardia* 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-Isobertinia* 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-Isobertinia* 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)
<i>Brachystegia allenii</i>	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		
<i>Brachystegia boehmii</i>	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	
<i>Brachystegia bussei</i>	dominant (virtually confined to rocky hills and escarpments)	Dej	f	C	f		
<i>Brachystegia floribunda</i>	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	
<i>Brachystegia glaberrima</i>	dominant (more characteristic of deeper plateau soils; widespread in wetter miombo)		f	C			
<i>Brachystegia glaucescens</i>	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		
<i>Brachystegia longifolia</i>	dominant (more characteristic of deeper plateau soils; also in northern Kalahari woodland)	xj	f	C			
<i>Brachystegia manga</i>	dominant (more characteristic of deeper plateau soils)	xe	f	C			
<i>Brachystegia microphylla</i>	dominant (virtually confined to rocky hills and escarpments; sometimes in scrub woodland towards altitudinal limits of miombo woodland)	De	f	f	C	x	C
<i>Brachystegia puberula</i>	dominant (not east of Kalahari sands; also in northern Kalahari woodland)		f	f			
<i>Brachystegia spiciformis</i>	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
<i>Brachystegia stipulata</i>	dominant (also in scrub woodland on certain shallow soils derived from siltstone)	xj	f	x		x	
<i>Brachystegia taxifolia</i>	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	
<i>Brachystegia utilis</i>	dominant (both on escarpments, ridges and certain plateau soils)	xej	f	C			
<i>Brachystegia wangermeeana</i>	dominant (more characteristic of deeper plateau soils; widespread in wetter miombo; also in northern Kalahari woodland)		f	C			
<i>Isobornia angolensis</i>	dominant	Di	f	C			
<i>Julbernardia globiflora</i>	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	
<i>Julbernardia paniculata</i>	dominant (also in northern Kalahari woodland)	Dj	f	C			
<i>Acacia nigrescens</i>	not characteristic (indicator for Mopane woodland and Undifferentiated woodland)	Ce	f	f			
<i>Acacia polyacantha</i>	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)
<i>Acacia sieberiana</i>	not characteristic (indicator for Undifferentiated woodland)	xej	f	f	f		f
<i>Azelia quanzensis</i>	characteristic (principal canopy associate). (White 1983 p. 95). This species occurs at a wide range of altitudes in the Zambezi 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 Zambezi dry deciduous forest (Fn; C. Dudley, pers. comm.).	xe	f	f			x
<i>Albizia amara</i>	not characteristic (indicator for Undifferentiated woodland)	xej	f	f	f		
<i>Albizia antunesiana</i>	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			
<i>Albizia versicolor</i>	not characteristic (indicator for Undifferentiated woodland)	xej	f	f	f		f
<i>Allophylus africanus</i>		xe	f	f			
<i>Anisophyllea boehmii</i>	not characteristic (indicator for Chipya woodland)		f	x			
<i>Anisophyllea pomifera</i>	indicator (principal canopy associate). [White 1983 p. 93]; this is not a canopy species (P. Smith, pers. comm.)	f	f	C			
<i>Antidesma venosum</i>	(this is not a miombo species, but a riverine species instead [P. Smith, pers. comm.])	xj	f	f	f		f
<i>Bauhinia petersiana</i>		xej	f	x			
<i>Bobgunnia madagascariensis</i>	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	
<i>Burkea africana</i>	characteristic (principal canopy associate; also scrub woodland at edges of dambos)	Cej	f	f		x	
<i>Cassia abbreviata</i>	not characteristic (indicator for Undifferentiated woodland)	xej	f	f			f
<i>Combretum adenogonium</i>	not characteristic (indicator for Undifferentiated woodland)	xej	f	x			
<i>Combretum collinum</i>	not characteristic (characteristic for Undifferentiated woodland and Chipya woodland)	xej	f	x			f
<i>Combretum molle</i>	not characteristic (indicator for Undifferentiated woodland)	xej	f	f			f
<i>Combretum zeyheri</i>	(This is a ubiquitous species that is also frequently found in miombo woodland [P. Smith, pers. comm.])	xej	f	x			f
<i>Crossopteryx febrifuga</i>		xej	f	f			f
<i>Croton sylvaticus</i>							x
<i>Cryptosepalum exfoliatum</i>	not characteristic (indicator for northern Kalahari woodland [ <i>Cryptosepalum exfoliatum</i> ssp. <i>pseudotaxus</i> ])	f	f	x	C		
<i>Cussonia arborea</i>		xe	f	x			
<i>Dalbergia nitidula</i>		xe	f	x			f
<i>Dichrostachys cinerea</i>	(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)
<i>Diospyros kirkii</i>		xej	f	x			
<i>Diplorhynchus condylocarpon</i>	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			
<i>Dombeya rotundifolia</i>	characteristic (principal canopy associate)	xej		x			
<i>Erythrophloeum africanum</i>	characteristic (principal canopy associate)	xe	f	C			
<i>Faurea rochetiana</i>	scrub woodland at edges of dambos		f	x		x	
<i>Faurea saligna</i>	indicator (principal canopy associate)	xe	f	C			C
<i>Flacourtia indica</i>		xej	f	x			f
<i>Flueggea virosa</i>		xej	f	f			f
<i>Hexalobus monopetalus</i>		xj	f	x			
<i>Hymenaea verrucosa</i>	characteristic (forest species in Zanzibar-Inhambane transition woodland)						x
<i>Kigelia africana</i>	not characteristic (indicator for Undifferentiated woodland)	xj	f	f			f
<i>Kirkia acuminata</i>	not characteristic (indicator for mopane woodland)	Ce	f	f			
<i>Landolphia kirkii</i>		f	f	x			f
<i>Lannea discolor</i>	not characteristic (indicator for Kalahari woodland)	xe		f			
<i>Lannea schweinfurthii</i>	not characteristic (indicator for Undifferentiated woodland)						x
<i>Lonchocarpus capassa</i>	not characteristic (indicator for Undifferentiated woodland)	xe	f	f			f
<i>Manilkara sansibarensis</i>	characteristic (forest species in Zanzibar-Inhambane transition woodland)						x
<i>Margaritaria discoidea</i>							x
<i>Markhamia obtusifolia</i>	not characteristic (indicator for Undifferentiated woodland)	xej	f	x			f
<i>Markhamia zanzibarica</i>		xe	f	f			f
<i>Marquesia macroura</i>	indicator (principal canopy associate)		f	C			
<i>Maytenus senegalensis</i>		xj	f	f			f
<i>Monotes africana</i>	(This species is characteristic of escarpment miombo woodland in Zambia [P. Smith, pers. comm.])	xj		f			
<i>Myrsine africana</i>		f	f	x			
<i>Ormocarpum kirkii</i>		xe	f	f			f
<i>Oxytenanthera abyssinica</i>	(lowland bamboo species)	xe	f	f			
<i>Ozoroa insignis</i>	not characteristic (indicator for Chipya woodland)	xej	f	f			f
<i>Parinari curatellifolia</i>	characteristic (principal canopy associate; also on shallow soils overlaying laterite and in scrub woodland at edges of dambos)	xj	f	C		x	f
<i>Pericopsis angolensis</i>	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)
<i>Ptilostigma thonningii</i>	not characteristic (indicator for Undifferentiated woodland)	xe	f	f	f		f
<i>Pleurostyla africana</i>		xj	f	f	f		f
<i>Pseudolachnostylis maprouneifolia</i>	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			
<i>Pterocarpus angolensis</i>	characteristic (principal canopy associate)	xeij	f	C			f
<i>Sclerocarya birrea</i>	not characteristic (characteristic for mopane woodland and Undifferentiated woodland)						x
<i>Securidaca longipedunculata</i>		xej	f	x			f
<i>Senna singuana</i>		xj	f	f			f
<i>Smilax anceps</i>	not characteristic (Chipya woodland indicator)		f	x			
<i>Steganotaenia araliacea</i>		xj	f	f			
<i>Sterculia africana</i>		xe	f	f			f
<i>Sterculia quinqueloba</i>		xe	f	f			f
<i>Stereospermum kunthianum</i>	(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
<i>Strychnos cocculoides</i>		xj	f	x			f
<i>Strychnos innocua</i>		xej	f	x			f
<i>Strychnos spinosa</i>		xj	f	f			f
<i>Syzygium guineense</i>	not characteristic (indicator for Chipya woodland and scrub woodland at edges of dambos [Syzgium 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
<i>Terminalia sericea</i>	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			
<i>Thespesia garckeana</i>	negative indicator (undifferentiated woodland)	xe	f	f			
<i>Uapaca kirkiana</i>	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	
<i>Uapaca nitida</i>	Several species of Uapaca occur scattered in miombo as small trees less than 10 m tall.	xj	f	x			f
<i>Uapaca sansibarica</i>	Several species of Uapaca occur scattered in miombo as small trees less than 10 m tall.	f	f	x			f
<i>Vangueria infausta</i>		xej	f	f			f
<i>Vangueriopsis lanciflora</i>	not characteristic (indicator for Kalahari woodland and scrub woodland at edges of dam-bos)	xj	f	f		x	

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