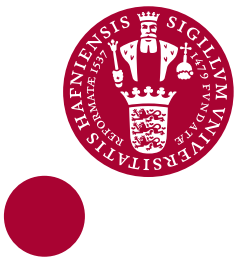

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Publication date:
2011

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

FOREST & LANDSCAPE

THE ROCKEFELLER FOUNDATION

World Agroforestry Centre
TRANSFORMING LIVES AND LANDSCAPES

FOREST & LANDSCAPE WORKING PAPERS 65 / 2011

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

VOLUME 5

Description and Tree Species Composition for Other Potential Natural Vegetation Types (Vegetation Types other than Forests, Woodlands, Wooded Grasslands, Bushlands and Thickets)

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Title
Potential natural vegetation map of eastern Africa. Volume 5. Description and tree species composition for other potential natural vegetation types.

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Collaborating Partner
World Agroforestry Centre

Publisher
Forest & Landscape Denmark
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Series - title and no.
Forest & Landscape Working Paper 65-2011

ISBN
ISBN 978-87-7903-555-3

Layout
Melita Jørgensen

Citation
Kindt, R., Lillesø, J.-P. B., van Breugel, P., Bingham, M., Sebsebe Demissew, Dudley, C., Friis, I., Gachathi, F., Kalema, J., Mbago, F., Minani, V., Moshi, H. N., Mulumba, J., Namaganda, M., Ndangalasi, H.J., Ruffo, C.K., Jamnadass, R. and Graudal, L. 2011. Potential natural vegetation of eastern Africa. Volume 5: Description and tree species composition for other potential natural vegetation types. Forest & Landscape Working Paper 65-2011

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

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Introduction

This book represents Volume 5 in a seven-volume series that documents the potential natural vegetation map that was developed by the VECEA (Vegetation and Climate change in East Africa) project. The VECEA map was developed as a collaborative effort that included partners from each of the seven VECEA countries (Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda and Zambia).

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

Acknowledgements

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

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

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

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

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

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

Abbreviations

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

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

Contents

List of Tables

1. Physiognomic definitions

In this volume, we describe vegetation types that were not handled in volumes 2 (describing forests and scrub forests), 3 (describing woodlands and wooded grasslands) and 4 (describing bushlands and thickets).

Grasslands are defined as lands covered with grasses and other herbs and where woody plants do not cover more than 10% of the ground (White 1983 p. 46, Figure 1).

Shrublands are defined as vegetation types with woody plants of heights up to 2 m (White 1983 p. 46). Although a cover percentage was not mentioned, we assume that vegetation types were shrubs cover between 10% and 40% should be classified as wooded grasslands (Figure 1).

Several vegetation types that we describe here are formations of distinct physiognomy. These include bamboo (B [Afromontane bamboo] and L [Lowland bamboo], bamboo species are defined as giant grasses of 2 to 20 m in height; this vegetation type is not classified as thicket despite having similar physiognomic characteristics], mangrove [M, defined as trees or bushes occurring on shores that are periodically flooded by sea water, not classified as forest], herbaceous fresh-water swamp and aquatic vegetation [X] and halophytic vegetation [Z, not classified as wooded grassland, bushland, wooded grassland or grassland]; White 1983 pp. 46 - 55).

Afroalpine vegetation (A) is physiognomically mixed vegetation (which does not readily fit the major physiognomic categories) that occurs on high mountains where night frosts are liable to occur throughout the year (White 1983 pp. 46 and 169).

Deserts (D) are not described as a major physiognomic type. We think that they could be defined as "areas where the differences in soil characteristics (such as soil colour) are more conspicuous than the vegetation itself and where the individual plants are never abundant enough in large enough areas to justify the classification of the vegetation as a physiognomic vegetation type such as grassland or shrubland".

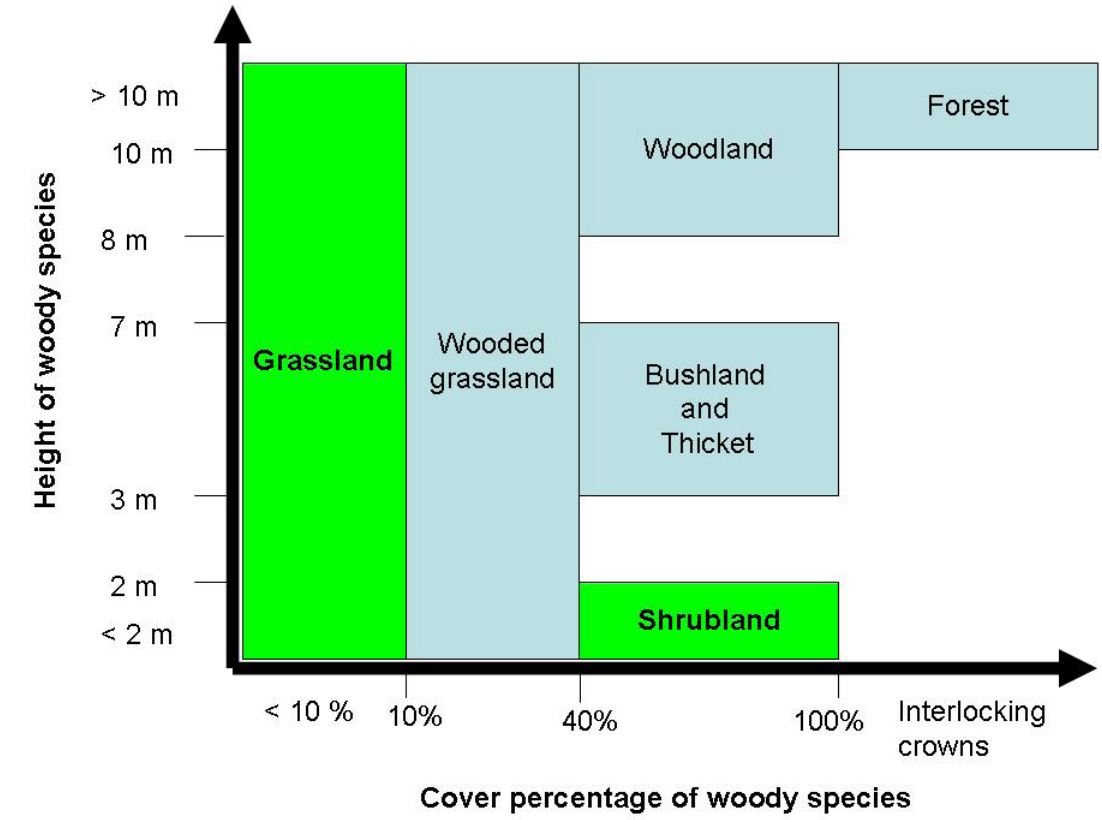


Figure 1. Main physiognomic categories, including the grassland and shrubland vegetation types described in this volume. Note that grassland is not defined by height of the vegetation.

2. Methodology

2.1. Main description of a vegetation type

In these sections, we relied heavily on The Vegetation of Africa (White 1983) - especially since this reference built on the extensive expertise that White (1983) 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 vegetation 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 the key reference on the vegetation of Africa, we mainly consulted 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 vegetation 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 vegetation type

For each of the vegetation types, we obtained information on species assemblages (those tree species expected to occur in a particular bushland or thicket) 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 vegetation type (for example, Afroalpine vegetation as it was described for Ethiopia by Friis *et al.* 2010), we created a separate column

within which we gave an indication that a particular tree species was expected to occur within that vegetation type and 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 [1] whether the species could **potentially** occur in the focal vegetation type and focal country **because the species was documented to occur in the same vegetation type in other countries.** For example, the species *Alchemilla argyrophylla* was documented to occur in Afroalpine vegetation in the national references from Kenya and Uganda. From the Flora of Tropical East Africa, 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 Afroalpine vegetation 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 vegetation type do NOT occur in that particular country and vegetation type in reality (meaning that, in reality, differences exist between species assemblages of the same vegetation 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 (*URL http://www.ville-ge.ch/musinfo/bd/cjb/africa*) whereas we generally attempted to use the same botanical names as adopted in the the Plant Resources of Tropical Africa (PROTA) database *(URL 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 were listed in at least one of the references that we consulted on tree species that are expected to be useful to farming or pastoral communities in the VECEA countries (see Appendix 1).

Information from White (1983) was used to collate information on the "regional status" of a species. In case that a species was listed by White (1983), then we sometimes mentioned that this was a characteristic species. In case that a species was listed by White (1983) for another vegetation type, then we sometimes mentioned that this was a characteristic species for other vegetation types.

1: 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 and Davenport [1996], Viskanic [1999]) for Uganda; and Burgess and Clarke [2000] for the coastal areas of Kenya and Tanzania)

2.4. Information on the distribution of altitude, rainfall and temperature for each vegetation type

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

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

3. Afroalpine vegetation (A)

3.1. Description

The vegetation of the highest mountains of tropical Africa (≥ 3800, including the Aberdares [Kenya], Mt. Elgon [Kenya and Uganda], Mt. Kenya, Mt. Kilimanjaro [Tanzania], Mt. Meru [Tanzania], the Ruwenzori Mts. [Uganda and DRC], the Virunga Mts. [Rwanda and DRC] and the higher peaks of Ethiopia [but see section 3.2]) are characterized by the occurrence of Giant *Senecio* species (up to 6 m; *Senecio* subgenus *Dendrosenecio*), Giant *Lobelia* species (up to 6 m), shrubby *Alchemilla* species and other plants of remarkable lifeforms. Since most of the species also occur in the montane Ericaceous (E, see Volume 3) and Afromontane forest belts (Fa, Fb and Fd, see Volume 2), Afroalpine vegetation can be regarded as an archipelago-like floristic region of extreme floristic impoverishment (White 1983 p. 169).

Afroalpine vegetation occurs on high mountains where night frosts are liable to occur throughout the year (White 1983 p. 46).

Knox and Palmer (1993, Fig 3) provide the following distribution pattern of the 11 species of giant *Senecio* species[2]:

- *Senecio* subgenus *Dendrosenecio adnivalis*: Ruwenzori Mts.
- *Senecio* subgenus *Dendrosenecio battiscombe*i: Aberdares and Mt. Kenya
- *Senecio* subgenus *Dendrosenecio brassiciformis*: Aberdares
- *Senecio* subgenus *Dendrosenecio cheranganiensis*: Cherangani Hills
- *Senecio* subgenus *Dendrosenecio elgonensis*: Mt. Elgon
- *Senecio* subgenus *Dendrosenecio erici-rosenii*: Ruwenzori,Virunga and Mitumba Mts.
- *Senecio* subgenus *Dendrosenecio johnstonii*: Mt. Kilimanjaro
- *Senecio* subgenus *Dendrosenecio keniensis:* Mt. Kenya
- *Senecio* subgenus *Dendrosenecio keniodendron*: Aberdares and Mt. Kenya
- *Senecio* subgenus *Dendrosenecio kilimanjari*: Mt. Kilimanjaro
- *Senecio* subgenus *Dendrosenecio meruensis*: Mt. Meru

2: Based on analysis of chloroplast DNA, these authors suggest that the *Dendrosenecio* subgenus originated on Mt. Kilimanjaro

Figure 3.1. Afroalpine vegetation in the foreground with rosettes of *Lobelia rhynchopetalum* (before flowering). In the background the montane Ericaceous belt (see Volume 2) on the slope of the valley with *Erica arborea*. Semien mountains (Ethiopia). Photograph by I. Friis and Sebsebe Demissew (October 2009). Reproduced from Biologiske Skrifter of the Royal Danish Academy of Sciences and letters, Vol. 58, Fig 30A. 2010.

Figure 3.2. Mosaic of grass sward and *Helichrysum crispinum* heath together with flowering and sterile individuals of *Lobelia rhynchopetalum*. Bale mountains (Ethiopia). Photograph by I. Friis and Sebsebe Demissew (September 2005). Reproduced from Biologiske Skrifter of the Royal Danish Academy of Sciences and letters, Vol. 58, Fig 30C. 2010.

Figure 3.3. Afroalpine vegetation in the Ruwenzori Mts (Uganda). Photograph by M. Namaganda (June 2008).

Figure 3.4. Afroalpine vegetation in the Ruwenzori Mts (Uganda). Photograph by M. Namaganda (June 2008).

Figure 3.5. Afroalpine vegetation on the Karisimbi Volcano (Rwandan side of the Virunga Mts.). Photograph by V. Minani (April 2006).

Figure 3.6. Typical East African bird species that occur in Afroalpine vegetation within their natural habitat. Shell guide to East African birds (1960; reproduced with permission from URL *http://ufdc.ufl.edu/UF00077050*).

3.2. VECEA region

Within the VECEA region, Afroalpine vegetation occurs in all VECEA countries except Malawi and Zambia (Figure 3.7, see also Volume 6).

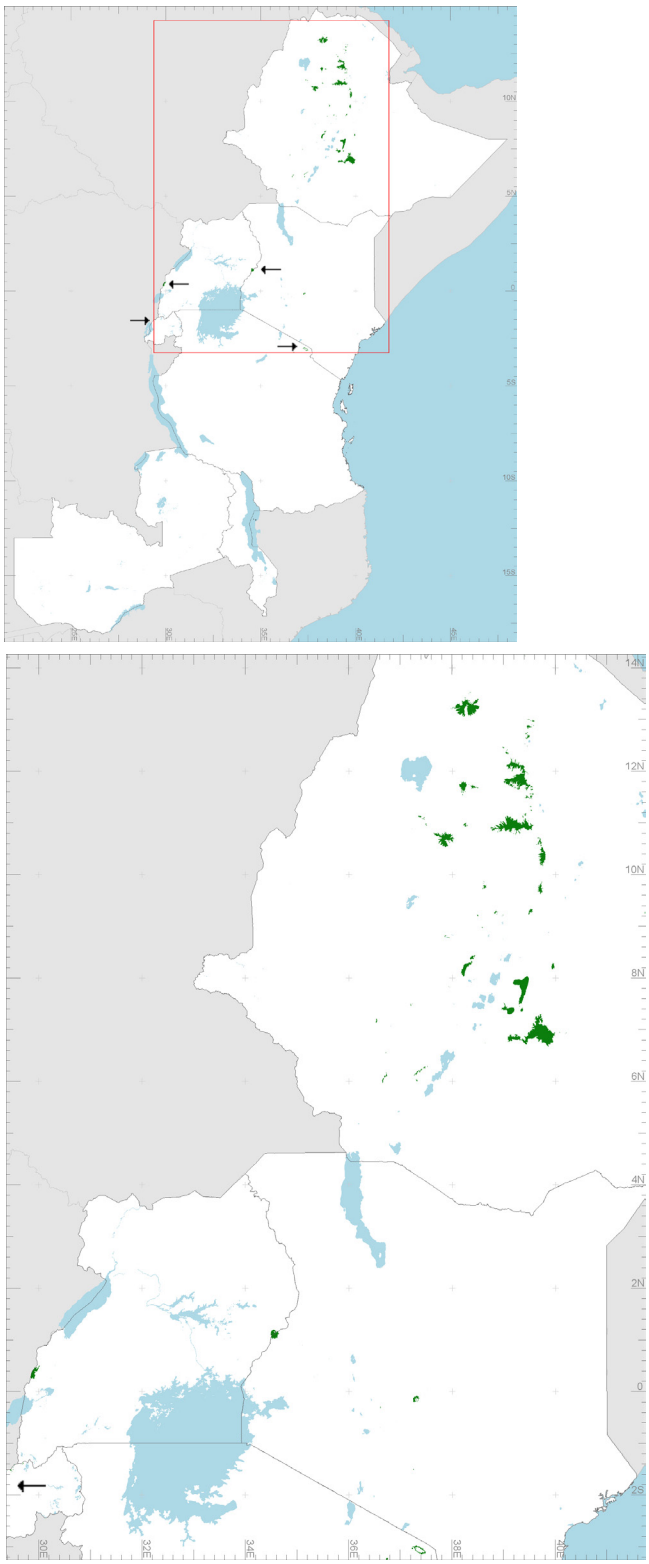


Figure 3.7. Mapped distribution of Afroalpine vegetation in the VECEA region (Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda and Zambia). Green polygons depict where we mapped this vegetation type. Arrows indicate some small patches of this vegetation type. This vegetation type was not found in Malawi and Zambia.

Afroalpine vegetation in Ethiopia (original mapping unit AA) is distinct by the absence of *Senecio* subgenus *Dendrosenecio* species and having only one giant *Lobelia* species. This vegetation type was mapped in Ethiopia by using the elevation contour of 3200 m (Friis *et al.* 2010 pp. 118 - 123).

Afroalpine vegetation was originally mapped in Kenya as "Alpine (giant groundsel and *Lobelia*) vegetation" (original mapping unit 7A) and "Undifferentiated moorland" (original mapping unit 7). The reason for including original mapping unit 7 was based on a comparison with vegetation types on the Ugandan side of Mt. Elgon; more details are provided in Volume 6.

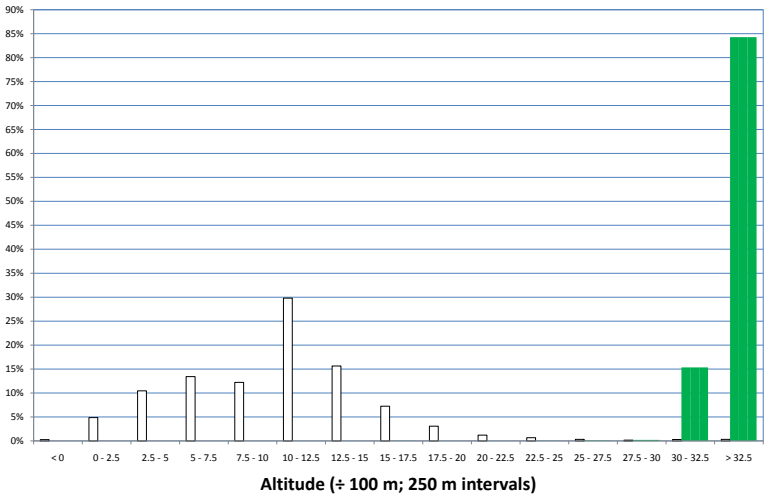
In Rwanda, Afroalpine vegetation was originally described as "pelouses (alpines)".

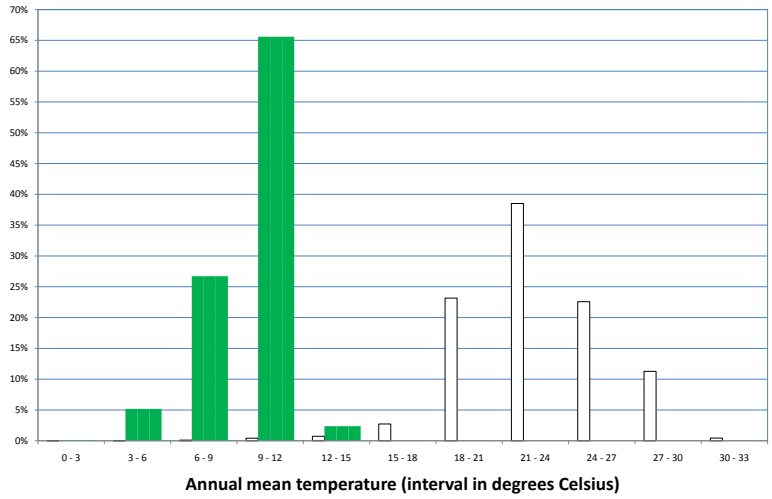
Gillman (1949 p. 18) indicates that areas that he mapped as "ridge and slope grassland" in Tanzania include "high altitude grassy scrub formations" such as those of the upper Kilimanjaro (he also listed the synonyms of "alpine meadow" and "moor-grassland"); we mapped these areas on Kilimanjaro as Afroalpine vegetation. Lovett (1993) says that the only mountains in Eastern Tanzania high enough to support an Alpine belt are the geologically recent volcanoes of Kilimanjaro, Meru and Hanang. However, high altitude grasslands containing many Afroalpine species are also found above the frost-determined forest line around 2400 m on the Lukwangule Plateau of the southern Uluguru, some peaks in the northern Udzungwa, uplands of the Kutulo plateau, the Mbeya mountains and the Ufipa plateau (Lovett 1993).

In Uganda, Afroalpine vegetation was originally described and mapped as Alchemilla - Helichrysum high montane moorland (original mapping unit A1).

Investigation of environmental distribution of Afroalpine vegetation in the VECEA region (Figure 3.6) shows that more than 99% of the samples occur above 3000 m, making this the vegetation type that occurs at the highest altitude of all vegetation types investigated in the VECEA region (excluding Afromontane deserts, however). The altitude interval above 3250 m contains the highest number of samples (84.3%); this is just above the altitude interval of 3000 – 3250 m that contains the highest number of samples of the montane Ericaceous belt (generally the second highest vegetation type). Afroalpine vegetation generally receives between 800 and 1800 mm annual rainfall (> 95% of samples).

(a)





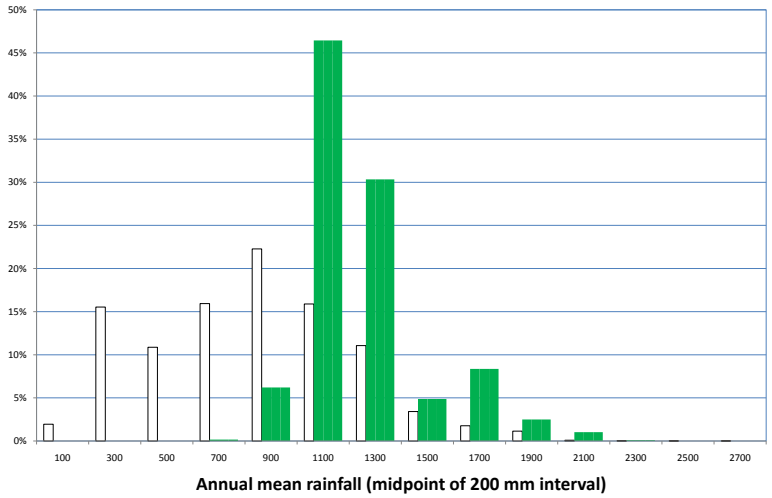


Figure 3.6. Histograms of the distribution of altitude (a), mean annual temperature (b) and mean annual rainfall (c). Bars at the centre of each interval show the percentage of samples within Afroalpine vegetation (A, *n* = 2,321). Bars on the left (open) show the overall percentage of samples (*n* = 740,047).

3.3. Species composition

Species assemblages were obtained from the following references:

- Ethiopia: Friis *et al.* 2010. Species mentioned mentioned in Appendix 3 for "Afroalpine vegetation" [AA] were coded "x" (unless they were characteristic species).
- Kenya. Species that were expected to occur in Afroalpine vegetation based on information from Beentje (1994), the Flora of Tropical East Africa and field experience from our Kenyan collaborator (F. Gachathi) were coded "x".
- Rwanda: Bloesch *et al.* (2009). All species that were mentioned to occur in floristic region 4B (subalpine and alpine volcano zones) and where a reference was made to 'formations à *Lobelia* et *Senecio*' or 'pelouses (alpines)' in the description of their ecology were coded "x" (unless they were characteristic species).
- Tanzania: Hedberg (1951). Species mentioned to occur in the Alpine belts of Mt. Kilimanjaro (p. 193) were coded "x" (unless they were characteristic species).[3]
- Uganda: Langdale-Brown *et al.* (1964). All species that were listed to occur in "*Alchemilla-Helichrysum* high montane moorland" in the Appendix 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: *Lobelia* and *Senecio* species were coded "C" based on the name of the mapping unit of "Alpine [giant groundsel and *Lobelia*] vegetation".
- Rwanda: *Lobelia* and *Senecio* species were coded "C".
- Tanzania: *Senecio* species were coded "C".
- Uganda: species that were listed as small trees in the appendix and for which the genus was mentioned in the main text were coded "C".

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

3: Hedberg (1951) does not provide species for the Afroalpine belt of Mt. Meru

Table 1. Species composition of Afroalpine vegetation (A)

Species	Regional status (see section 2.3)	(Ethiopia)	(Kenya)	(Rwanda)	(Tanzania)	(Uganda)
Alchemilla argyrophylla	characteristic (genus)		x		f	x
Alchemilla elgonensis	characteristic (genus)		x			f
Alchemilla johnstonii	characteristic (genus)		x	x	f	x
Lobelia deckenii	characteristic (genus)					C
Lobelia rhynchopetalum	characteristic (genus)	C				
Lobelia stuhlmannii	characteristic (genus)			C		
Lobelia telekii	characteristic (genus)		C			C
Lobelia wollastonii	characteristic (genus)			C		C
Senecio subgenus *Dendrosenecio adnivalis*	characteristic (genus)					C
Senecio subgenus *Dendrosenecio elgonensis*	characteristic (genus)		f			C
Senecio subgenus *Dendrosenecio johnstonii*	characteristic (genus)		C	C		f
Senecio subgenus *Dendrosenecio keniodendron*	characteristic (genus)		C			
Senecio subgenus *Dendrosenecio kilimanjari*	characteristic (genus)				C	
Senecio myriocephalus	characteristic (genus)	x				
Senecio subsessilis	characteristic (genus)		f	C	f	f
Adenocarpus mannii		x	f	x	f	f
Andropogon amethystinus	(grass)		f		f	x
Asparagus africanus		x	f		f	
Conyza newii		x	f	f	f	f
Discopodium eremanthum		x	f		f	f
Discopodium penninervium		x	f	f	f	f
Erica arborea		C	x	f	f	f
Festuca abyssinica	(grass)		f		f	x
Helichrysum formosissimum				x		C
Helichrysum forskahlii					x	
Hypericum revolutum		C	f	f	f	f
Inula confertiflora		x				
Leonotis ocymifolia		x	f		f	
Myrsine africana		x	f	f	f	f
Nuxia congesta		x	f	f	f	f
Rapanea melanophloeos		x	f	f	f	f
Sinarundinaria alpina	Afromontane bamboo	x	f	f	f	f

4. Afromontane bamboo (B)

4.1. Description

Sinarundinaria alpina (synonym: *Arundinaria alpina*) is one of the four bamboo species (giant grasses with erect woody stems of 2 - 20 m [or even taller] that sometimes form pure and virtually impenetrable communities, and that persist for several years, then flower gregariously and then die back,) that are indigenous to Africa (the other species are *Oxytenanthera abyssinica* [mapped in the VECEA map as "L", see below], *Oreobambos buchwaldii* [it was recorded within species assemblages for various forest vegetation types] and *Arundinaria tessellata* [current name: *Thamnocalamus tessellatus*; it replaces ***Sinarundinaria alpina*** in South Africa]). ***Sinarundinaria alpina*** occurs on most of high mountains of East Africa (Ethiopia to southern Tanzania), but south of Tanzania it is only known to occur on the North Viphya Plateau (Malawi), Dedza Mt. (Malawi) and Mt. Mulanje (Malawi); White 1983 pp. 55 and 166). The Flora Zambesiaca confirms that ***Sinarundinaria alpina*** does not occur in Zambia. The species presently does not occur on the North Viphya Plateau (C. Dudley, personal observations).

In East Africa, *Sinarundinaria alpina* is mostly found between 2400 and 3000 m, although it ascends on Mt. Kenya to 3500 m and descends in the Uluguru Mts. (Tanzania) to 1630 m. It grows most vigorously on deep volcanic soils and gently slopes where the annual rainfall exceeds 1250 mm. The largest areas are found on the Aberdare Range (Kenya, 65000 ha), the Mau Range (Kenya, 51000 ha) and Mt Kenya (39000 ha; White 1983 p. 166). ***Sinarundinaria alpina*** does not form a belt on Mt. Kilimanjaro, whereas a bamboo belt occurs on the adjacent Mt. Meru (White 1983 p. 167).[4]

Hemp (2006) provides the following speculations about the absence of the bamboo zone on Mt. Kilimanjaro:

> "Another feature of the forests of Kilimanjaro is the absence of a bamboo zone, which occurs on all other tall mountains in East Africa with a similarly high rainfall. Observations on other East African mountains showed that the occurrence of bamboo is linked to a special type of disturbance: the activity of large herbivores. ***Sinarundinaria alpina*** stands are favoured by elephants and buffaloes. On Kilimanjaro these megaherbivores occur on the northern slopes, where it is too dry for a large bamboo zone to develop. They are excluded from the wet southern slope forests by topography and humans who have cultivated the foothills for at least 2000 years. From studies on Mt Kenya (Vanleeuwe and Lambrechts [1999]) it is known that elephants climb slopes only up to a steepness of about 30 degrees. On the south-western and north-eastern slopes of Kilimanjaro, very deep (up to several 100 m) and very steep (>30 degree) valleys exist, which reach high up into the alpine zone. These deep gorges prevent large herbivores migrating from the northern side of the mountain to the south-

4: Friis *et al.* 2010 (p. 95) mention that Hedberg only recorded distinct mountain bamboo zones from the Aberdares, Mt. Elgon, Mt. Kenya, Mt. Meru, Ruwenzori Mts., and Virungu Mts.

ern. Combined with human occupation of the wetter slopes, this means that the southern and south-eastern montane forests of Mt Kilimanjaro are no longer accessible for buffaloes and elephants. This interplay of biotic and abiotic factors could explain not only the lack of a bamboo zone on Kilimanjaro but also offers possible explanations for the patterns of diversity and endemism."

Various tree species occur scattered within the bamboo. These tree species probably became established when bamboo plants died following their gregarious flowering (White 1983 p. 167).

Figure 4.1. Afromontane bamboo (*Sinarundinaria alpina;* synonym: *Arundinaria alpina*) in Kabatwa (Volcanoes National Park, Rwanda). Photograph by V. Minani (October 2009).

Figure 4.2. Afromontane bamboo (*Sinarundinaria alpina*; synonym: *Arundinaria alpina*) on the Virunga Mts. (Rwandan side). Photograph by V. Minani.

Figure 4.3. Edge of thicket of Afromontane bamboo (*Sinarundinaria alpina*; synonym: *Arundinaria alpina*) near Masha (Ethiopia). In the national reference for Ethiopia, Afromontane bamboo was not described separately from Afromontane forest types in which Afromontane bamboo occurs; this image was included with images for Afromontane rain forest (Fa). Photograph by I. Friis and Sebsebe Demissew (September 2005). Reproduced from Biologiske Skrifter of the Royal Danish Academy of Sciences and letters, Vol. 58, Fig 25E. 2010.

Figure 4.4. Edge of thicket of Afromontane bamboo (*Sinarundinaria alpina*; synonym: *Arundinaria alpina*) after mass-flowering near Masha (Ethiopia). In the national reference for Ethiopia, Afromontane bamboo was not described separately from Afromontane forest types in which Afromontane bamboo occurs; this image was included with images for Afromontane rain forest (Fa). Photograph by I. Friis and Sebsebe Demissew (January 2009). Reproduced from Biologiske Skrifter of the Royal Danish Academy of Sciences and letters, Vol. 58, Fig 25F. 2010.

4.2. VECEA region

Within the VECEA region, Afromontane bamboo was originally mapped in Kenya, Rwanda, Tanzania and Uganda (Figure 4.5, also see Volume 6). ***Sinarundinaria alpina*** also occurs in Ethiopia and Malawi. *Sinarundinaria alpina* does not occur in Zambia.

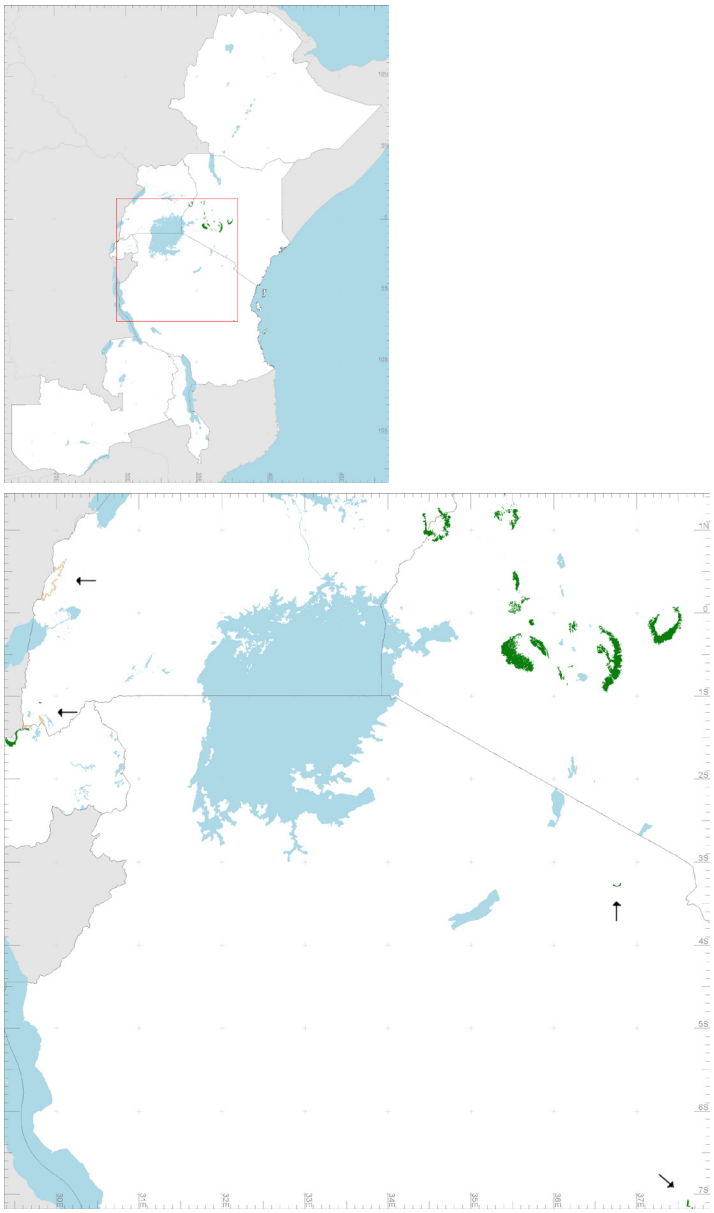


Figure 4.5. Mapped distribution of Afromontane bamboo in the VECEA region (Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda and Zambia). Where this vegetation type does not occur in mosaic, it is depicted by green polygons. This vegetation type is also mapped as part of different vegetation mosaics (sown in greyish-brown). Arrows indicate some of the smaller polygons corresponding to this vegetation type such as Mt. Meru and the Uluguru Mts. of Uganda. *Sinarundinaria alpina* (synonym: *Arundinaria alpina*) also occurs in Ethiopia and Malawi. The species probably also occurs more widely in the countries where this species was mapped. The only VECEA country where *Sinarundinaria alpina* does not occur is Zambia.

Afromontane bamboo occurs in Ethiopia within Afromontane rain forest (Fa; Friis *et al.* 2010 figs. 25E and 25F, see Volume 2) and Afromontane undifferentiated forest [Fb], but does not form a distinct belt in this country (Friis *et al.* 2010 pp. 77 and 95).

In Kenya, Afromontane bamboo was originally mapped as "mountain bamboo thicket" (original mapping unit 59), "Bamboo-woodland and scrub mixtures" (mapping unit 51a), "Bamboo-forest mixtures" (mapping unit 51b), "Open forest with gaps of bamboo origin" (mapping unit 51c) and "clearings and scrub (originating) from bamboo vegetation" (mapping unit 41).

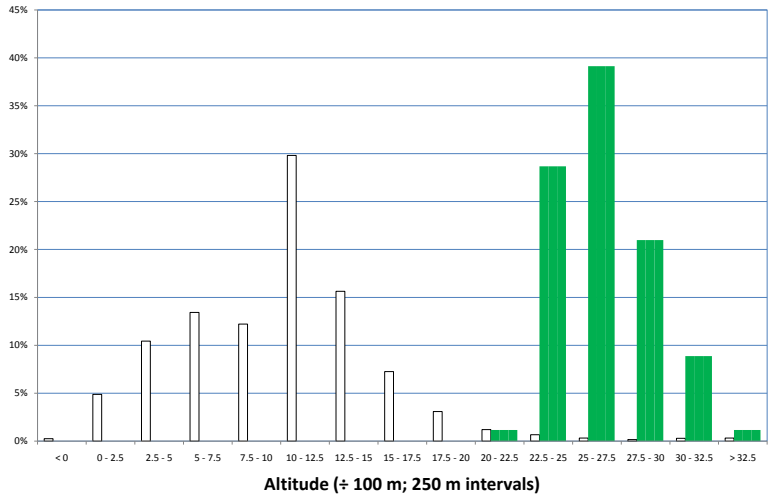
In Malawi, the species occurs locally within Afromontane undifferentiated forest (Fbj) and as open riverine stands in Afromontane single-dominant *Widdringtonia whytei* forest (Fc; C. Dudley, personal observations).

In Tanzania, Afromontane bamboo forms a distinct belt on Mt. Meru and occurs on other mountains such as Mt. Kilimanjaro - see section 4.1). Lovett (1990 p. 292) says that, in Tanzania, the bamboo ***Sinarundinaria alpina*** has a sporadic distribution that may result from an opportunistic establishment strategy in Afromontane undifferentiated forest niches that are available at the time of the species' intermittent gregarious flowering - rather than being a reflection of specific environmental conditions. The Central African Rail Link Development Survey (CARLDS 1952 p. 63) used mapping unit G of "Upland Bamboo". In this reference, the Livingstone Escarpment in southern Tanzania is described as an almost pure stand of *Sinarundinaria alpina*; another large block occurs on the south face of the Rungwe Mountain. For the VECEA map, we used a combination of visual interpretation (to obtain the upper boundary of an Afromontane bamboo zone) and altitude contours (2600 m was set as the lower boundary of an Afromontane bamboo zone) on Mt. Meru (see Volume 6).

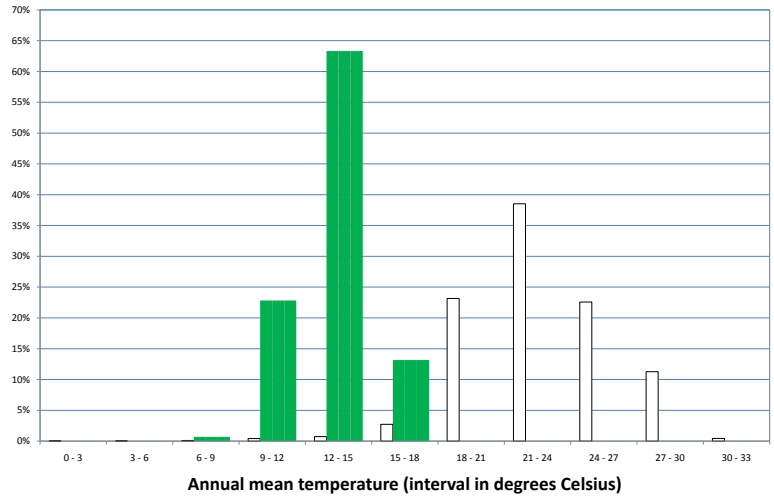
In Uganda, Afromontane bamboo was originally described and mapped as "*Arundinaria* montane bamboo forest" (original mapping unit B4).

Investigation of environmental distribution of Afromontane bamboo 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 more than 95% of the samples occur between 2250 and 3250 m. This range corresponds reasonably well with the altitudinal range reported by White (1983; 2400 – 3000 m), especially since White (1983) further mentioned that Afromontane bamboo also occurs above and below these limits (see also section 4.1). The altitude interval of 2500 to 2750 m contains the highest number of samples (39.1%); this is just below the altitude interval of 2750 – 3000 m that contains the highest number of samples of the Afromontane single-dominant *Hagenia abyssinica* forest (Fd; 46.4%) and well above the altitude intervals that contain the highest numbers of samples for Afromontane rain forest (Fa) and Afromontane undifferentiated forest (Fbu and Fbj combined). Afromontane bamboo generally receives between 1000 and 2000 mm annual rainfall (> 95% of samples).

(a)



(b)



(c)

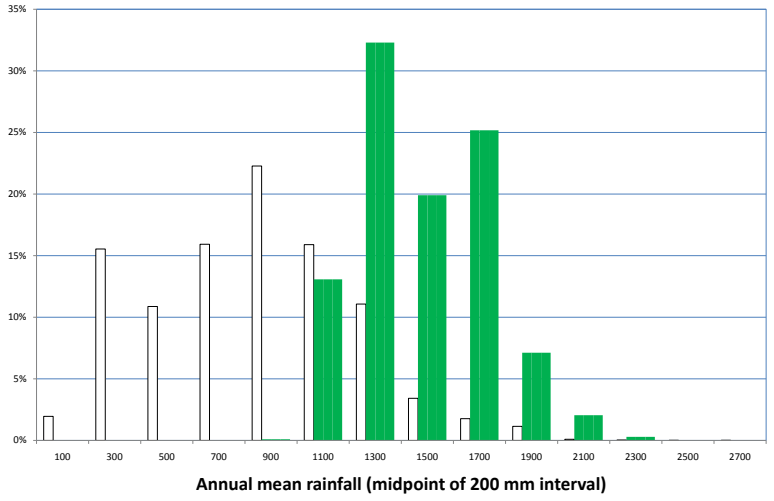


Figure 4.6. Histograms of the distribution of altitude (a), mean annual temperature (b) and mean annual rainfall (c). Bars at the centre of each interval show the percentage of samples within Afromontane bamboo (A, *n* = 1,025). Bars on the left (open) show the overall percentage of samples (*n* = 740,047).

4.3. Species composition

Species assemblages were obtained from the following references:

- Kenya: Trapnell (1997). Species listed in Annex 1 to only occur marginally in the forest or in montane bamboo at high altitudes for "montane sclerophyll forest" or "montane sclerophyll and/or moist montane forest" were coded "C". Suffix "b" indicates that species was only listed only for Afromontane undifferentiated forest (Fb; synonym: montane sclerophyll forest). Numbers show the maximum height of the species provided in the Annex (Trapnell 1997). 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 collaborator (F. Gachathi) were coded "x".
- Rwanda: Bloesch *et al.* (2009). All species that were mentioned to occur in floristic region 4 (volcano zone) and where a reference was made to 'bambouseraies' in the description of their ecology were coded "x" (unless they were characteristic species).
- Tanzania: White *et al.* (1983 p. 167). All species mentioned to occur in Afromontane bamboo and that were expected to occur in Tanzania (see section 2.3) were coded "C" (unless they were dominant).
- Uganda: Langdale-Brown *et al.* (1964) and Howard and Davenport (1996). All species that were listed to occur in "*Arundinaria* montane bamboo forest" in the Appendix were coded "x" (unless they were characteristic species). Species listed to occur in Echuya forest (a forest indicated in Langdale-Brown *et al.* [1964 p. 107] to only contain mapping unit B4 [*Arundinaria* montane bamboo forest]) in the Uganda Forest Department Biodiversity Database (Howard and Davenport [1996]) were coded "xb".

Characteristic species were determined as:

- Kenya: All species were assumed to be characteristic. ***Sinarundinaria alpina*** was added as the dominant species ("D").
- Rwanda: ***Sinarundinaria alpina*** was coded as the dominant species ("D").
- Tanzania: ***Sinarundinaria alpina*** was coded as the dominant species ("D").
- Uganda. Species characterized as trees in the appendix were coded "C". ***Sinarundinaria alpina*** was coded as the dominant species ("D").

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 vegetation type in other countries (see section 2.3).

Table 4. Species composition of Afromontane bamboo (B)

Species	Regional status (see section 2.3)	(Ethiopia)	(Kenya)	(Malawi)	(Rwanda)	(Tanzania)	(Uganda)
Sinarundinaria alpina	dominant	f	D	f	D	D	D
Agauria salicifolia		f	x	f	x	f	xb
Albizia adianthifolia			f	f	f	f	xb
Albizia gummifera		f	f	f	f	f	xb
Allophylus abyssinicus		f	f	f	f	f	xb
Berberis holstii		f	x	f		f	f
Bersama abyssinica		f	f	f	f	f	xb
Cassipourea ruwensoriensis		f	f		f	f	xb
Cornus volkensii	characteristic		C24	f	f	C	f
Crotalaria agatiflora		f	x	f	f	f	f
Croton macrostachyus		f	f	f	f	f	xb
Discopodium penninervium		f	f	f	f	f	xb
Dodonaea viscosa		f	f	f	f	f	xb
Dombeya torrida	characteristic	f	x	f	f	C	C
Dovyalis abyssinica		f	f	f		f	xb
Dovyalis macrocalyx			f	f	f	f	xb
Ehretia cymosa		f	f	f	f		xb
Ekebergia capensis		f	f	f	f	f	xb
Embelia schimperi		f	f	f	x	f	f
Erica arborea		f	x		f	f	f
Erythrina abyssinica		f	f	f	f	f	xb
Faurea saligna	characteristic		f	f	f	C	xb
Ficalhoa laurifolia				f	f	f	xb
Galiniera saxifraga		f	f	f	f	f	xb
Hagenia abyssinica	characteristic	f	C15	f	f	C	C
Hypericum revolutum		f	Cb12	f	f	f	xb
Ilex mitis	characteristic	f	f	f	x	C	C
Juniperus procera	characteristic	f	f	f		C	f
Lepidotrichilia volkensii	characteristic	f	C10	f	f	C	xb
Macaranga capensis		f	f	f	f	f	xb
Maesa lanceolata		f	f	f	f	f	xb
Maytenus acuminata			f	f	f	f	x
Maytenus undata		f	f	f	f	f	xb
Neoboutonia macrocalyx			f	f	f	f	xb
Nuxia congesta	characteristic	f	x	f	f	C	xb
Nuxia floribunda			f	f	f	f	xb
Pavetta oliveriana		f	f		f	f	xb
Peddiea fischeri			x		f	f	xb
Phytolacca dodecandra		f	f	f	f	f	xb
Pittosporum viridiflorum		f	f	f	f	f	xb
Podocarpus latifolius	characteristic		x	f	f	C	C
Polyscias fulva		f	f	f	f	f	xb
Pouteria adolfi-friedericii		f	f	f	f	f	xb

Species	Regional status (see section 2.3)	(Ethiopia)	(Kenya)	(Malawi)	(Rwanda)	(Tanzania)	(Uganda)
Pouteria altissima		f	f		f	f	xb
Prunus africana	characteristic	f	f	f	f	C	f
Psychotria mahonii			f	f	f	f	xb
Rapanea melanophloeos	characteristic	f	x	f	x	C	C
Rhamnus prinoides		f	x	f	x	f	xb
Rhus natalensis		f	f	f	f	f	xb
Rhus vulgaris		f	f	f	f	f	xb
Rubus apetalus		f	x	f	f	f	xb
Rubus volkensii		f	x			f	f
Sambucus ebulus			x			f	f
Schefflera volkensii		f	C24			f	f
Scutia myrtina		f	f	f	f	f	xb
Solanecio mannii		f	f	f	f	f	xb
Syzygium guineense		f	f	f	f	f	xb
Tabernaemontana stapfiana	characteristic		f	f	f	C	f
Vangueria apiculata		f	f	f	f	f	xb
Xymalos monospora			f	f	f	f	xb

5. Desert (D)

5.1. Description

White (1983) does not think that there is an objective criterion to separate arid regions from wet regions, although he also mentions that semi-desert areas usually begin to appear where the mean annual rainfall drops below 250 mm, the southern boundary of the Sahara desert corresponds to the 150 mm isohyet and the northern boundary of the Sahara desert corresponds to the 100 mm isohyet. However, he defines semi-deserts as areas where the differences in soil characteristics (such as soil colour) are more conspicuous than the vegetation itself, but where the plants are still sufficiently evenly distributed so that the vegetation can be further classified in physiognomic categories such as "semi-desert grassland" and "semi-desert shrubland" (White 1983 pp. 52 - 53). We therefore think that deserts can be defined as "areas where the differences in soil characteristics (such as soil colour) are more conspicuous than the vegetation itself and where the individual plants are never abundant enough in large enough areas to justify the classification of the vegetation as another physiognomic vegetation type such as grassland or shrubland" (see also White 1983 p. 53).

Areas in northern Kenya where annual rainfall is 150 mm are sometimes regarded as desert. Areas in the driest parts of northern Kenya where annual rainfall is higher than 150 mm and where extensive stone pavement areas are devoid of vegetation are **edaphic desert** areas. They are classified as edaphic vegetation since they occur in mosaic with semi-desert shrubland and dwarf bushland (White 1983 p. 53).

The Chalbi desert of Marsabit district (Kenya) is an edaphic desert that is part of a closed drainage basin. This desert has numerous springs that originate from subsurface flows originating from the surrounding mountains. The accumulation of salts after seasonal floodwaters have evaporated inhibit plant growth except very locally (White 1983 p. 120). The halophytic grass *Drake-brockmania somalensis* occurs near outlets of the major tributary streams; this vegetation type was classified as halophytic vegetation in the VECEA map (Z, see below).

Figure 5.1 Desert with tufts of the grass *Panicum turgidum*. These tufts collect wind-blown sand and may eventually develop into dunes. Northwest of Asaita (Ethiopia). Altitude approximately 400 m. 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 14B. 2010.

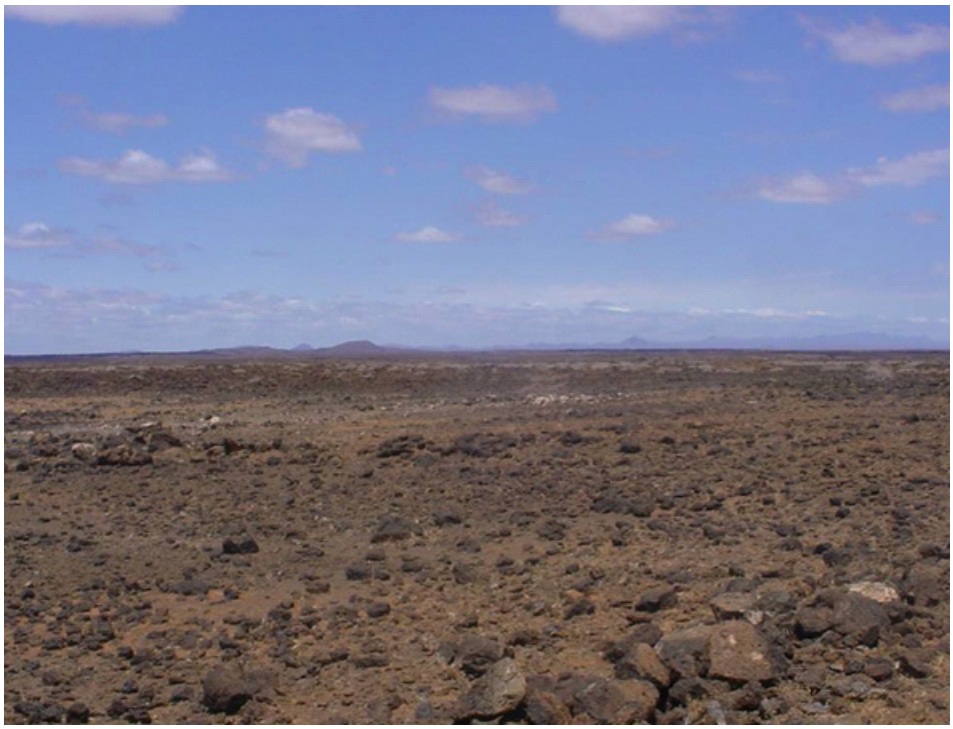


Figure 5.2 Barren land in Marsabit District (Kenya). Photograph by F. Gachathi (2009).

Figure 5.3 Floodplain of Habasweni (Kenya). Photograph by F. Gachathi (2009).

Figure 5.4 Afromontane "moss and lichen" desert on the Mubabura Volcano (Rwandan side of the Virunga Mts.). Photograph by V. Minani (November 2006).

5.2. VECEA region

Within these volumes, we use the name of "desert" as a synonym of "lowland desert". We thus excluded Afromontane deserts from the "desert" vegetation type.

Within the VECEA region, deserts (excluding Afromontane desert) only occur in Ethiopia and Kenya (Figure 5.5; see also Volume 6). Some areas covered with rock or snow on mountain peaks were classified as "Afromontane deserts" and were mapped on the Aberdares (Kenya), Mt. Kenya and Mt. Kilimanjaro (Tanzania). We did not map the "Afroalpine moss and lichen desert" of the Virunga mountains of Rwanda.

Figure 5.5. Mapped distribution of desert (excluding Afromontane desert) in the VECEA region (Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda and Zambia). In Kenya, this vegetation type is depicted by green polygons. In Ethiopia, this vegetation type is mapped in mosaic with semi-desert vegetation (greyish-brown polygons). The arrow indicates the polygon that corresponds to the Chalbi desert (an edaphic desert).

In Ethiopia, deserts were mapped together with Somalia-Masai semi-desert grassland and shrubland in the mapping unit of "Desert and semi-desert scrubland" (DSS). In this country, the shrub *Leptadenia pyrotechnica* and the grass *Panicum turgidum* form tufts in completely dry and sandy deserts. These tufts collect wind-blown sand and may eventually develop into dunes (Friis *et al.* 2010, pp. 44 - 46, Figure 14B). The tree *Gyrocarpus hababensis* is found among large boulders of quaternary lava flows within desert areas; big boulders between which soil may accumulate and plants are protected from sun and desiccation occur in many areas (Friis *et al.* 2010, pp. 44 - 45, figure 14A). The Ethiopian mapping unit of "Desert and semi-desert scrubland" [DSS]) was mapped by using the contour of 400 m (Friis *et al.* 2010 p. 47).

The Range Management Handbook of Kenya (RMHK) volume that described Marsabit District (Schwartz *et al.* 1991) described and mapped "barren land" (vegetation type 9). This vegetation type corresponds to areas where vegetation is sparse and frequently occurs in strips. In years with extremely low rainfall, these areas could be characterized as deserts, whereas these areas green up after rainfall. Two subtypes are recognized: (i) barren lands with dwarf shrubs on drainage lines (original vegetation subtype 9.1); and (ii) barren lands vegetation with annual grasses of the *Aristida - Tetrapogon* complex (original vegetation subtype 9.2). *Indigofera spinosa* is the most frequent dwarf shrub of vegetation subtype 9.1 (it is also one of the two species that dominate Somalia-Masai semi-desert shrubland [S]). Original vegetation subtype 9.2 often consist of pure stands of either *Aristida adscensionis* or *Tetrapogon cenchriformis*; these annual grasses are also the most frequent grasses in vegetation subtype 9.1 (RMHK, Schwartz *et al.* 1991 p. 35). In the VECEA map, we mapped all polygons that were originally mapped as vegetation type 9 as desert. We included the polygon of "Chalbi desert (liable to flood)" of the Marsabit district vegetation map.

The Marsabit map contained various mosaic mapping types of desert (original vegetation subtypes 9.1 or 9.2) with deciduous bushland (original vegetation type 7) or semi-desert grassland and shrubland (original vegetation type 8). In the VECEA map, all these mosaics were mapped as semi-desert grassland and shrubland (S).

In a harmonized GIS map that was later developed by Dennis Herlocker (he was the main botanist involved in the RMHK project; see volume 6), mapping type 9 from Marsabit was changed to mapping unit 30 of "barren land". This vegetation type also occurs in Turkana district (where no species were provided, but the vegetation is described as "sparse" [< 2%]) and Wajir district (where this vegetation type was not sampled in the field, but is expected to correspond to subtype 9.2 of Marsabit district).

We investigated the environmental distribution of desert in the VECEA region together with the environmental distribution of Somalia-Masai semi-desert grassland and shrubland (S), see section 9 in this volume. Results are provided in the section for Somalia-Masai semi-desert grassland and shrubland (S). The reason for not showing results from desert separately is that we discovered that drier areas occur in Ethiopia (where desert was not mapped separately from semi-desert vegetation) than in Kenya. Hence we

think that only showing results for the Kenyan manifestation of desert misrepresents the environmental limits of desert in the VECEA region.

5.3. Species composition

Species assemblages were obtained from the following references:

- Ethiopia: Friis *et al.* 2010. We assumed that the woody species mentioned in Appendix 3 for "Desert and semi-desert scrubland" [DSS] were more typical of Somalia-Masai semi-desert grassland and shrubland [S] (or even deciduous bushland [Bd]). We only listed species for Ethiopian desert that were either described in the main text to grow in "completely dry, sandy desert" or identified on figures for "desert".
- Kenya: Species listed in the Range Management Handbook of Kenya Volume that describes Marsabit District (Schwartz *et al.* 1991) for "barren land" (vegetation type 9) were coded "C". The suffix refers to the vegetation subtype (9.1 and 9.2).

Characteristic species were determined as:

- Ethiopia: Those species that were mentioned in the description of the vegetation type in the main text or identified on figures were coded as "C".
- Kenya: All species were assumed to be characteristic.

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

Table 5. Species composition of Desert (D)

Species	Regional status	(Ethiopia)	(Kenya)
Aristida adscensionis	characteristic ephemeral grass species of Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket		C12
Barleria proxima			C2
Blepharis linariifolia			C12
Cenchrus pennisetiformis	(grass)		C12
Gyrocarpus hababensis		C	f
Indigofera spinosa	characteristic dwarf shrub species of Somalia-Masai semi-desert shrubland		C12
Leptadenia pyrotechnica		C	
Leptothrium senegalense	(grass)		C2
Panicum turgidum	dominant grass species of Somalia-Masai semi-desert grassland	C	f
Tetrapogon cenchriformis	(grass)		C12

6. Grassland (excluding semi-desert grassland and edaphic grassland, G)

6.1. Description

White (1983) attempted to distinguish between climatic, edaphic and secondary grasslands. However, he admitted that is was not always easy to decide to which category a particular grassland type should belong since various factors may operate together. For example, grasslands may occur in soils that are incapable of supporting trees, but the soils themselves may have developed under unusual climatic conditions (White 1983 p. 51). The occurrence of semi-desert grassland (S) seems to be under climatic and edaphic control - rather than classifying it as climatic grassland or edaphic grassland, we classified it separately within the VECEA map as mapping unit S (see below).

Much of the grasslands which were considered to be climatic grasslands by early explorers are in fact secondary as a result from fire. However, the statement that no tropical grassland would be a true climatic climax is probably also incorrect (White 1983 pp. 50 - 51).

6.2. VECEA region

Within the VECEA region, "climatic grasslands" (i.e. grasslands after excluding areas mapped as semi-desert grassland [S] or edaphic grassland [g] by VECEA) were only mapped in northern Kenya and Uganda (Figure 6.1, see also Volume 6). However, it is possible that climatic grasslands occur in other countries (see below).

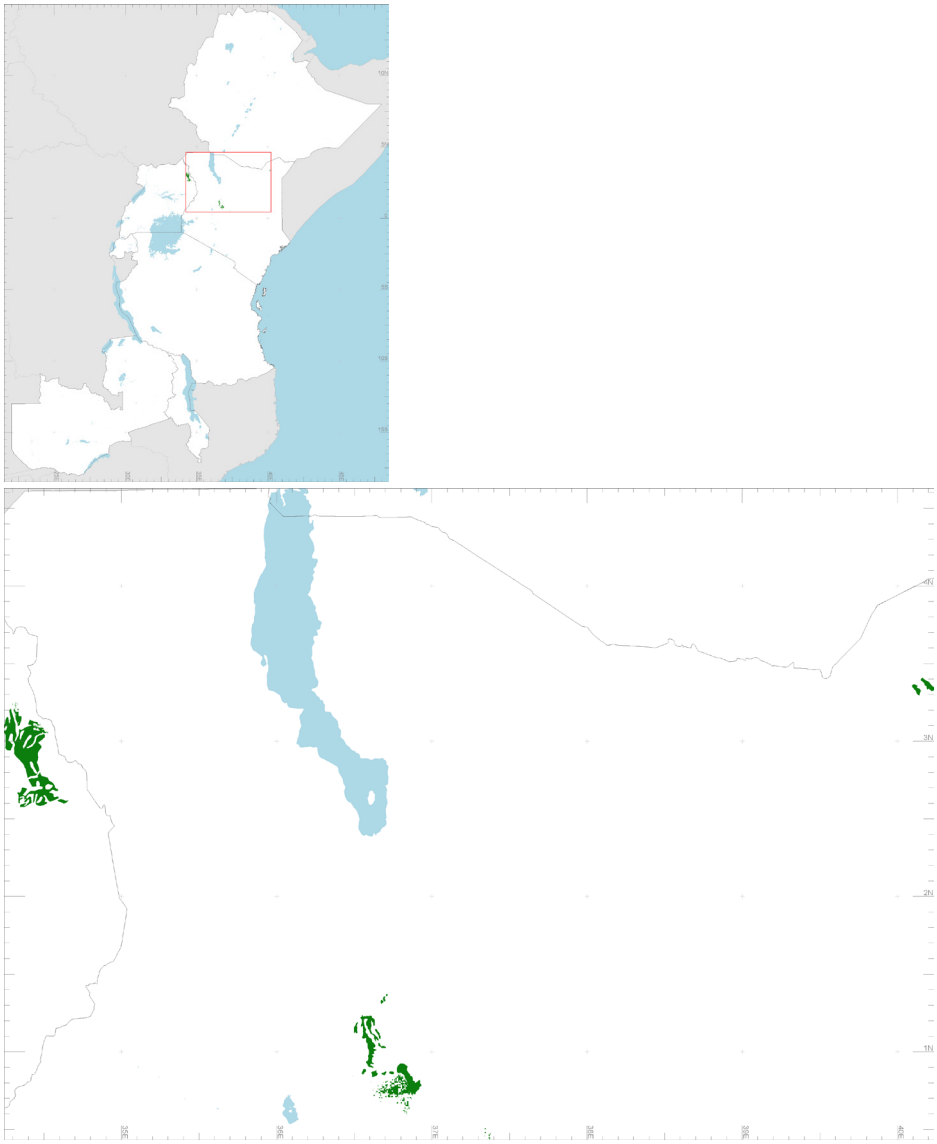


Figure 6.1. Mapped distribution of grasslands (excluding semi-desert grassland [S] and edaphic grassland [g]) in the VECEA region (Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda and Zambia). Green polygons depict where we mapped this vegetation type. It is possible, however, that similar or other types of grasslands occur in other countries.

From the Range Management Handbook of Kenya (RMHK; Schwartz *et al.* 1991; Shaabani *et al.* 1992abc; Herlocker *et al.* 1993; Herlocker *et al.* 1994abcd), we classified the following original mapping units as climatic grasslands: mapping unit 27.1 (a perennial grassland type occurring in Mandera District), mapping unit 27.3 (a perennial grassland type occurring in Samburu District) and mapping unit 27.4 (a perennial grassland type occurring in Samburu District). With climatic grasslands for Kenya, we did not include various other mapping units that were mapped in the RMHK as (perennial) grassland or annual grassland since we inferred from their descriptions that they would be better classified as edaphic grassland (g), the edaphic grassland subtype that occurs on volcanic soils (gv), edaphic wooded grassland (we), Somalia-Masai semi-desert grassland and shrubland (S), open types of deciduous bushland (Bd) or halophytic vegetation (Z) (see volume 6 and within the descriptions of these other vegetation types).

The area that we mapped as climatic grassland from Uganda corresponds to the vegetation type that was originally mapped as "*Chrysopogon* grass steppe"[5] (original mapping unit S1). *Chrysopogon* grassland is described in the Uganda national reference as a natural climax vegetation type that occurs in Karamoja under an annual rainfall of 380 - 500 mm and on black clays. Its aerial cover is between 60 and 90 percent. The dominant grass species are *Chrysopogon aucheri* and *Pennisetum mezianum*. Shrubs sometimes occur and include scattered *Acacia drepanolobium, Acacia mellifera* and *Dichrostachys cinerea* (these are all species that were listed for deciduous bushland [Bd]). Since grasses are inconspicuous in typical deciduous bushland (Bd, White 1983 p. 114), since deciduous wooded grassland (Wd) is typical of higher rainfall areas within this floristic region (White 1983 p. 128), since Somalia-Masai semi-desert grassland (S) occurs in areas where annual rainfall is in between 100 and 200 mm (White 1983 p. 115), since Langdale-Brown *et al.* (1964) did not include this vegetation type with communities on sites with impeded drainage, and since Langdale-Brown *et al.* (1964) mapped this vegetation type as a distinct ecological type (type 20 of "Grass steppe", page 101), we distinguished it as a separate potential natural vegetation type. However, White (1983) seems to have included this vegetation type within Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket (Bd, original mapping unit 42) in the African vegetation map that he prepared.

As described in volume 6, areas that were originally mapped in the Tanzania base map (Gillman 1949) as "ridge and slope grasslands" were all reclassified as forests. Some montane grassland areas in Tanzania have existed for thousands of years, however. This seems to be especially the case for montane grasslands that are under the influence of Lake Malawi, and also seems to include various montane grassland areas in Malawi (Jonathan Timberlake, personal communication). Montane grasslands (≥ 1500 m) are among the most difficult vegetation types to characterize in Malawi since their origins remain controversial and since the age of some of these grasslands are estimated at hundreds or thousands of years [6]. Some montane grasslands occurring at the highest elevations (≥ 2200 m) are dominated by grass species that are almost entirely restricted to these altitudes (C. Dudley, personal observations).

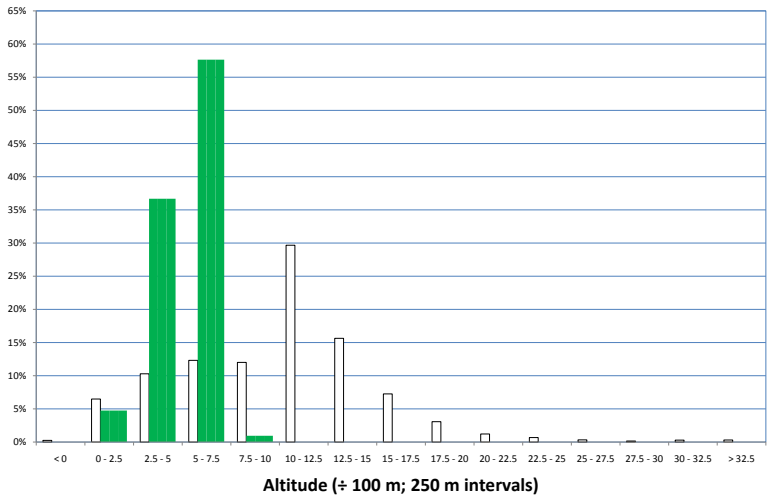
5: in the Ugandan vegetation map, a distinction is made between "savanna" and "steppe". Savanna is defined as a formation of grasses that are at least 80 cm high and where the grasses form a continuous layer (note, however, that there are various wooded grassland subtypes), whereas steppe is defined as open herbaceous vegetation where perennial grasses are usually less than 80 cm high and widely spaced. Grass and herb steppes are subtypes of steppes where trees and shrubs are virtually absent. Within the VECEA map, we do not differentiate "steppe" and therefore classified the Ugandan *Chrysopogon* steppe as a grassland physiognomic type (we assumed that the cover of woody species was lower than 10%, although the cover percentage was not provided by Langdale-Brown et al. 1964).

6: Shaxson (1976) agrees with Chapman and White (1970 p. 91) that there are no climatic grasslands in Malawi, and that grasslands in Malawi are either edaphic or secondary (derived from forests due to the influence of fire).

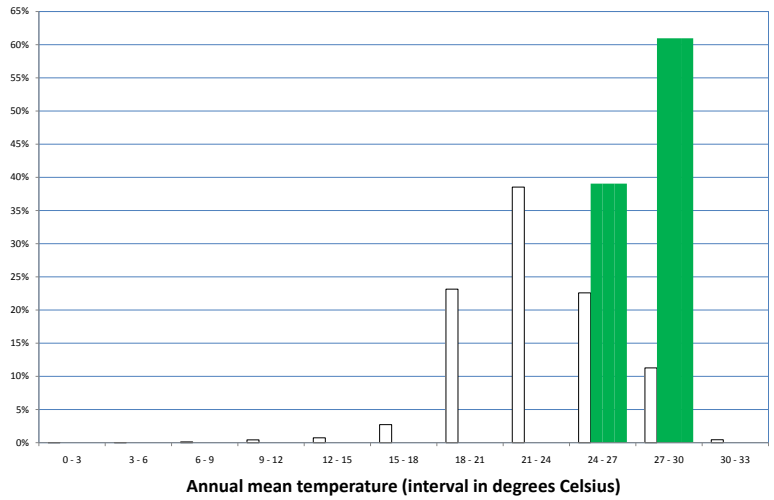
Whether some montane grassland areas should be treated and mapped as distinct potential natural vegetation types depends on the interpretation that succession to forests is not possible (any longer). Our decision in VECEA was to not to treat montane grasslands as distinct potential natural vegetation types, but an alternative vegetation map may introduce such potential natural vegetation type.

Investigation of environmental distribution of climatic grassland in the VECEA region (Figure 6.2; limits are for areas of the VECEA map where this vegetation type is not mapped as mosaic) shows that more than 90% of the samples occur in an interval from 1000 – 2250 m. This is well above the main range for Somalia-Masai semi-arid grassland and shrubland (S) where 97.7% of samples occur below 750 m. Climatic grassland mainly receives between 400 and 800 mm rainfall (> 95% of samples). There is some overlap with the rainfall range where semi-arid grassland and shrubland occurs (11.2 % of samples receive between 400 and 800 mm in this vegetation type).

(a)



(b)



(c)

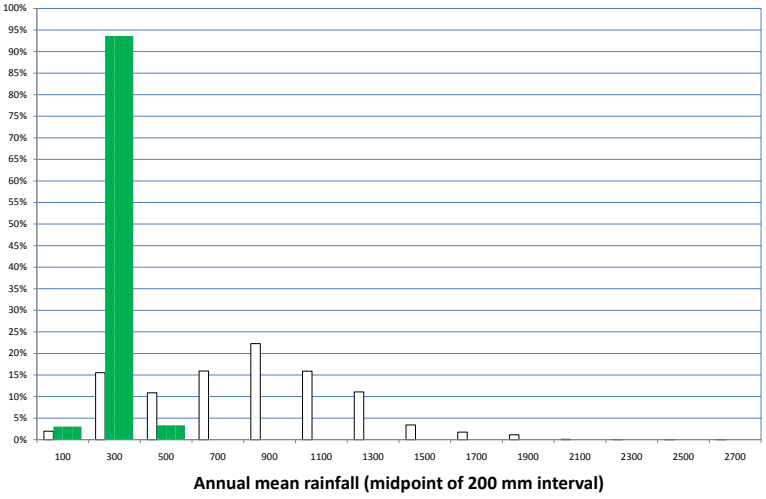


Figure 6.2 Histograms of the distribution of altitude (a), mean annual temperature (b) and mean annual rainfall (c). Bars at the centre of each interval show the percentage of samples within grassland excluding semi-desert grassland and edaphic grassland (G, *n* = 407). Bars on the left (open) show the overall percentage of samples (*n* = 740,047).

6.3. Species composition

Species assemblages were obtained from the following references:

- Kenya: Range Management Handbook of Kenya (RMHK; Shaabani *et al.* 1992c [Mandera District]; Shaani *et al.* 1992a [Samburu District] and Herlocker *et al.* 1993 [Isiolo District]). Species listed for mapping units 27.1 (Mandera District), 27.3 (Samburu District) or 27.4 (Samburu District) were coded "x". The suffix referred to the original mapping subtype.
- Uganda: Langdale-Brown *et al.* (1964). All species that were listed to occur in "*Chrysopogon* grass steppe" in the Appendix were coded "x".

Characteristic species were not determined.

Table 6. Species composition of grassland (excluding semi-desert grassland and edaphic grassland; G)

Species	**Regional status** (see section 2.3)	(Kenya)	(Uganda)
Chrysopogon aucheri	Somalia-Masai edaphic grassland, Somalia-Masai semi-desert grassland and shrubland, *Combretum* woodland (in Marsabit district)		x
Microchloa kunthii	edaphic grasslands of the Serengeti plains; secondary grasslands of the Loita plains	x4	
Pennisetum mezianum	edaphic grasslands of the Serengeti plains	x4	x
Pennisetum sphacelatum	(grass)	x3	
Sporobolus helvolus	(grass)	x1	
Themeda triandra	Somalia-Masai edaphic grassland	x34	
Trichoneura mollis	(grass)	x1	
Acacia drepanolobium	Somalia-Masai edaphic grassland, biotic *Acacia* wooded grassland		x
Acacia mellifera	Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket, scattered in seasonally waterlogged grassland within *Acacia-Commiphora* bushland		x
Barleria prionitis			x
Dichrostachys cinerea	Sudanian woodland, Zanzibar-Inhambane secondary grassland and wooded grassland		x

7. Lowland bamboo (L)

7.1. Description

Oxythenanthera abyssinica is one of the four bamboo species (giant grasses of 2 - 20 m or even taller with erect woody stems that persist for several years, flower gregariously and then die back, sometimes forming pure and virtually impenetrable communities) that are indigenous to Africa (one other species is *Sinarundinaria alpina* [mapped as B]). ***Oxythenanthera abyssinica*** is widespread in the Sudanian and Zambezian regions (White 1983 p. 55).

Figure 7.1. Thicket of lowland bamboo (*Oxythenanthera abyssinica*) within *Combretum – Terminalia* woodland and wooded grassland (the latter vegetation type is classified as Combretum wooded grassland in the VECEA map [Wc, see volume 3]). South of Asosa (Ethiopia). Altitude approximately 1400 m. Photograph by I. Friis and Sebsebe Demissew (November 2006). Reproduced from Biologiske Skrifter of the Royal Danish Academy of Sciences and letters, Vol. 58, Fig 18M. 2010.

Figure 7.2. Lowland bamboo (*Oxythenanthera abyssinica*) within miombo woodland, west foot of the Mwera Plateau (Tanzania). Gillman (1949, Figure 7). Image obtained from URL: *http://www.jstor.org/stable/211155*

7.2. VECEA region

Within the VECEA region, lowland bamboo (dominated by ***Oxythenanthera abyssinica***) was only mapped as separate vegetation type in Uganda (Figure 7.3). ***Oxythenanthera abyssinica*** occurs in other VECEA countries, but is not expected to be present in Kenya and Rwanda.

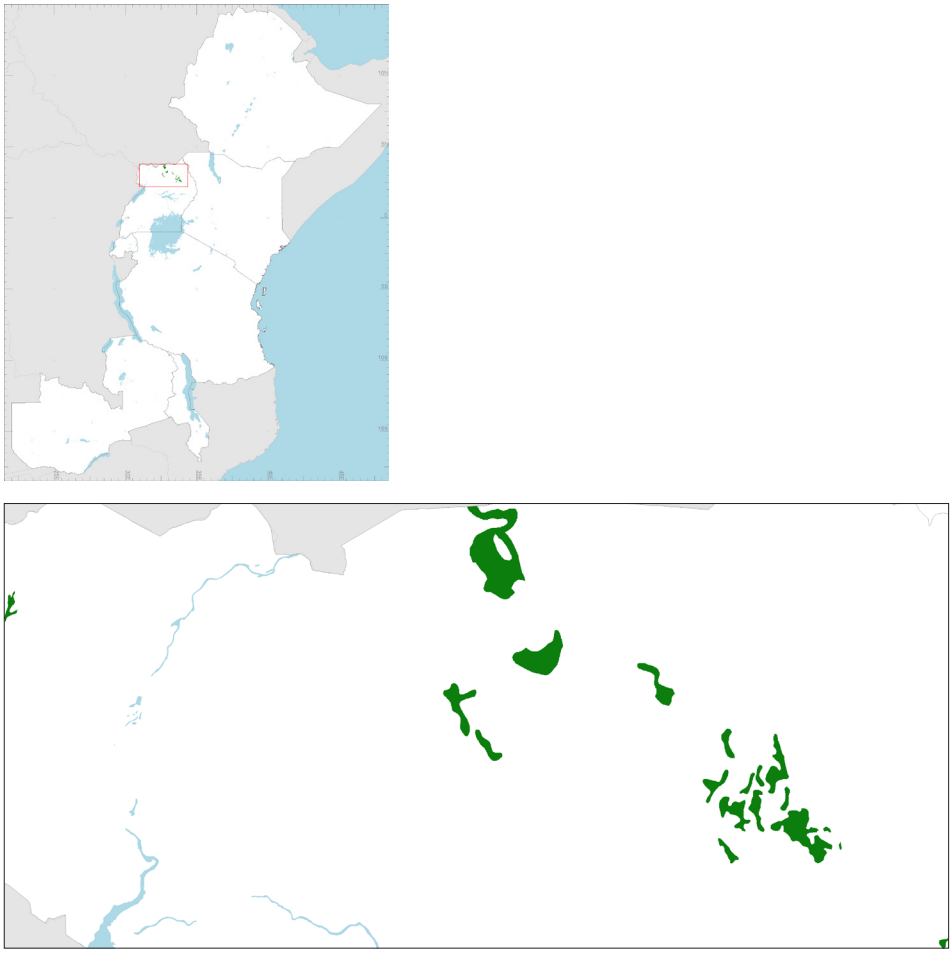


Figure 7.3. Mapped distribution of lowland bamboo in the VECEA region (Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda and Zambia). Green polygons depict where we mapped this vegetation type. *Oxythenanthera abyssinica* occurs more widely as it is only absent from Kenya and Rwanda.

In Uganda, this vegetation type was originally mapped as "lowland bamboo thicket" (original mapping unit G3).

Oxythenanthera abyssinica is known to occur in Ethiopia where it is present in *Combretum* woodland [Wc], especially in river valleys (Friis *et al.* 2010 pp. 62 and 68, figs. 18M and 18N).

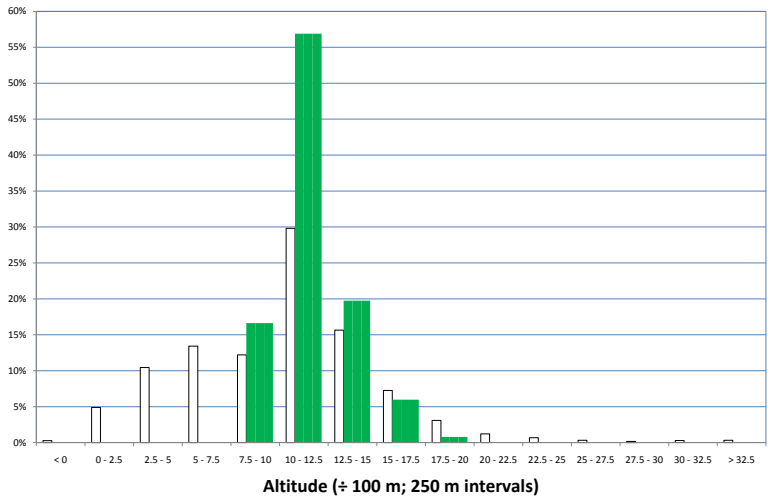
For Malawi, ***Oxythenanthera abyssinica i***s recorded to occur in miombo woodland (Wm) and Undifferentiated woodland (Wn).

Gillman (1949 p. 12) mentions that ***Oxythenanthera abyssinica*** is a Tanzanian woodland subtype that is dominant throughout the large woodlands south of 8 º S (i.e. miombo woodlands) and also on the high ground bordering the Lake Tanganyika trough of the east.

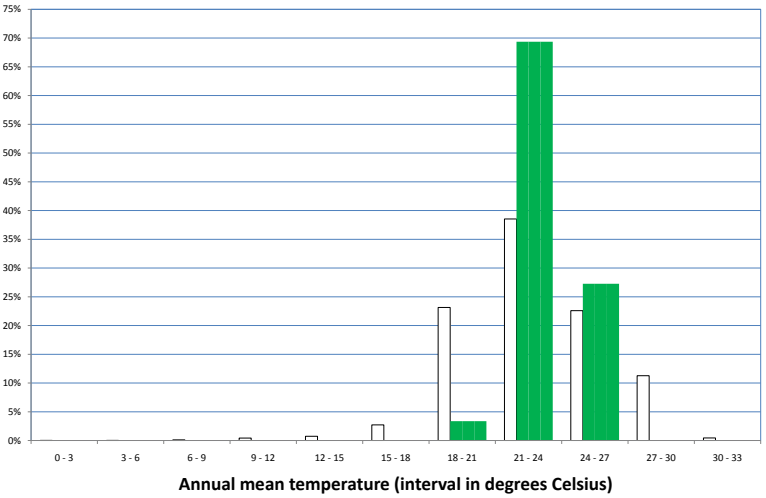
In Zambia, Fanshawe (1971) recorded that ***Oxythenanthera abyssinica*** occurs in Chipya woodland [Wy], Undifferentiated woodland [Wn] and riparian forest [fr]).

Investigation of environmental distribution of lowland bamboo in the VE-CEA region (Figure 7.4) shows that more than 90% of the samples occur in an interval from 750 – 1500 m. Lowland bamboo mainly receives rainfall between 1000 and 1400 mm (97.7% of samples).

(a)



(b)



(c)

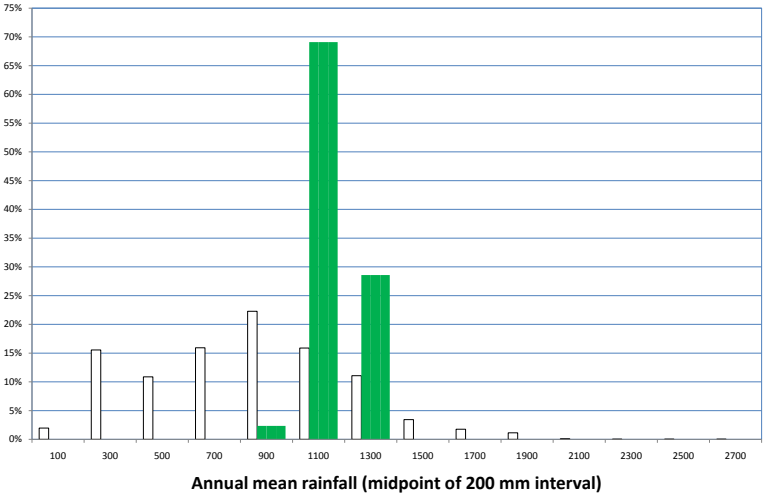


Figure 7.4. Histograms of the distribution of altitude (a), mean annual temperature (b) and mean annual rainfall (c). Bars at the centre of each interval show the percentage of samples within Lowland bamboo (L, *n* = 385). Bars on the left (open) show the overall percentage of samples *(n* = 740,047).

7.3. Species composition

Langdale-Brown *et al.* (1964 p. 54) lists ***Oxythenanthera abyssinica*** as the only tall species in lowland bamboo thicket. We did not prepare species assemblage information for ***Oxythenanthera abyssinica.***

8. Mangrove (M)

8.1. Description

Mangrove is dominated by trees that occur on shores that are periodically flooded by sea-water. Mangrove was classified by White (1983) as a major physiognomic type and not as a subtype of forests - especially since near climatic and edaphic limits of mangrove, many mangrove species form communities that physiognomically resemble bushland and thickets but are otherwise very similar to "mangrove forests". All true mangrove species either have pneumatophores which are exposed at low tide or are viviparous (or nearly so, most African species show both these features). The *Bruguiera, Ceriops* and *Rhiziphora* mangrove species are viviparous: the embryo develops precociously ('exceptionally early') after which the hypocotyl undergoes enormous development. Mangrove species have succulent leaves. Their roots are able to desalinate seawater to a high degree but some salts also accumulate in their tissues (only *Avicennia* species excrete salt from their leaves) (White 1983 pp. 54 - 55 and 261).

The true mangrove species that occur in East Africa include ***Avicennia marina, Bruguiera gymnorhiza, Ceriops tagal, Heritiera littoralis, Lumnitzera racemosa, Rhizophora mucronata, Sonneratia alba, Xylocarpus granatum*** and ***Xylocarpus moluccensis***. All these species extend further to the east and most reach the western Pacific Ocean (White 1983 p. 261).

Figure 8.1. Mangrove forest. Tanga region of Tanzania. Photograph by H. N. Moshi (May 2009).

Figure 8.2. M. Typical East African bird species from mangrove within their natural habitat. Shell guide to East African birds (1960; reproduced with permission from URL *http://ufdc.ufl.edu/UF00077050*).

8.2. VECEA region

Within the VECEA region (Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda and Zambia), mangrove occurs on the coasts of Kenya and Tanzania.

Not surprisingly, investigation of environmental distribution of mangrove in the VECEA region shows that all samples occur below 250 m (Figure 8.4). Mangrove occurs under a wide range of rainfall (almost all samples receive between 600 and 1800 mm annual rainfall).

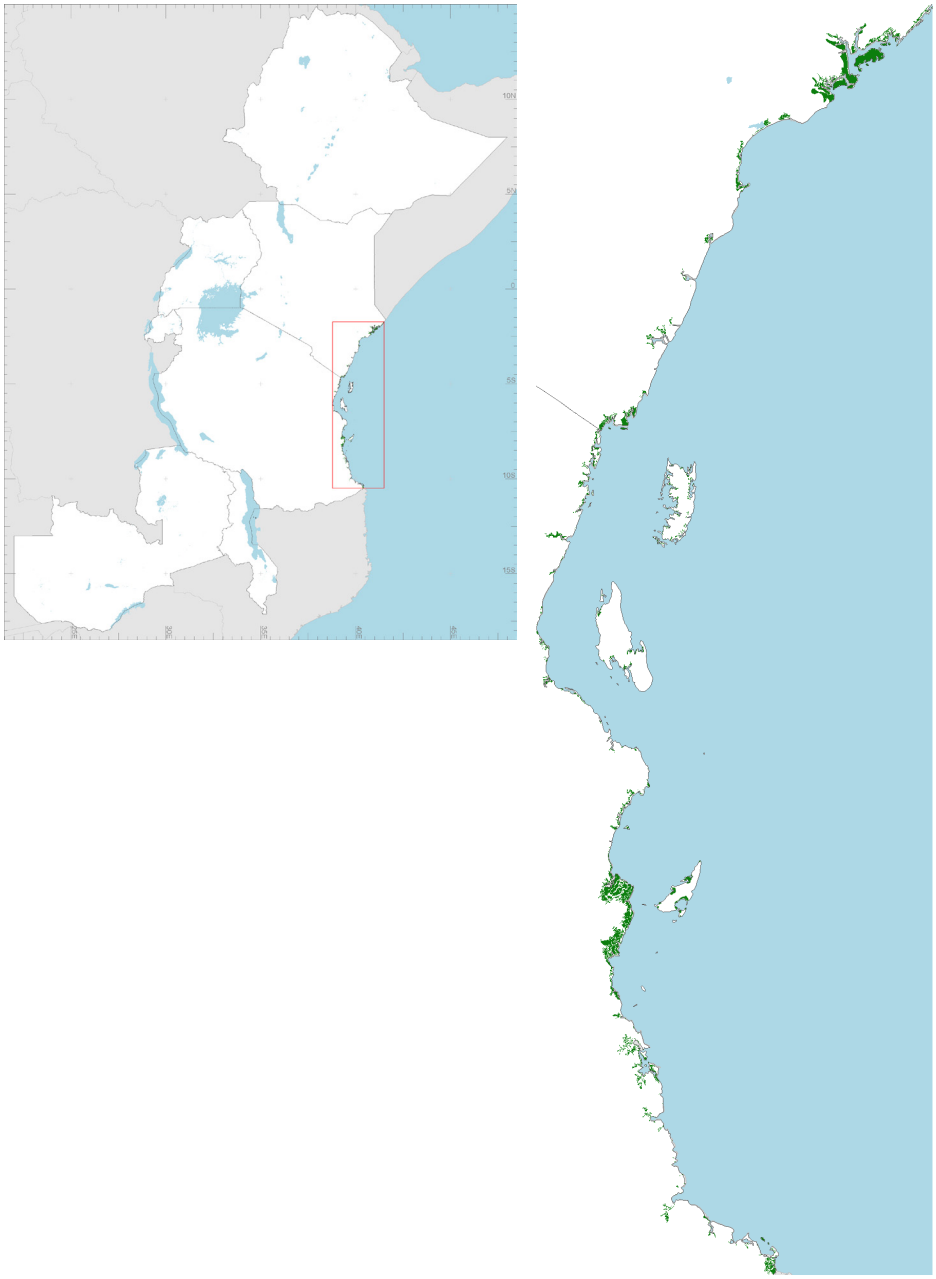
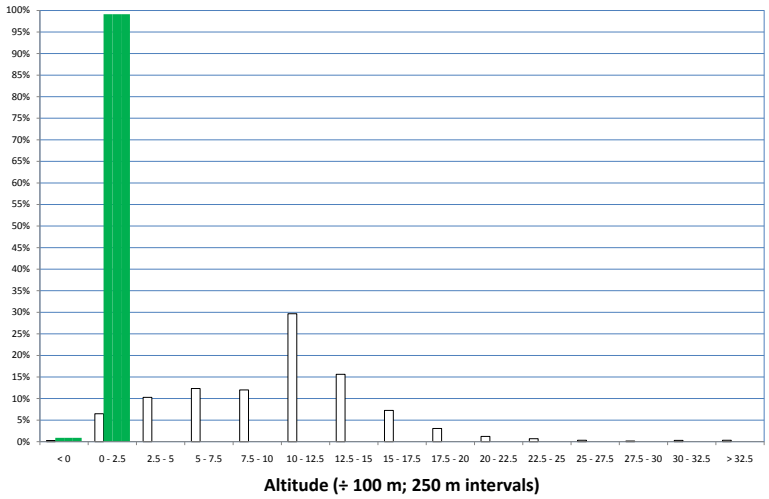
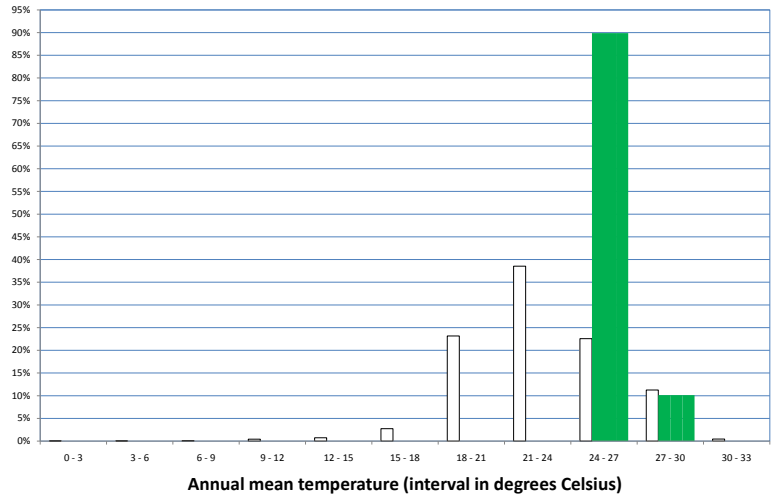


Figure 8.3. Mapped distribution of mangrove in the VECEA region (Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda and Zambia). Green polygons depict where we mapped this vegetation type.

(a)



(b)



(c)

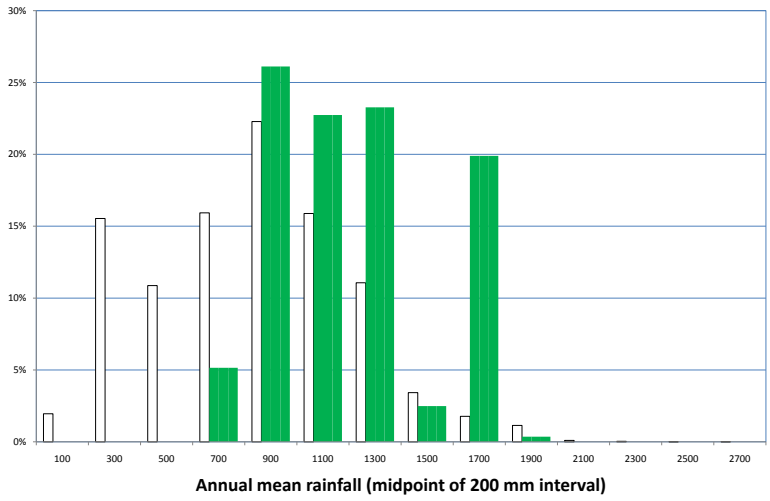


Figure 8.4 Histograms of the distribution of altitude (a), mean annual temperature (b) and mean annual rainfall (c). Bars at the centre of each interval show the percentage of samples within Mangrove (M, *n* = 563). Bars on the left (open) show the overall percentage of samples (*n* = 740,047).

8.3. Species composition

Species assemblages were obtained from the following reference:

- White (1983 p. 261). The nine species described for the Mangrove flora of East Africa were all included.

Table 8. Species composition of Mangrove (M)

Species	**Regional status** (see section 2.3)
Avicennia marina	mangrove in East Africa
Bruguiera gymnorhiza	mangrove in East Africa
Ceriops tagal	mangrove in East Africa
Heritiera littoralis	mangrove in East Africa
Lumnitzera racemosa	mangrove in East Africa
Rhizophora mucronata	mangrove in East Africa
Sonneratia alba	mangrove in East Africa
Xylocarpus granatum	mangrove in East Africa
Xylocarpus moluccensis	mangrove in East Africa

9. Somalia-Masai semi-desert grass land and shrubland (S)

9.1. Description

White (1983) does not think that there is an objective criterion to separate arid regions from wet regions, although he also mentions that semi-desert areas usually begin to appear where the mean annual rainfall drops below 250 mm, the southern boundary of the Sahara desert corresponds to the 150 mm isohyet and the northern boundary of the Sahara desert corresponds to the 100 mm isohyet. However, he defines semi-deserts as areas where the differences in soil characteristics (such as soil colour) are more conspicuous than the vegetation itself, but where the plants are still sufficiently evenly distributed so that the vegetation can be further classified in physiognomic categories such as "semi-desert grassland" and "semi-desert shrubland" (White 1983 pp. 52 - 53, see also the description of desert [D] above).

Where annual rainfall is between 100 and 200 mm in the Somalia-Masai region, semi-desert grassland (dominated by ***Centropodia glauca, Eragrostis mahrana*** and ***Panicum turgidum)*** occurs on deep sand. Under similar rainfall conditions, semi-desert shrubland occurs on stony soils (White 1983 p. 115). Most primary shrubland areas in African lowlands occur under a semi-desert climate and where edaphic conditions influence the vegetation (such as Somalia-Masai shrubland occurring on gypseous soils [these soils are themselves also partially a result from the dry climate]; White (1983 p. 50). *Lagenantha cycloptera* is a gypsum-tolerant succulent species that forms almost pure stands (20% cover) on white calcareous soils in the old Chalbi lake bed in Marsabit district (White 1983 p. 120).

Semi-desert annual grassland is the most extensive vegetation type in Marsabit district (covering one third of the area, especially in the driest parts). The dominant grasses are *Aristida adscensionis* and *Aristida mutabilis*; during drought periods, these grasses may be absent for years. Woody plants are nearly always present (then providing 2 -20 percent ground cover), sometimes in the forms of shrubs (***Duosperma eremophilum***) or sometimes as bushes or bushy trees such as *Acacia horrida, Acacia reficiens, Acacia senegal, Acacia seyal, Acacia tortilis* and several *Commiphora* spp. (White 1983 p. 120).

Semi-desert dwarf shrubland (< 1 m high) is the second-most extensive vegetation type in Marsabit district (covering 28 percent of the area). ***Duosperma eremophilum*** and ***Indigofera spinosa*** dominate or co-dominate 71% and 64% percent of all dwarf shrubland respectively. The more moisture demanding ***Duosperma eremophilum*** occupies somewhat heavier and wetter soils, whereas ***Indigofera spinosa*** occupies the drier sites. When these species occur together, they often show a catenary relationship with ***Indigofera*** dominant on the compact soils of ridge tops and ***Duosperma*** dominant in shallow depressions (White 1983 p. 120). Extensive areas are without woody species, but bushes and small trees including *Acacia etbaica,*

Acacia mellifera, Acacia reficiens, Acacia senegal, Acacia seyal, Acacia tortilis, Boswellia neglecta and various *Commiphora* species have a scattered occurrence with 2 to 20 percent cover (White 1983 p. 120).

Figure 9.1 Semi-desert grassland with the annual grass species *Aristida mutabilis*. Marsabit District (Kenya). Photograph by F. Gachathi (2009).

Figure 9.2 Semi-desert vegetation with the dwarf shrub *Indigofera spinosa*. *Acacia tortilis* occurs as a scattered emergent species. Turkana District (Kenya). Photograph by F. Gachathi (2010).

Figure 9.3 Semi-desert vegetation near Dolo Odo (Ethiopia). Photograph by T. Cole (2008, with permission from this author).

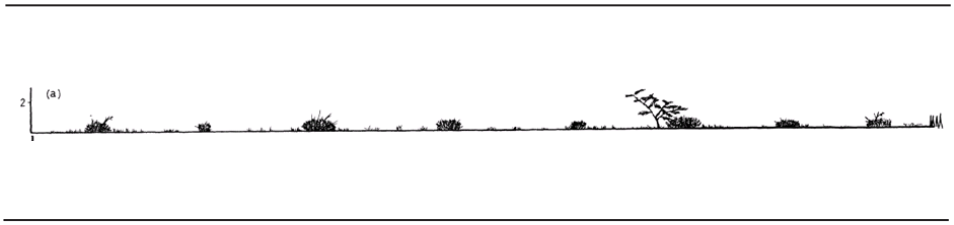


Figure 9.4. SD. Profile diagram of *Duosperma* (probably *D. eremophilum*) dwarf shrub grassland. The grass species is of the *Enneapogon* genus. Pratt *et al*. (1966, Fig 6a). Image obtained from URL: *http://www.jstor.org/stable/2401259*.

9.2. VECEA region

Within the VECEA region, Somalia-Masai semi-desert grassland and shrubland was only mapped in Ethiopia and Kenya (Figure 9.5, see also Volume 6).

Figure 9.5. Mapped distribution of Somalia-Masai semi-desert grassland and shrubland in the VECEA region (Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda and Zambia). Green polygons depict where we mapped this vegetation type. In Ethiopia, this vegetation type is mapped in mosaic with desert (D) and was mapped as greyish-brown polygons. The vegetation mosaics (greyish-brown) in Marsabit District correspond to mosaics of semi-desert vegetation with stunted deciduous bushland (BdK, see Volume 4).

In Ethiopia, Somalia-Masai semi-desert grassland and shrubland was mapped together with desert (excluding Afromontane desert) in the the Ethiopian mapping unit of "Desert and semi-desert scrubland" (DSS). In this country, "Desert and semi-desert scrubland" was mapped by using the contour of 400 m (Friis *et al.* 2010 p. 47). We suspect that some sections that were mapped in Ethiopia as "Desert and semi-desert scrubland" (DSS) could alternatively be classified and mapped as (open types of) deciduous bushland (Bd). Friis *et al.* (2010 p. 47) mention that "there is a rather poorly marked transition zone to the surrounding terrestrial vegetation types (mapping units '*Acacia-Commiphora* woodland and bushland proper' and '*Combretum-Terminalia* woodland and wooded grassland') inside which there may be vegetation that physiognomically and floristic is similar to these mapping units". Friis *et al.* (2010 p. 47) further mention that the western part of the Afar floristic region contains an open and depauperate type of deciduous bushland (Bd). Friis *et al.* (2010 p. 44) also mention that 117 of the 131 species recorded for "Desert and semi-desert scrubland" also occur in the adjacent deciduous bushland (Bd).

The Range Management Handbook of Kenya (RMHK) Volume for Marsabit District (Schwartz *et al.* 1991) described and mapped "dwarf shrub - annual grassland" (vegetation type 8). This vegetation type is defined physiognomically by less than 1 percent cover of trees and shrubs. ***Duosperma eremophilum*** and ***Indigofera spinosa*** are the dwarf shrub species with the highest cover percentages (Schwartz *et al.* 1991 p. 35). In the VECEA map, we classified the original vegetation type 8 as semi-desert grassland and shrubland. We included from the Marsabit vegetation map mosaic mapping types of desert (original vegetation subtypes 9.1 or 9.2) with deciduous bushland (original vegetation type 7) or semi-desert grassland and shrubland (original vegetation type 8).

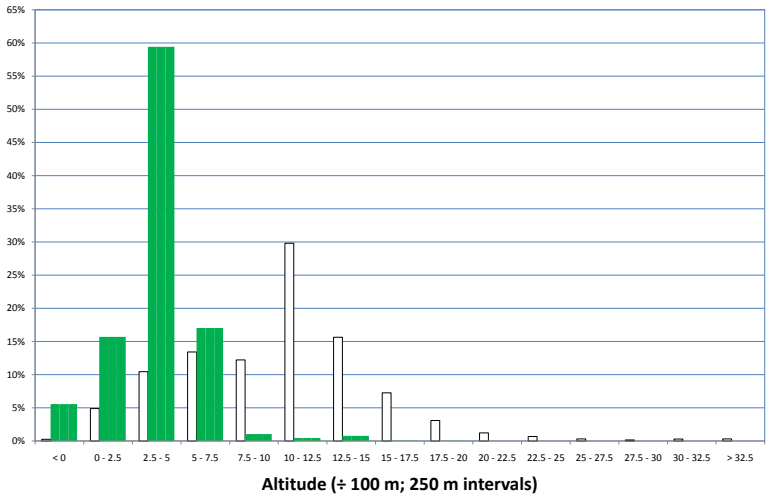
In a harmonized GIS map that was later developed by Dennis Herlocker (he was the main botanist involved in the RMHK project; Schwartz *et al.* 1991; Shaabani *et al.* 1992abc; Herlocker *et al.* 1993, 1994abcd), mapping units 25 and 26 corresponded to "deciduous dwarf shrub [perennial] grassland" (Isiolo and Samburu Districts) and "deciduous dwarf shrub annual grassland" (Marsabit and Turkana Districts) respectively. We remapped all corresponding areas as semi-desert grassland and shrubland.

An area that was mapped in the original Tanzania map as "desert and semi-desert" and subsequently by White (1983) as Somalia-Masai semi-desert grassland and shrubland (mapping unit 54b) was mapped in VECEA as halophytic vegetation. An explanation is provided in the description of halophytic vegetation (Z), see below.

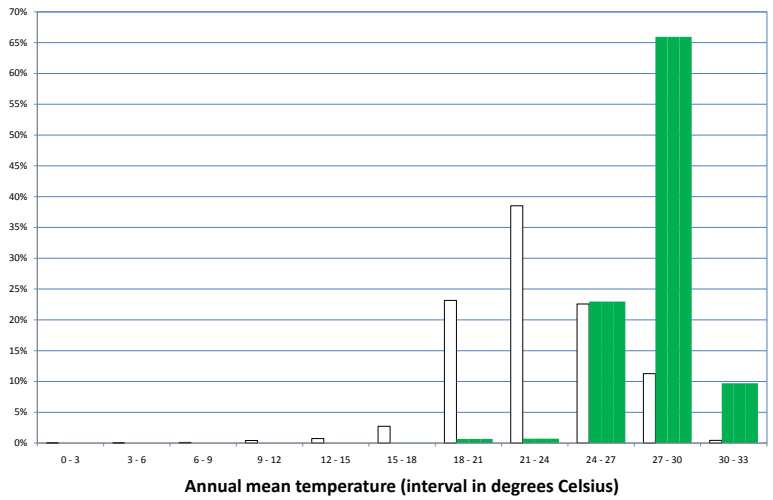
We investigated the environmental distribution of Somalia-Masai semi-desert grassland and shrubland in the VECEA region together with that of Desert (D; Figure 9.6). The main reason is that we expect that the main manifestation of desert occurs in Ethiopia and not in Kenya, whereas desert was not mapped separately in Ethiopia. Desert and semi-desert vegetation types mainly occur below 750 m (> 95% of samples). This is not surprising given

the altitudinal limit of 400 m that was used in Ethiopia to map the original mapping type of a desert and semi-desert mosaic. Some samples occur below sea level (5.6%; another vegetation type with several samples below sea level is halophytic vegetation [Z; 6.5%;]). Annual rainfall in desert and semi-desert vegetation types is mainly between 0 and 600 mm (nearly all samples). Most samples receive less than 400 mm (88.8%). Since desert and semi-desert vegetation types are mapped in mosaic in Ethiopia and since drier areas occur in Ethiopia than Kenya, we were not able to investigate differences in rainfall between desert and semi-desert vegetation. It appears from the histogrammes, however, as if a considerable part of semi-desert vegetation receives more rainfall than reported by White (1983; i.e. between 150 and 250 mm). Where 5.9% of samples receive less than 150 mm (which are possibly areas that could be classified as desert), 64.5% of samples receive more than 250 mm. It is therefore possible that the mapped area of Somalia-Masai semi-desert grassland and shrubland is exagerated in the VECEA region (possibly partially as a consequence of using an altitude limit to map this vegetation type in Ethiopia).

(a)



(b)



(c)

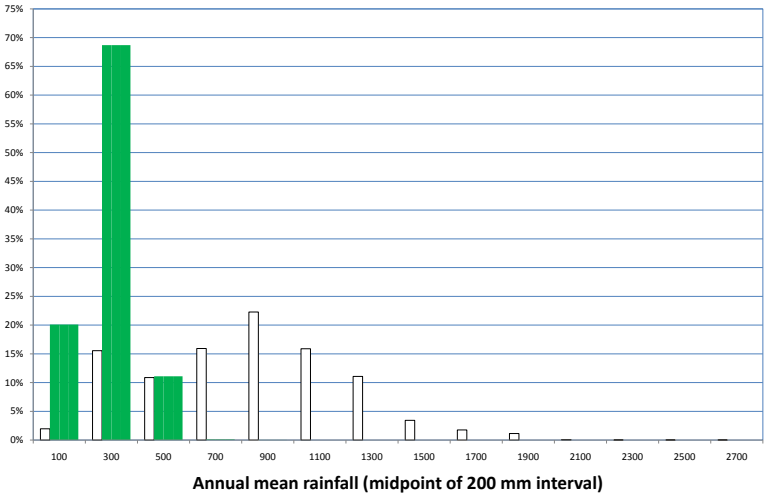


Figure 9.6. Histogrammes of the distribution of altitude (a), mean annual temperature (b) and mean annual rainfall (c). Bars at the centre of each interval show the percentage of samples (n = 31,370) within desert (D; excluding Afromontane desert) or Somalia-Masai semi-desert grassland and shrubland (S). Bars on the left (open) show the overall percentage of samples (n = 740,047).

9.3. Species composition

Species assemblages were obtained from the following references:

- Ethiopia: Friis *et al.* 2010. Species mentioned in Appendix 3 for "Desert and semi-desert scrubland" [DSS] were coded "x" (unless they were characteristic species).
- Kenya: Species that were expected to occur in semi-desert vegetation based on information from Beentje (1994), the Flora of Tropical East Africa and field experience from our Kenyan collaborator (F. Gachathi) were coded "x". A suffix of "a" (annual grasses) was given for species listed for mapping unit 26 of the Range Management Handbook of Kenya (RMHK; Schwartz *et al.* 1991; Shaabani *et al.* 1992abc; Herlocker *et al.* 1993, 1994abcd). A suffix of "p" (perennial grasses) was given for species listed for mapping unit 25 of the RMHK.

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: The two most frequent grass and dwarf shrub species listed in the Range Management Handbook of Kenya Volume for Marsabit District (Schwartz *et al.* 1991) for "dwarf shrub - annual grassland" (vegetation type 9) 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 vegetation type in other countries (see section 2.3).

Table 9. Species composition of Somalia-Masai semi-desert grassland and shrubland (S)

Species	Regional status (see section 2.3)	(Ethiopia)	(Kenya)
Acacia bussei	not characteristic (characteristic for *Acacia-Commiphora* deciduous bushland)	x	f
Acacia drepanolobium	not characteristic (characteristic for deciduous bushland and biotic savanna)	f	x
Acacia edgeworthii		x	f
Acacia ehrenbergiana		C	
Acacia etbaica	characteristic (semi-desert dwarf shrubland in Marsabit)	f	f
Acacia gerrardii	not characteristic (characteristic for biotic *Acacia* wooded grassland)	f	x
Acacia horrida	characteristic (semi-desert annual grassland in Marsabit)	f	f
Acacia mellifera	characteristic (semi-desert dwarf shrubland in Marsabit)	f	f
Acacia nilotica	not characteristic (characteristic for *Acacia-Commiphora* deciduous bushland)	f	x
Acacia oerfota		x	f
Acacia reficiens	characteristic (semi-desert annual grassland and dwarf shrubland in Marsabit)	f	f
Acacia senegal	characteristic (semi-desert annual grassland and dwarf shrubland in Marsabit)	x	xa
Acacia seyal	characteristic (semi-desert annual grassland and dwarf shrubland in Marsabit)	f	x
Acacia tortilis	characteristic (semi-desert annual grassland and dwarf shrubland in Marsabit)	x	xa
Acacia zanzibarica		x	f
Adenium obesum	not characteristic (characteristic for *Acacia-Commiphora* deciduous bushland)	x	f
Aerva javanica	characteristic (principal shrubby species on coastal plain of Somalia)		f
Aloe breviscapa	characteristic (dwarf shrublands on gypseous soils in Somalia)		f
Aloe rigens	characteristic (dwarf shrublands on gypseous soils in Somalia)	f	f
Aloe scobinifolia	characteristic (dwarf shrublands on gypseous soils in Somalia)		f
Aristida adscensionis	not characteristic (ephemeral grass species in *Acacia-Commiphora* deciduous bushland)		xp
Aristida mutabilis	characteristic (associated annual grass species of *Indigofera spinosa* dwarf shrublands on sandy alluvial plains near Lake Turkana)		xa
Balanites aegyptiaca		x	f
Balanites pedicellaris		x	f
Balanites rotundifolia	not characteristic (characteristic for *Acacia-Commiphora* deciduous bushland)	f	x
Blepharis linariifolia			xa
Boscia angustifolia		x	f
Boscia coriacea	not characteristic (characteristic for *Acacia-Commiphora* deciduous bushland)	f	x
Boswellia rivae		x	f
Cadaba farinosa	not characteristic (characteristic for *Acacia-Commiphora* deciduous bushland)	f	x
Cadaba glandulosa		x	f
Cadaba mirabilis		x	xa
Cadaba rotundifolia		x	f
Calotropis procera		x	f

Species	Regional status (see section 2.3)	(Ethiopia)	(Kenya)
Capparis cartilaginea		x	f
Capparis decidua		x	
Caralluma edithae	characteristic (one of the two species that form most of the phytomass of communities of dwarf succulents)		f
Caralluma penicillata	characteristic (one of the two species that form most of the phytomass of communities of dwarf succulents)		f
Cenchrus pennisetiformis	(grass)		xa
Centropodia glauca	characteristic (dominant grass species in semi-desert grassland on deep sand)		f
Chasmanthera dependens		x	f
Chrysopogon plumulosus	characteristic (grass species that was possibly dominant before overgrazing)		xp
Cissus rotundifolia	not characteristic (characteristic for *Acacia-Commiphor*a deciduous bushland)	x	f
Cocculus hirsutus		x	f
Combretum aculeatum	not characteristic (characteristic for *Acacia-Commiphora* deciduous bushland)	x	f
Commiphora africana	not characteristic (characteristic for *Acacia-Commiphora* deciduous bushland)	x	f
Commiphora erlangeriana		x	f
Commiphora erythraea	not characteristic (characteristic for *Acacia-Commiphora* deciduous bushland)	x	
Commiphora gileadensis		x	
Commiphora guidottii		x	f
Commiphora habessinica		x	f
Commiphora incisa		x	f
Commiphora kua		x	f
Commiphora myrrha		x	f
Commiphora samharensis		C	f
Commiphora sphaerocarpa		x	f
Cordeauxia edulis		x	
Cordia sinensis	not characteristic (characteristic for *Acacia-Commiphora* deciduous bushland)	f	xap
Cordia suckertii		x	
Cynanchum clavidens		x	
Cynanchum gerrardii		x	
Dactyloctenium aegyptium	(grass)		xap
Delonix elata	not characteristic (characteristic for *Acacia-Commiphora* deciduous bushland)	x	f
Dobera glabra	not characteristic (characteristic for *Acacia-Commiphora* deciduous bushland)	x	f
Duosperma eremophilum	characteristic (semi-desert annual grassland and dwarf shrubland in Marsabit)		Cap
Eragrostis mahrana	characteristic (dominant grass species in semi-desert grassland on deep sand)		f
Euphorbia columnaris	characteristic (gypseous soils)		f
Euphorbia cuneata	characteristic (dwarf shrublands on gypseous soils in Somalia)	x	xa
Euphorbia mosaica	characteristic (gypseous soils)		f
Euphorbia multiclava	characteristic (dwarf shrublands on gypseous soils in Somalia)		f
Euphorbia sepulta	characteristic (gypseous soils)		f

Species	Regional status (see section 2.3)	(Ethiopia)	(Kenya)
Farsetia longisiliqua	characteristic (principal shrubby species on coastal plain of Somalia)		f
Grewia similis	not characteristic (characteristic for East Africa evergreen and semi-evergreen bushland)	f	x
Grewia tenax	not characteristic (characteristic for *Acacia-Commiphora* deciduous bushland)	f	x
Helichrysum glumaceum	characteristic (dominant on rocky plateau surfaces near Lake Turkana)		f
Hyphaene thebaica	palm species	x	
Indigofera oblongifolia		x	
Indigofera spinosa	characteristic (dwarf shrublands on sandy alluvial plains near Lake Turkana)		Cap
Ipomoea donaldsonii		x	f
Ipomoea sultani	characteristic (dwarf shrublands on gypseous soils in Somalia)		f
Jatropha pelargoniifolia	characteristic (principal shrubby species on coastal plain of Somalia)		f
Kelleronia splendens	characteristic (dwarf shrublands on gypseous soils in Somalia)	x	f
Lannea triphylla	not characteristic (characteristic for *Acacia-Commiphora* deciduous bushland)	x	f
Lawsonia inermis		x	f
Leptadenia arborea		x	
Leptadenia hastata		x	f
Leptothrium senegalense	(grass)		xp
Leucas abyssinica	characteristic (dwarf shrublands on gypseous soils in Somalia)	f	f
Leucas tomentosa		x	f
Lycium europaeum	characteristic (dwarf shrublands on gypseous soils in Somalia)		f
Lycium shawii		x	f
Maerua crassifolia		f	xa
Maerua oblongifolia		x	f
Melocarpum hildebrandtii	characteristic (dwarf shrublands on gypseous soils in Somalia)	x	f
Momordica sessilifolia		x	f
Momordica spinosa		x	f
Moringa peregrina		x	
Ochradenus baccatus	characteristic (dwarf shrublands on gypseous soils in Somalia)	C	f
Oropetium capense			xa
Panicum turgidum	characteristic (dominant in semi-desert grassland on deep sand)	f	f
Pelargonium christophoranum	characteristic (gypseous soils)		f
Salvadora persica	not characteristic (characteristic for *Acacia-Commiphora* deciduous bushland)	x	xa
Sarcostemma viminale	not characteristic (characteristic for *Acacia-Commiphora* deciduous bushland)	x	f
Senna alexandrina		x	f
Senna longiracemosa		x	f
Senna sophera		x	
Sericocomopsis hildebrandtii	not characteristic (characteristic for *Acacia-Commiphora* deciduous bushland)	f	xap
Sericocomopsis pallida	not characteristic (characteristic for *Acacia-Commiphora* deciduous bushland)	x	f
Sesamothamnus busseanus		x	f

Species	Regional status (see section 2.3)	(Ethiopia)	(Kenya)
Sesbania sesban		x	f
Sporobolus helvolus	(grass)		xp
Sporobolus pellucidus	(grass)		xp
Sporobolus spicatus	characteristic (associated perennial grass species of Indigofera spinosa dwarf shrublands on sandy alluvial plains near Lake Turkana)		f
Sterculia africana	not characteristic (characteristic for *Acacia-Commiphora* deciduous bushland)	x	f
Suaeda monoica	characteristic (semi-desert dwarf shrubland in Marsabit)	x	f
Tamarindus indica		x	f
Tamarix aphylla		x	f
Tamarix nilotica		x	f
Terminalia brevipes		x	f
Tetrapogon cenchriformis	(grass)		xa
Tragus berteronianus	(grass)		xp
Vernonia cinerascens		x	f
Wrightia demartiniana		x	f
Ziziphus spina-christi		x	f

10. Fresh-water swamp (X)

10.1. Description

Permanent swamps occur in depressions where water permanently floods the surface to a shallow depth (seasonal swamps are usually covered with edaphic grassland [see g]). Most of the shallower lakes outside the Guineo-Congolian floristic region (especially those that are not strongly saline, see halophytic vegetation [Z]) have a wide belt of reed-swamp where the dominant species are usually rooted in the soil and have stems that rise out of the water (inside the Guineo-Congolian region, most swampy areas are covered with swamp forest [fs]). The most abundant reed-swamp species is ***Cyperus papyrus*** (a giant sedge species) but other species can also be dominant such as ***Miscanthus violaceus***, *Phragmites australis* and *Phragmites mauritianus* grasses (White 1983 pp. 55 and 265).

True aquatic species occur in deeper water beyond the reed swamp and are either completely submerged or have floating leaves. A belt of floating grasses (principally *Vossia cuspidata, Paspalidium germinatum* and *Panicum repens*, but often invaded by *Cyperus papyrus*) frequently separates the reed-swamp from the aquatic vegetation (White 1983 p. 55).

Towards the landward margin of reed-swamp, often a narrow zone occurs of small trees and shrubs that are adapted to swamp conditions. The principal species are *Aeschynomene elaphroxylon, Aeschynomene pfundii, Ficus trichopoda* (scattered juveniles of swamp-forest trees), *Ficus verruculosa* (scattered juveniles of swamp-forest trees), *Kotschya africana, Mimosa pigra, Sesbania sesban* and *Syzygium cordatum* (scattered juveniles of swamp-forest trees; White 1983 p. 266).

Figure 10.1 Freshwater swamp in Morogoro District (Tanzania). Photograph by H. N. Moshi (2010).

Figure 10.2 Freshwater swamp dominated by *Cyperus papyrus* west of Mbale Town (Uganda). Photograph by J. Kalema (November 2010).

Figure 10.3 Freshwater swamp in Rwanda occurring at medium altitudes in that country in Akanyaru. Photograph by C. K. Ruffo (October 2009).

Figure 10.4 Typical East African birds of freshwater swamps and lakes within their natural habitat. Shell guide to East African birds (1960; reproduced with permission from URL *http://ufdc.ufl.edu/UF00077050*).

10.2. VECEA region

Within the VECEA region, fresh-water swamp was found in all VECEA countries (see Volume 6). Open water vegetation was mapped as "water" in the VECEA map. Some additional information about open water vegetation types can be obtained from Ethiopia (Friis *et al.* 2010).

In Ethiopia, fresh-water swamp was mapped originally within the vegetation type of "Fresh-water marshes and swamps, floodplains and lake shore vegetation" (original mapping unit FLV - MFS).

In Kenya, fresh-water swamp was mapped partially by including all areas mapped as "*Papyrus*, swamp; grass and reed swamp" (original mapping unit 9) in the Trapnell *et al.* (1966, 1969, 1976, 1986) map [see volume 6]. In northern Kenya (mapped in VECEA from district vegetation maps available from the Range Management Handbook of Kenya [RMHK; Schwartz *et al.*. 1991; Shaabani *et al.* 1992abc; Herlocker *et al.*. 1993, Herlocker *et al.*. 1994abcd], mapping unit 29 was defined as "Seasonally flooded grassland swamp" in Baringo District and "Seasonally flooded grassland and permanent swamp" in Isiolo District. For mapping unit 29.1 of Baringo District ("*Cyperus papyrus* permanent swamp and *Echinochloa - Cynodon - Brachiaria* seasonally flooded grassland"), species that were listed were *Cyperus papyrus, Cynodon dactylon* and *Echinochloa haploclada*. For Mapping unit 29.2 of Isiolo District ("*Echinochloa - Sorghum* seasonally flooded grassland and permanent swamp"), undefined *Echinochloa* and *Sorghum* species were listed; this vegetation type occupies and area of outflow and deposition of the Ewaso Ng'iro River.

Malawi's largest fresh-water swamps appear to be dominated by *Typha domingensis* rather than *Cyperus papyrus*. It was not always clear how typical fresh-water swamp species could be distinguished from typical species of edaphic grassland (g): while fresh-water swamps are always with open water, their edges may change considerably seasonally, especially where the landscape is very flat. Some species in these locations may survive well once open water has receeded in the dry season. Species that are principally found within these marginal situations were excluded from the species assemblage for Malawi (see section 10.3). Introduced invasive species such as *Eichhornia crassipes, Pistia stratiotes* and *Salvinia molesta* are locally dominant in some places (C. Dudley, pers. comm.).

In the original vegetation map of Rwanda, medium altitude swamps (original mapping unit 5A) were mapped separately from high altitude swamps (original mapping unit 5B). Medium altitude swamps are principally ***Cyperus papyrus*** swamps, although *Phoenix reclinata* occurs in some places. High altitude swamps where *Cyperus latifolius* is the main species start appearing above 1800 m in Rwanda. In the highest locations, *Lobelia mildbraedii* or *Erica kingaensis* and *Syzygium cordatum* colonize sections of these swamps (Prioul 1981).

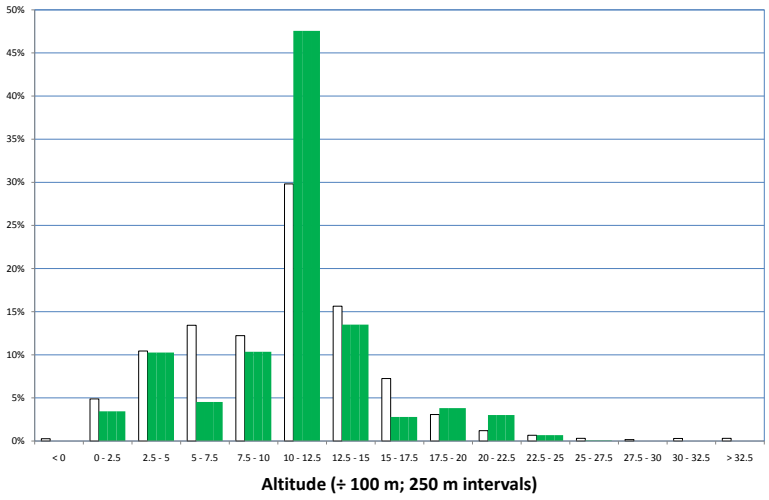
In Tanzania, fresh water swamp corresponds to the area mapped originally as "permanent swamp vegetation" (original mapping unit 6).

The original vegetation maps of Uganda contained the subtypes of ***Cyperus papyrus*** swamp (original mapping unit X1) and ***Miscanthus violaceus*** (synonym: *Miscanthidium violaceum*) swamp (original mapping unit X2). ***Miscanthus violaceus*** swamps are slightly drier than ***Cyperus papyrus*** swamps and they are often situated between the latter and dry land. Langdale-Brown *et al.*. (1964 p. 74) suggest that *Miscanthus violaceus* swamps may be successional stage leading towards swamp forest (fs).

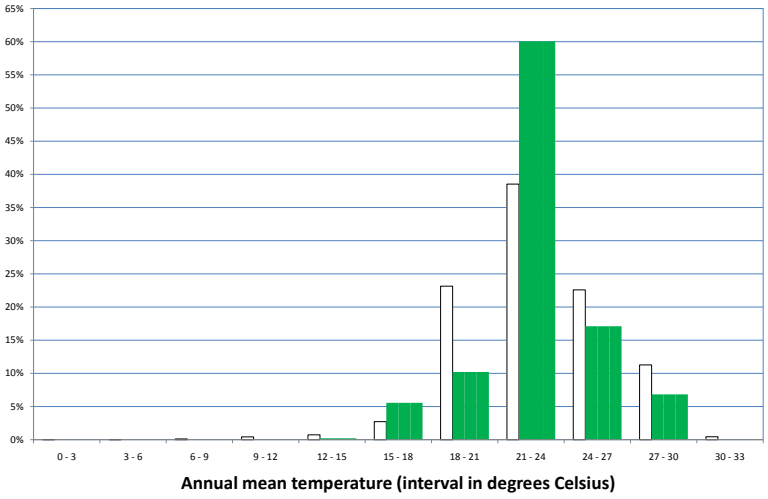
Fanshawe (1971 p. 62) included descriptions of fresh water swamps (that remain flooded throughout the dry season) and alkaline swamps (shallow brackish lakes which periodically dry up completely) in his general treatment of Zambian "grasslands" (original mapping unit 17). He refers to Lake Bangweulu, the Lukanga swamp and the Busanga swamp as the best known swamp areas of Zambia. He describes that certain species such as ***Cyperus papyrus*** tend to form pure stands over extensive areas.

Investigation of environmental distribution of fresh water swamps in the VECEA region (Figure 10.5; limits are for areas of the VECEA map where this vegetation type is not mapped as mosaic) shows that the samples occur in a wide interval from 250 – 2000 m (> 90% of samples). This wide interval agrees with topographic and other non-climatic explanations for the occurrence of this vegetation type. Likewise, a wide range in rainfall was observed for this vegetation type (> 90% of samples receiving between 400 and 1600 mm of rainfall).

(a)



(b)



(c)

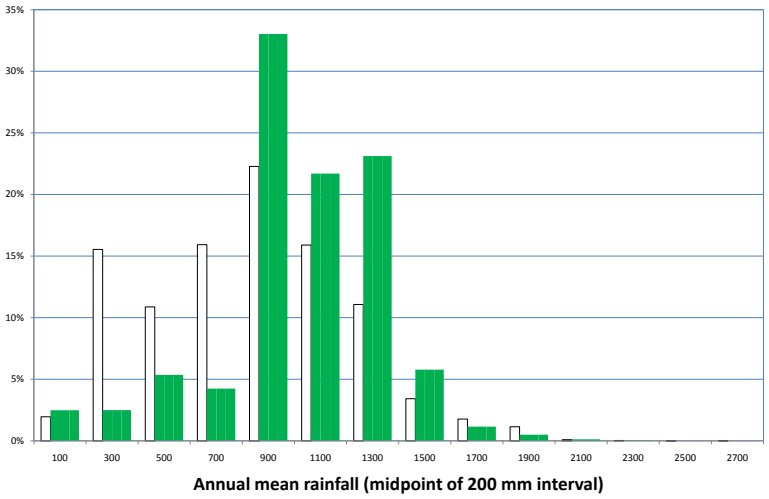


Figure 10.5. Histograms of the distribution of altitude (a), mean annual temperature (b) and mean annual rainfall (c). Bars at the centre of each interval show the percentage of samples within fresh-water swamp (X, *n* = 7,211). Bars on the left (open) show the overall percentage of samples (*n* = 740,047).10.3. Species composition

10.3. Species composition

Species assemblages were obtained from the following references:

- Ethiopia: Friis *et al.* 2010. Species mentioned in Appendix 3 for "Fresh-water marshes and swamps, floodplains and lake shore vegetation" [FLV - MFS] were coded "x" (unless they were characteristic species).
- Kenya : Species that were expected to occur in freshwater swamp based on information from Beentje (1994), the Flora of Tropical East Africa and field experience from our Kenyan collaborator (F. Gachathi) were coded "x". Species that were also listed for Edaphic wooded grassland on drainage-impeded or seasonally flooded soils (wd) were coded "xw" (we suspect that these are typical species for ecotones between edaphic wooded grassland and freshwater swamp).
- Malawi: Blackmore *et al.* (1988), Gibbs-Russell (1977), Howard-Williams (1977), Jackson and Wiehe (1958), White *et al.* (2001) supplemented by unpublished data from our Malawian collaborator (C. Dudley). Species mentioned in these references were coded "x" (unless they were characteristic species).
- Rwanda: Bloesch *et al.* (2009). All species that were mentioned to occur in floristic region 5A (medium altitude swamp [1300 - 1500 m]) were coded "xm" (unless they were characteristic species). All species that were mentioned to occur in floristic region 5B (high altitude swamp [1900 - 2500 m]] were coded "xh" (unless they were characteristic species).
- Uganda: Langdale-Brown *et al.* (1964). The woody species and dominant herb species mentioned in the appendix to occur in "*Cyperus papyrus* swamp" (X1) were coded "xc" (unless they were characteristic species). The woody species and dominant herb species mentioned in the appendix to occur in "*Miscanthidium* swamp" (X2) were coded "xm" (unless they were characteristic species). Woody species were coded "w" with the same suffices.
- Zambia: Fanshawe (1971). All species listed for the description of "fresh water swamps" were coded "C".

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: Species suggested from the name of mapping unit in the Trapnell *et al.* (1966, 1969, 1976, 1986) map were coded "C".
- Malawi: Those species that were mentioned to be dominant were coded "C".
- Rwanda: Species that were listed by Prioul [1981] for medium altitude swamps were coded ("Cm"). Species that were listed by Prioul [1981] for high altitude swamps were coded ("Ch").
- Uganda: Species mentioned in the main text were coded "C".
- Zambia: All species were assumed to be characteristic species.

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

Table 10. Species composition of fresh-water swamp (X)

Species	Regional status (see section 2.3)	(Ethiopia)	(Kenya)	(Malawi)	(Rwanda)	(Tanzania)	(Uganda)	(Zambia)
Cyperus papyrus	the main constituent of most of the shallower lakes (except those that are strongly saline) outside the Guineo-Congolian region (where swamp forests are more prominent); also in floating mats		C	x	Cm	C	Cc	C
Abrus precatorius		f	x	f	f	f	f	f
Acacia abyssinica		f	x	f	f	f	f	
Acacia elatior			xw				f	
Acacia gerrardii		f	xw	f	f	f	f	f
Acacia hockii		f	xw	f	f	f	f	f
Acacia oerfota		f	xw			f	f	
Acacia polyacantha		f	xw	f	f	f	f	f
Acacia seyal		f	xw	f		f	f	f
Acacia xanthophloea			xw	x		f		
Aeschynomene abyssinica		x	xw	f		f	f	f
Aeschynomene cristata		C	x	f		f	f	f
Aeschynomene elaphroxylon	trees on the landward margin of reed-swamp	C	x	x	f	f	f	f
Aeschynomene pfundii	trees on the landward margin of reed-swamp	C	x	x		f		f
Aeschynomene schimperi		C	x	f	f	f	f	f
Alchornea cordifolia			x		f	f	f	
Allophylus africanus		f	f	f	xm	f	f	f
Allophylus kiwuensis			f		xh		f	
Anthocleista grandiflora			x	f		f	f	
Azima tetracantha			x	f	f	f	f	f
Bridelia micrantha		f	f	f	f	f	wc	f
Cadaba rotundifolia		f	xw					
Campylospermum vogelii					xm	f	f	
Ceratophyllum demersum	submerged community in deeper water beyond the reed swamp		f	x		f	f	
Cissampelos mucronata		f	f		f	f	Cc	
Combretum constrictum			x			f		
Commelina diffusa			f	x		f	f	

Species	Regional status (see section 2.3)	(Ethiopia)	(Kenya)	(Malawi)	(Rwanda)	(Tanzania)	(Uganda)	(Zambia)
Cordyla africana			x	f		f		f
Cyperus dives			x			f		
Cyperus latifolius		f			Ch			
Dissotis rotundifolia	principal associate of papyrus		f			f	Cc	
Echinochloa pyramidalis	species rooted in *Vossia cuspidata* mats (grass)		f	x		f	f	
Echinochloa stagnina	species rooted in *Vossia cuspidata* mats (grass)		f			f	f	C
Eichhornia crassipes	free-floating species, pest introduced from tropical America (the water hyacinth)	f	f	x		f		
Euclea divinorum		f	f	f	xm	f	f	f
Ficus verruculosa	juveniles of swamp-forest trees on the landward margin of reed-swamp		f	f	f	f	wc	f
Hemarthria altissima	(grass)			x		f		
Heterotis canescens	associate of *Miscanthus violaceus* in shallower lakes in which papyrus is absent						Cm	
Hibiscus diversifolius	principal associate of *papyrus*	f	f	x	f	f	f	f
Hypericum revolutum		f	f	f	xh	f	f	f
Impatiens burtonii							x	
Ipomoea aquatica			f	x		f	f	
Ipomoea rubens			x	x		f	f	
Kanahia laniflora		f	x					
Keetia gueinzii		f	f	f	xh	f	f	f
Kotschya africana	trees on the landward margin of reed-swamp	f	x	x	f	f	f	f
Leersia hexandra	associate of *Miscanthus violaceus* in shallower lakes in which papyrus is absent (grass)	f	f	x		f	Ccm	C
Lemna perpusilla	free-floating species		f	x		f	f	
Leonotis nepetifolia			x			f	f	
Loudetia phragmitoides	in shallow water on the landward side of *papyrus* swamp (grass)		f			f	f	
Ludwigia leptocarpa	principal associate of *papyrus*			x				f
Ludwigia octovalvis	principal associate of *papyrus*		x	x				f
Ludwigia stenorraphe			x	f				f
Ludwigia stolonifera	principal associate of *papyrus*			x				
Macaranga schweinfurthii			f		xhm	f	f	f
Maytenus acuminata			f	f	xh	f	f	f

Species	Regional status (see section 2.3)	(Ethiopia)	(Kenya)	(Malawi)	(Rwanda)	(Tanzania)	(Uganda)	(Zambia)
Maytenus heterophylla		f	f	f	xm	f	f	f
Melanthera scandens	principal associate of *papyrus*		f			f	x	
Mikania capensis	principal associate of *papyrus*		f		f	f	x	
Miscanthus violaceus	in shallow water on the landward side of *papyrus* swamp; also forms a distinct zone in shallower water from which *papyrus* is absent (grass)						Cm	
Nymphaea lotus	community with floating leaves in deeper water beyond the reed swamp	f	f	x		f	f	
Nymphaea nouchali	community with floating leaves in deeper water beyond the reed swamp		f	x	Cm	f	f	
Oreobambos buchwaldii	/bamboo species indigenous to Africa)		x	f		f	f	f
Oryza longistaminata	(grass)		f			f	f	C
Oxyanthus speciosus		f	f	f	xh	f	f	f
Parkinsonia aculeata			x					
Pavetta subcana		f	x			f	f	
Peddiea fischeri			f		xh	f	f	
Peddiea rapaneoides					xh		f	
Pennisetum macrourum	(grass)							C
Pennisetum purpureum	(grass)		f	x		f	f	
Persicaria decipiens		f	f			f	Cc	
Phoenix reclinata	(palm species)	f	f	x	Cm	f	f	f
Phragmites mauritianus	common in silted areas and lakes of volcanic origin in East Africa (grass)		x	C		f	f	C
Phyllanthus reticulatus		f	x	f		f	f	f
Phyllanthus sepialis		f	x			f	f	
Phyllanthus somalensis			x					
Pistia stratiotes	free-floating species	f		x				
Pluchea ovalis			x		f	f	f	
Pseudarthria hookeri			x	f	f	f	f	f
Pseudosabicea arborea					xh	f	f	
Pseudospondias microcarpa			x		f	f	f	f

Species	Regional status (see section 2.3)	(Ethiopia)	(Kenya)	(Malawi)	(Rwanda)	(Tanzania)	(Uganda)	(Zambia)
Psychotria peduncularis			f	f	xh	f	f	f
Pycreus mundtii			f	x	Cm	f	f	
Raphia farinifera	(palm species)		x			f	f	
Rumex usambarensis			x		f	f	f	
Salvadora persica		f	xw	f		f	f	f
Senna didymobotrya		f	x	f	f	f	f	f
Sesbania bispinosa			x			f		
Sesbania keniensis			x			f		
Sesbania macrantha			x	f	f	f	f	f
Sesbania sericea			x	f		f	f	
Sesbania sesban	trees on the landward margin of reed-swamp	C	x	x	f	f	f	f
Sporobolus pyramidalis	(grass)		f	x		f	f	
Syzygium cordatum	juveniles of swamp-forest trees on the landward margin of reed-swamp		f	x	Ch	f	wc	f
Tacazzea apiculata		f	f		xm			
Typha domingensis			x	C		f	f	
Typha latifolia	locally replaces *papyrus* at higher altitudes		x				f	
Utricularia gibba	associate of *Miscanthus violaceus* in shallower lakes in which *papyrus* is absent		f	x		f	f	
Vallisneria spiralis	submerged community in deeper water beyond the reed swamp			x				
Vangueria apiculata		f	f	f	xh	f	f	f
Vigna luteola	principal associate of papyrus		f	x		f	f	
Voacanga africana			x	f		f	f	f
Voacanga thouarsii			x	x			f	f
Vossia cuspidata	floating mat at the edge of reed-swamps, also pioneer of reed-swamp		f	x		f	f	
Zanthoxylum usambarense		f	f		xm	f		

11. Halophytic vegetation (Z)

11.1. Description

Halophytes are a relatively small group of plant species that can grow on saline soils. The most typical halophytes absorb soluble salts (especially Sodium chloride) and tolerate high concentrations in the cell sap of their leaves. The vegetation on saline soils is dominated by halophytes and is physiognomically varied, including halophytic grassland, wooded grassland, shrubland and bushland (White 1983 pp. 55 and 266).

Saline soils are frequently found in arid and semi-arid regions where rainfall is insufficient to transport salts. The distribution of saline soils is also partially determined by geology as they can occur in wetter regions around springs that bring soluble salts to the surface (White 1983 p. 266). The halophytic grass *Drake-brockmania somalensis* occurs near outlets of the major tributary streams to the Chalbi desert (Kenya, this edaphic desert is seasonally flooded, White 1983 p. 120).

In parts of East Africa, salts that are derived from volcanic deposits rich in Sodium are deposited in lake basins and river valleys. As a consequence, halophytic vegetation occurs in most of the lake basins of the Eastern Rift (especially Lakes Bogoria [Kenya], Elementeita [Kenya], Eyasi [Tanzania], Nakuru [Kenya], Magadi, Manyara [Tanzania], Natron [Tanzania], Rukwa [Tanzania] and Turkana [Kenya]). Halophytic vegetation also occurs around Lake Mweru Wantipa (Zambia), a lake that also lies in a down-faulted depression with internal drainage (White 1983 pp. 266 - 267).

The halophytic vegetation in the Lake Rukwa basin (Tanzania) is chiefly grassland and can be subdivided in three zones: (i) the beach zone that marks the maximum extent of the lake has pure stands of 1 to 2 m tall Sporobolus robustus; (ii) the alkaline swamp is colonized by *Diplachne fusca* (current name: *Leptochloa fusca*; this grass species also dominates alkaline swamps south of Lake Eyasi [Tanzania]); and (iii) the alkaline flats (areas of the lake bed that are successively flooded or drying up) are colonized first by *Sporobolus spicatus* (a species that is also a chief plant around other lake basins in the Eastern Rift) but are replaced by *Odyssea jaegeri* when the lake shallowly refills (White 1983 p. 267).

Many of the flat valleys in the drier parts of Tanzania have alkaline soils. This is especially the case for the flood plains of the Pangani River as large amounts of salt are released from the volcanic deposits of Mt. Kilimanjaro and Mt. Meru. Prominent halophytes include *Salvadora persica*, *Suaeda monoica, Sporobolus robustus* and *Triplocephalum holstii*. Other species occur on the flood plain such as *Acacia xanthophloea* (a species that may not persist if high levels of sodium reach their rooting horizon [White 1983 p. 30]) and *Sesbania sesban* (White 1983 p. 267).

Figure 11.1 Salt pan surrounded by scrub of *Suaeda monoica* (Chenopodiaceae). The surrounding vegetation is desert (D) and semi-desert (S). Between Dichioto (Ethiopia) and the border with Djibouti. Approximate altitude 200 m. 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 35B. 2010.

Figure 11.2 Salt pan surrounded by scrub of *Suaeda monoica* (Chenopodiaceae). In the background lava flows without vegetation (desert [D]). Between Dichioto (Ethiopia) and the border with Djibouti. Approximate altitude 200 m. 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 35D. 2010.

Figure 11.3. Z. A section of the Pangani floodplain not far from Hedaru with halophytic vegetation characterized by Suaeda monoica. Altitude approximately 650m. The Pare Mountains can be seen in the background. Photograph taken during the rainy season Photograph by H. N. Moshi (May 2009).

Figure 11.4 Detail of *Suaeda monoica*. Photograph in same location as previous photograph (Figure 11.3). Photograph by H. N. Moshi (May 2009).

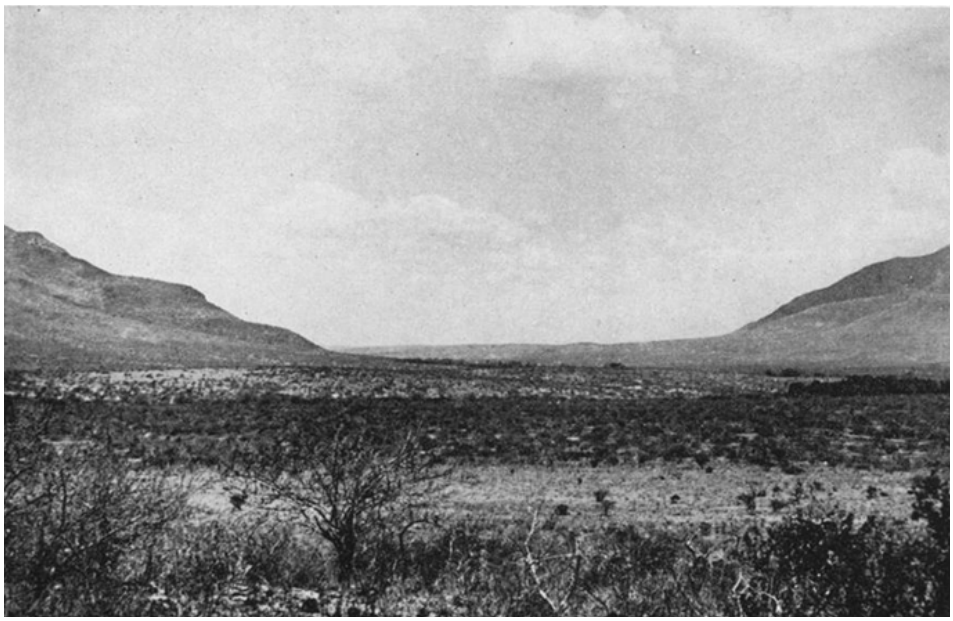


Figure 11.5 The original caption for this photograph was: semi-arid vegetation in the Mkomazi gap between the southern Pare and the west Usambara mountains (Tanzania; photograph by P. J. Greenway). Although this area was mapped by Gillman (1949) as "desert and semi-desert", we mapped it in the VECEA map as halophytic vegetation since we expect that most of these areas typically contain *Suaeda monoica* (salt bush; see also photographs 11.3 and 11.4 from the same general area). Gillman (1949, Fig 17). Image obtained from URL: *http://www.jstor.org/stable/211155*.

11.2. VECEA region

Within the VECEA region, halophytic vegetation was mapped for Ethiopia, Kenya and Tanzania (Figure 11.8, see also Volume 6). This vegetation type was described to occur in Zambia as well, but was not mapped in this country.

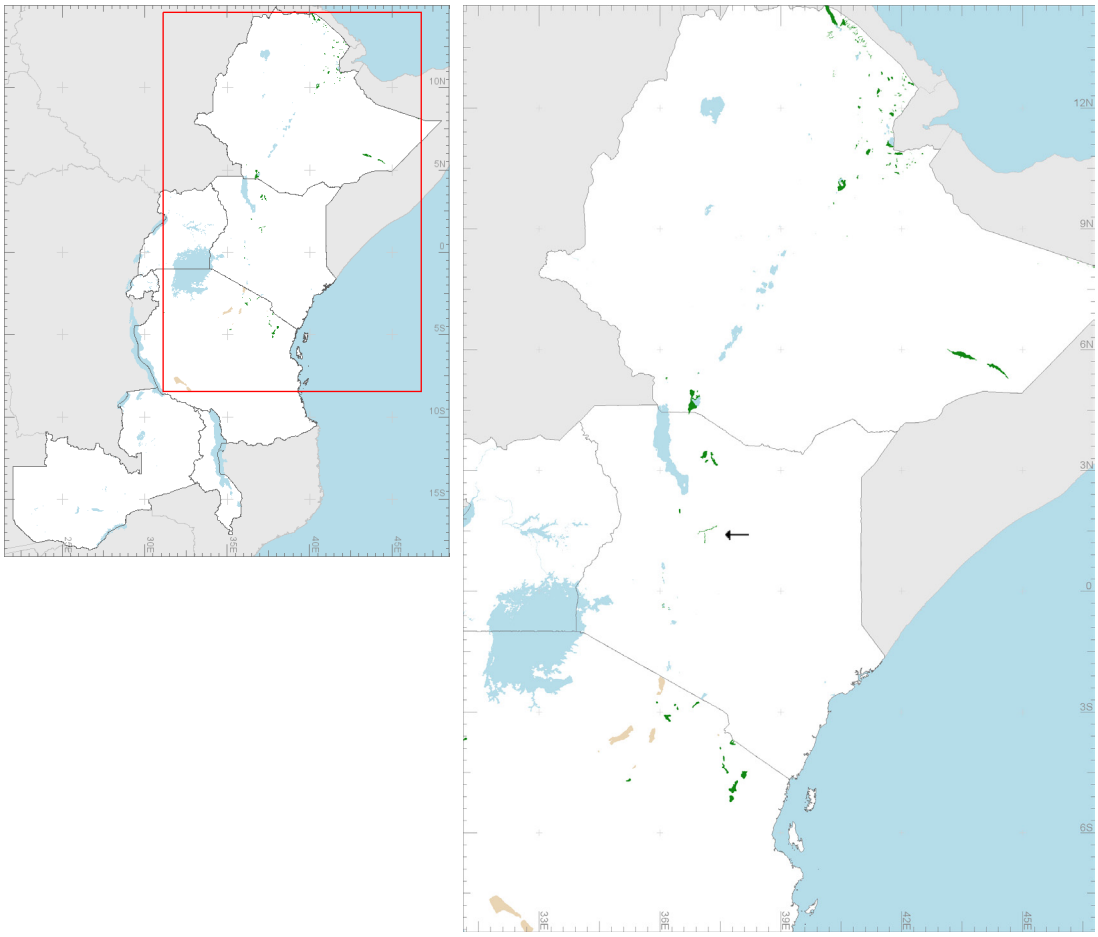


Figure 11.6. Mapped distribution of halophytic vegetation in the VECEA region (Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda and Zambia). Where this vegetation type does not occur in mosaic, it is depicted by green polygons. This vegetation type is also mapped as part of different vegetation mosaics (shown in greyish-brown). This vegetation type was described to occur in Zambia as well, but was not mapped in this country. An alternative classification of a polygon from Samburu District (Kenya, indicated by an arrow) would have been as riverine vegetation.

In Ethiopia, halophytic vegetation was originally mapped as "Salt pans, saline-brackish and intermittent wetlands and salt-lake shore vegetation" (SLV-SSS).

In Kenya, halophytic vegetation corresponds partially to "saline grassland and salt pans" (mapping unit 32) of the Trapnell *et al.* (1966, 1969, 1976, 1986) map. The area mapped in northern Kenya as "shrubland to grassland on saline soils" (mapping unit 12 in the original vegetation map of Marsabit district) was also mapped in VECEA as halophytic vegetation [7] (see Volume 6).

Although there was only one obvious name that referred to halophytic vegetation for in the Range Management Handbook of Kenya, i.e. "shrubland to grassland on saline soils" occurring in Marsabit District (Schwartz *et al.* 1991), we also classified vegetation types 27.11 and 12.1 as halophytic vegetation in the VECEA map.

(i) Mapping unit 27.11 is *Sporobolus consimilis* (perennial) grassland and occurs in Turkana District. The description of this vegetation type mentioned that the highly saline to sodic soil between the water courses only supports vegetation growth when the nearby seasonal Logipi-Alablab Lake reaches its maximum levels. When this happens, a sparse growth of ***Suaeda*** (species not identifed) may occur (Herlocker *et al.* 1994d p. 54). Furthermore, *Sporobolus consimilis* (the only other species listed) is a species that occurs in Zambia on the beaches of saline lakes.

(ii) Mapping unit 12.1 is "*Salvadora - Acacia tortilis - Acacia elatior* evergreen to semi-deciduous bushland" and occurs in Samburu District. We made this decision based on the reported dominance of *Salvadora persica*, ***Suaeda monoica*** and an undefined *Tamarix* species, and based on the mention of salty water present in shallow wells dug in nearby tributary stream beds (Shaabani *et al.* 1992a p. 41). Based on the shape of this polygon and presence of *Acacia elatior, Acacia tortilis, Balanites* sp. and *Hyphaene coriacea*, an alternative mapping decision could have been to identify this vegetation as riverine bushland as this mapping unit has both riverine as halophytic characteristics.

In the original map that we consulted for Tanzania, the "desert and semi-desert" mapping unit represents vegetation that is "non-existent, as in permanent or temporary salt pans or on rock and ice (such as the alpine desert of Kilimanjaro); or areas where the vegetation is so thinly scattered that the aspect of the land is dominated at all seasons by the colour of the soil" (cf. the definition of semi-desert formulated by White (1983) [see VECEA mapping unit S]). Gillman (1949 p. 18) continues with:

> "The plants may be low bushes or stunted trees (mostly spiny or thorny), succulent climbers, bulbous or tuberous succulents and thinly scattered, mostly ephemeral grasses. The comparatively

7: In a harmonized GIS map that was later developed by Dennis Herlocker (he was the main botanist involved in the Range Management Handbook of Kenya; RMHK; Schwartz *et al.* 1991; Shaabani *et al.* 1992abc; Herlocker *et al.* 1993, Herlocker *et al.* 1994abcd), the original mapping type 12 for Marsabit District (Schwartz *et al.* 1991) was reclassfied as "*Lintonia - Acacia seyal*" (newer mapping unit 17.2; 17 indicates the physiognomy of evergreen shrubland]). Based on descriptions and species compositions, we classified the vegetation type mapped as 17.1 (*Euclea - Croton* evergreen shrubland) in Samburu District as an evergreen bushland type (Be). There was no mapping unit 17.3.

small areas carrying saltbush (usually exclusively ***Suaeda monoica***) that should theoretically be classified as bushland were also grouped with semi-desert on the map."

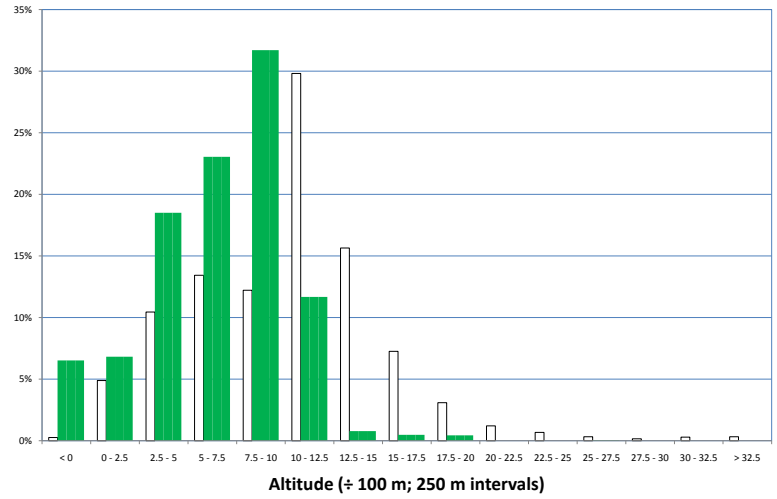
The extract above shows the connection between semi-desert vegetation and halophytic vegetation as ***Suaeda monoica*** is a halophyte (White 1983 p. 267; Friis *et al.* 2010 p. 148 [8]. In volume 6 we show how some areas in Mkomazi gap between the Pare and west Usambara mountains that were mapped by Gillman as "desert and semidesert" (see also Figure 17 in Gillman 1949) were subsequently mapped by White (1983) as Somalia-Masai semi-desert grassland and shrubland (mapping unit 54b). However, we think that the description of this vegetation (as halophytic vegetation in the floodplains of the Pangani River) was given in White's treatment of halophytic vegetation (White 1983 p. 267; see above). Since the description was given regionally as halophytic vegetation, we also mapped these areas in Tanzania as halophytic vegetation - and thereby also excluded the mapping of semi-desert vegetation from Tanzania.

In Zambia, Fanshawe (1971 p. 62) lists "alkaline swamp" under the general description of mainly edaphic grasslands (original mapping unit 17; freshwater swamp is given the same treatment in Zambia). Fanshawe gives a very similar description as given by White (1983) (based on Vesey-Fitzgerald 1963) for the beach zone, alkaline swamp and alkaline flat of Lake Rukwa (see above), with the exception that in Zambia *Sporobolus consimilis* is the grass species occurring on the beach zone.

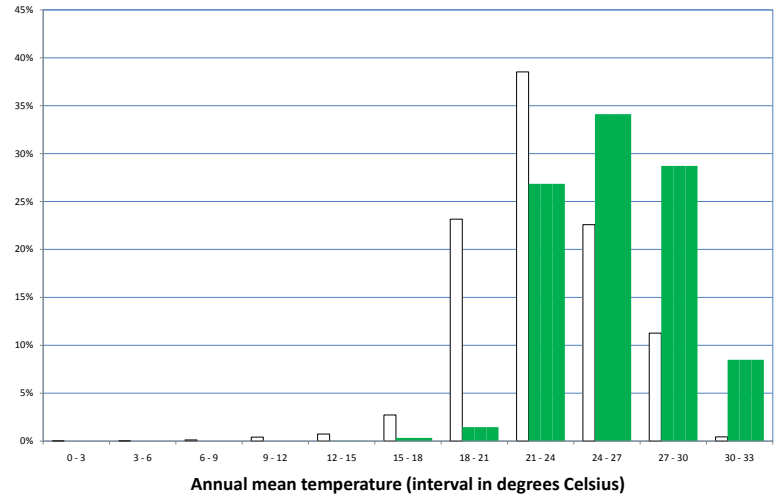
Investigation of environmental distribution of halophytic vegetation in the VECEA region (Figure 11.9; limits are for areas of the VECEA map where this vegetation type is not mapped as mosaic) shows that more than 95% of the samples occur below 1250 m. There is considerable overlap with the altitudinal range of freshwater swamps (X) as this vegetation type has 76.1% of samples in this altitude interval. However, only halophytic vegetation occurs below sea level (6.5% of samples) among these two types. The rainfall interval of 200 – 400 mm contained the highest number of samples (27.6%); this is well above the rainfall interval of 800 – 1000 mm that contained the highest number of samples of freshwater swamp (33.0%). Despite of this situation, there is still considerable overlap in rainfall for both these types.

8: Friis *et al.* (2010 p. 148) mention that *Suaeda monoica* is the only woody species that occurs in "salt-water lakes, salt-lake shores, marsh and pan vegetation" (original mapping unit SLV). In Ethiopia, *Suaeda monoica* also occurs in "desert and semi-desert scrubland" (original mapping unit DSS, mapped in VECEA as semi-desert vegetation [S]) and "*Acacia-Commiphora* woodland and bushland" (original mapping unit ACB, mapped in VECEA as deciduous bushland [Bd]).

(b)



(c)



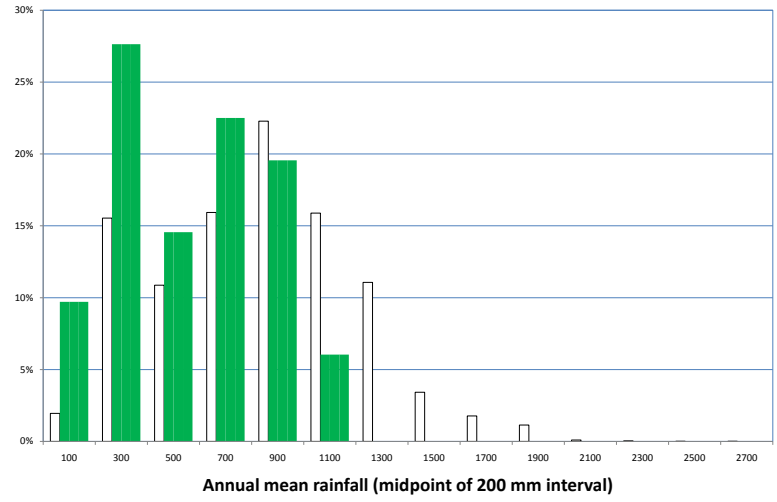


Figure 11.9. Histograms of the distribution of altitude (a), mean annual temperature (b) and mean annual rainfall (c). Bars at the centre of each interval show the percentage of samples within Halophytic vegetation (Z, *n* = 2,946). Bars on the left (open) show the overall percentage of samples (*n* = 740,047).

11.3. Species composition

Species assemblages were obtained from the following references:

- Ethiopia: Friis *et al.* 2010. Species mentioned in Appendix 3 for "Salt pans, saline-brackish and intermittent wetlands and salt-lake shore vegetation" [FLV - SSS] were coded "x" (unless they were characteristic species).
- Kenya: Species that were expected to occur in halophytic vegetation based on information from Beentje (1994), the Flora of Tropical East Africa and field experience from our Kenyan collaborator (F. Gachathi) were coded "x".
- Tanzania (columns "ZlT" and "ZaT"): White (1983 p. 267). Species mentioned to occur around saline lakes in East Africa were coded "C" in column "Zlt". In another column "Zat", species listed for other types of halophytic vegetation (typically occurring on alkaline soils) in Tanzania was coded "x".
- Zambia: Fanshawe (1971). All species listed for the description of "alkaline swamps" were coded "C".

Characteristic species were determined as:

- Ethiopia: Those species that were mentioned in the description of the vegetation type in the main text were coded "C".
- Kenya: Species listed for "shrubland to grassland on saline soils" in Volume II.1 (Marsabit District) of the Range Management Handbook of Kenya (Schwartz *et al.* 1991 p. 38) were coded "C".
- Tanzania: All species were assumed to be characteristic species and were coded "C". However, *Acacia xanthophloea* was not included as a characteristic species since this species may not be able to tolerate large concentrations of Sodium (see above).
- Zambia: All species were assumed to be characteristic.

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

Table 11. Species composition of halophytic vegetation (Z)

Species	Regional status (see section 2.3)	(Ethiopia)	(Kenya)	ZIT (Tanzania subtype)	ZaT (Tanzania subtype)	(Zambia)
Acacia xanthophloea	not characteristic (flood plain of the Pangani river, possibly in a cyclical cycle with *Suaeda monoica* as the species does not tolerate high levels of soluble salts in the rooting horizon)		f	f	x	
Azima tetracantha	not characteristic (characteristic for Lake Victoria evergreen and semi-evergreen bushland and thicket)		x	f	f	f
Cyperus laevigatus	chief plants around saline lakes in Kenya and Uganda		f	C	f	
Drake-brockmania somalensis	halophytic grass that grows near the outlets at the edge of the Chalbi desert		C			
Kanahia laniflora		f	x			
Leptadenia hastata		f	x			
Leptochloa fusca	alkaline swamp in the Lake Rukwa basin; Wembere depression south of Lake Eyasi (grass)		f	C	f	C
Odyssea jaegeri	alkaline flats around Lake Rukwa (grass)					C
Pemphis acidula			x	f	f	
Salsola dendroides			C			
Salvadora persica	prominent halophyte in flood plain of the Pangani river	f	f	f	C	f
Sesbania sesban	flood plain of the Pangani river	f	x	f	C	f
Sporobolus robustus	beach zone on fringe of Lake Rukwa; prominent halophyte in the flood plain of the Pangani river (grass)				C	
Sporobolus spicatus	chief plants around saline lakes in Kenya and Uganda; alkaline flats around Lake Rukwa (grass)		C	C	f	C
Suaeda monoica	prominent halophyte in flood plain of the Pangani river; replaces *Acacia xanthophloea* when the water table rises; also in semi-desert dwarf shrubland	C	C	f	C	
Triplocephalum holstii	prominent halophyte in flood plain of the Pangani river		f	f	C	

12. Edaphic grassland on drainage-impeded or seasonally flooded soils (edaphic vegetation type, g)

12.1. Description

White (1983)did not strictly apply a differentiation between edaphic wooded grassland (with cover percentages of 10 - 40% woody species) and edaphic grassland (with cover percentages of <10% woody species) since both types intergrade and edaphic wooded grasslands are often difficult to delimit from the more open grasslands with which they are associated (White 1983 pp. 50 - 52). **Within the VECEA map, we loosely [9] defined "edaphic wooded grassland" as "edaphic grassland with scattered woody species" and "edaphic grassland" as "edaphic grassland without scattered woody species". This means that some vegetation types that would have been classified as "edaphic grasslands" in a strict physiognomic classification system (*i.e.* woody cover < 10%) may have been allocated to "edaphic wooded grasslands".**

The most widespread edaphic grasslands are those associated with seasonally or permanently waterlogged soils. They are limited in areas with short or no dry seasons (such as the Guineo-Congolian floristic region), but are widespread in regions which experience strongly seasonal rainfall (such as the Indian Ocean coastal belt and the Somalia-Masai, Sudanian and Zambezian floristic regions). Waterlogged soils usually occur in depressions which receive more water than is supplied by incident rainfall, but sometimes parent material has an overriding effect such as on edaphic grasslands that occur on volcanic soils (mapped as a distinct VECEA subtype [gv]; White 1983 p. 51). Alkaline grasslands that occur in basins are considered to be halophytic vegetation (mapped separately in VECEA as Z; White 1983 p. 100).

Although White (1983) described edaphic grasslands and wooded grasslands separately for the various floristic regions, we did not apply a floristic classification system to edaphic grasslands and edaphic wooded grasslands in the VECEA map.

Zambezian edaphic grassland [10] is widespread and occurs principally in four habitats: (i) seasonally waterlogged depressions on the Central African Plateau that are covered with edaphic grassland ("dambos"); (ii) flood plains of rivers and basins with internal drainage; (iii) Kalahari Sand of low relief; and (iv) sandy edges of dambos (White 1983 pp. 99 - 101):

Dambo grassland occurs above 1200 m and where there is seasonal flooding (some parts remain boggy throughout the year). The vegetation is usually a medium-dense grass mat of rather uniform appearance and height (50 to 100 cm with flowering culms of 1 to 2 m). ***Loudetia simplex*** is the most

9: among the exceptions that we made to the general rule, we did not include suffrutex grassland among wooded grassland types and neither did we include edaphic grassland on volcanic soils (gv) among wooded grassland types (although scattered *Acacia mellifera* may occur).

10: edaphic grasslands were studied in detail in several places because swarms of red locusts (*Nomadacris septemfasciata)* only originate from certain edaphic grassland areas. Four recognized major outbreak areas of the red locust are the Mweru-wa-Ntipa depression in Zambia and the Rukwa valley, the Malagarasi drainage basin and the Wembere depression in Tanzania (Vesey-Fitzgerald 1963).

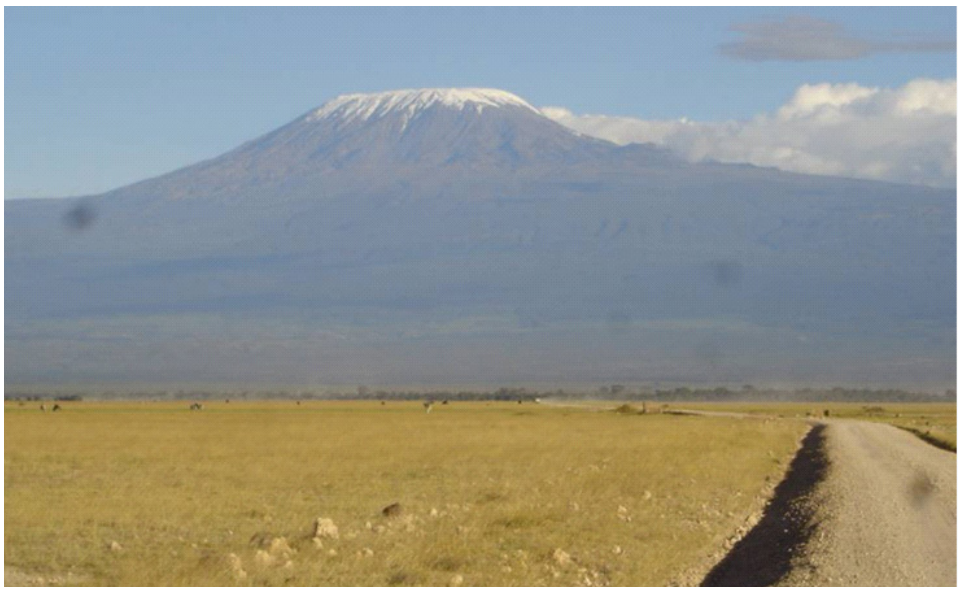


Figure 12.1Edaphic grassland in Amboseli National Park (Kenya). Photograph by F. Gachathi (2008).

Figure 12.2 A typical dambo near Mbala (Zambia) with its centre of open grassland and fringe of small trees. In the background, Miombo woodland (Wm) with *Brachystegia microphylla* (a species virtually confined to rocky hills and escarpments, White 1983 p. 93). Burtt *et al.* (1942 p. 79) comment that "a dambo often gives the impression of a wide road through the general monotony of the *Brachystegia* forest" (i.e. miombo woodland [Wm]). Burtt *et al*. (1942, Photograph 7). Image obtained from URL: *http://www.jstor.org/stable/2256690*.

Figure 12.3 The "rain pond catena" in Tanzania was classified by the VECEA project as a catena of Somalia-Masai *Acacia-Commiphora* deciduous bushland and thicket (Bdd) / edaphic grassland on drainage-impeded or seasonally flooded soils (g). Although the water-receiving depressions are typically treeless grasslands, usually they are separated from deciduous bushland (Bd) by an ecotone of wooded grassland that is dominated by gall *Acacias* (especially *A. drepanolium, A. seyal, A. malacocephala* and *A. pseudofistula*; White 1983 p. 116; see also Gillman 1949 p. 29). Gillman (1949, Fig 30; this is one of the photographs that was cited by White (1983 p. 116) for Somalia-Masai edaphic grassland).

characteristic grass species and is dominant over large areas (White 1983 pp. 99 - 100).

Flood-plain grassland occurs in the valleys of larger rivers where erosion has covered the valley floors with alluvium (mostly heavy clay) and where seasonal rainfall results in seasonal waterlogging. These valleys are covered with a complex and constantly changing mosaic of edaphic grassland, permanent swamp vegetation (X) and termite-mound thickets ("bush groups", see termitary vegetation [T]), which makes it very difficult to impossible to map these types separately. Floodplain grasslands can be subdivided into wetter types and better-drained types. The most extensive areas of floodplain grasslands of the Zambezian region occur in the Lake Chilwa basin of Malawi, the Malagarasi and Rukwa valleys of Tanzania, the Bangweulu and Mweru Wantipa basins of Zambia and the Chambeshi, Kafue and Upper Zambezi valleys of Zambia (White 1983 p. 100).

Kalahari suffrutex grassland is a short wiry grassland that occurs on oligotrophic Kalahari Sand that is seasonally waterlogged. Trees are virtually absent and have been replaced by rhizomatous geoxylic suffrutices that are usually less than 0.6 m tall. At least under the present conditions, their stems are burnt back to ground level every year. The underground parts are usually of massive proportions and greatly exceed the phytomass of grasses, so these communities can be described as "underground forests" although above-ground they look like grasslands most of the year. Most of the suffrutex species are closely related to forest or woodland tree or liana species. The most abundant suffrutex is ***Parinari capensis*** and the most widespread dominant grasses are ***Loudetia simplex*** and ***Monocymbium ceresiiforme*** (White 1983 pp. 100 - 101). Widely distributed suffrutices described by Fanshawe (1971 p. 45) to occur in catenary regression stages of Kalahari woodlands include *Annona stenophylla, Chamaeclitandra henriqesiana, Diospyros chamaethamnus, Diospyros virgata, Gardenia brachythamnus, Lannea edulis, Leptactina benguelensis, Napoleonaea gossweilleri,* ***Parinari capensis***, *Pygmaeothamnus zeyheri, Strobilanthopsis linifolia* and *Strychnos gossweileri.*

Most of the dambos are fringed by a narrow zone of sparse wiry grassland with abundant geoxylic suffrutices that are similar to Kalahari suffrutex grassland (White 1983 pp. 100 - 101). Fanshawe (1971 p. 52) describes suffrutex wooded grassland that occurs within a catenary sequence from Undifferentiated woodland (Wn) to grassland. Common suffrutices include *Annona stenophylla, Astripomoea malvacea, Brackenridgea arenaria*, *Combretum platypetalum, Cryptosepalum maraviense, Duosperma crenatum, Eriosema englerianum, Fadogia homblei, Gnidia kraussiana, Hibiscus rhodanthus, Ipomoea vernalis, Lannea edulis, Litogyne gariepina,* ***Parinari capensis*** and *Pygmaeothamnus zeyheri.*

Edaphic grassland in the Somalia-Masai floristic region was classified as edaphic wooded grassland, although treeless plains dominated by *Chrysopogon plumulosus* were described to occur in Somalia within deciduous bushland (Bd) and water-receiving depressions with black and cracking clays in Central Tanzania are treeless (but they are separated by an ecotone of wooded grassland, however; see edaphic wooded grassland [we]; White 1983 p. 116).

Edaphic grassland that occurs on volcanic soils is mapped and described as a distinct subtype (mapping unit gv; see below).

Edaphic grassland of the Zanzibar-Inhambane region was described as a edaphic wooded grassland (we) since woody trees occur (although widely scattered; these areas also contain thicket-covered termite mounts [mapping unit T]; White 1983 p. 189).

In most Sudanian edaphic grasslands there is an admixture of woody plants (White 1983 p. 107). Edaphic grasslands were not described by White (1983) for the Afromontane floristic region, although he stated that "there are undoubtedly small areas of edaphic grassland" (White 1983 p. 168). No mention is made of edaphic grasslands for the Lake Victoria regional mosaic.

12.2. VECEA region

Within the VECEA region, edaphic grassland on drainage-impeded or seasonally flooded soils occurs in all countries (Figure 12.4, see also Volume 6), although we did not find a description for Rwanda.

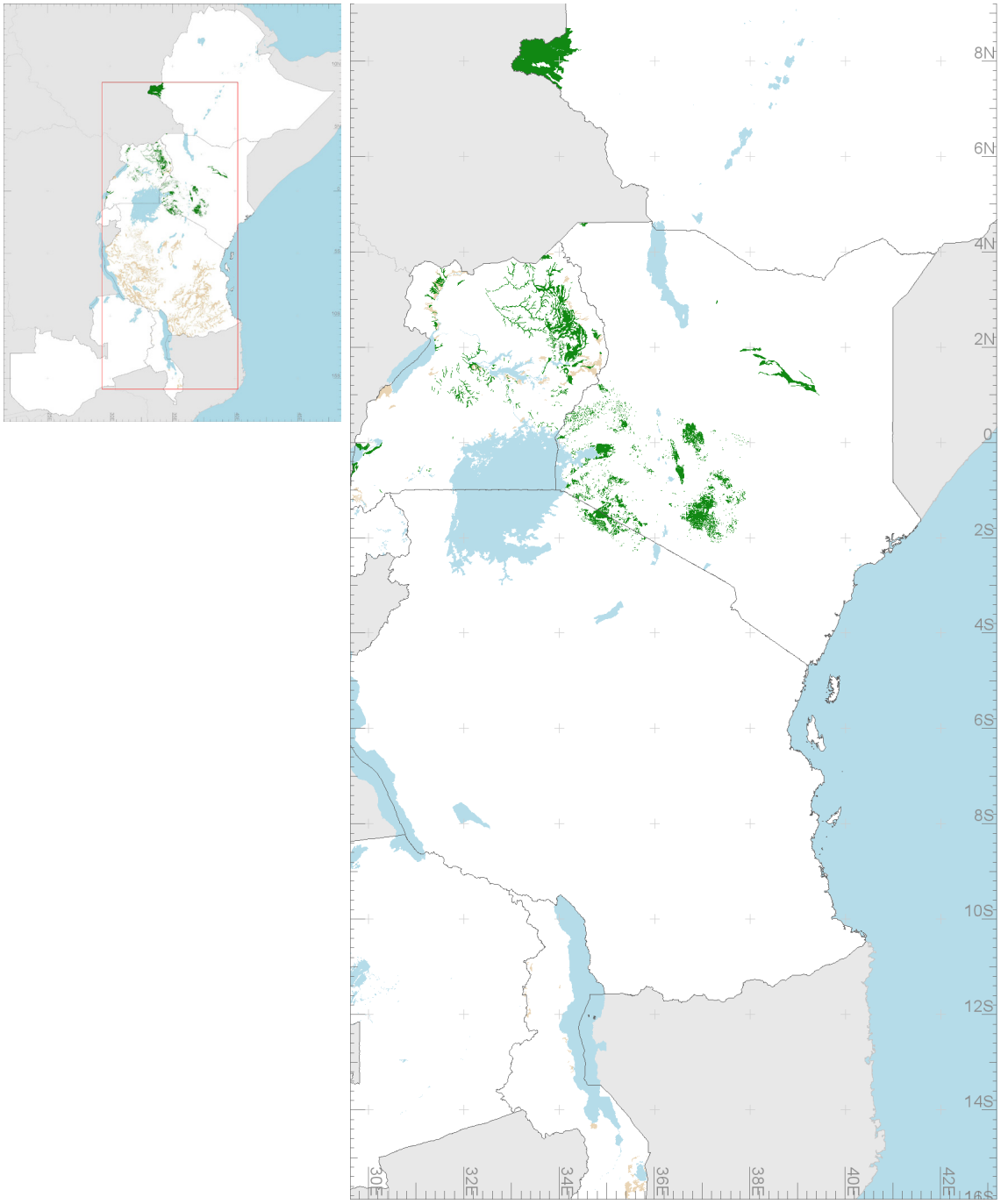


Figure 12.4. Mapped distribution of edaphic grassland on drainage-impeded or seasonally flooded soils in the VECEA region (Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda and Zambia). The subtype of edaphic grassland on volcanic soils was excluded (see Figure 13.3). Where this vegetation type does not occur in mosaic, it is depicted by green polygons. This vegetation type is also mapped as part of different vegetation mosaics (shown in greyish-brown). In Tanzania, this vegetation type often occurs in mosaic with Undifferentiated woodland (Wn) in miombo woodland – Undifferentiated woodland – edaphic grassland catenas. This vegetation type most likely has a wider distribution than depicted here.

In Ethiopia, edaphic grassland on drainage-impeded or seasonally flooded soils was described to occur on areas with black cotton soils that may be flooded during rainy seasons. These areas without trees occur in mosaic with forests and Evergreen bushlands (within the Dry Afromontane Forest and grassland complex [DAF]). No information on species composition was provided (Friis *et al.* 2010 p. 81).

In Kenya, edaphic grassland on drainage-impeded or seasonally flooded soils corresponds to areas that were mapped by Trapnell *et al.* (1966, 1969, 1976, 1986) as the following edaphic grassland types: 8 (grassland and clump grasslands - undifferentiated vlei and drainage-line types), 8a (evergreen clump grassland on vlei soils), 8b (clump grassland with *Acacia gerrardii*), 47 (open grassland areas on clay plains - *Themeda* and *Themeda - Pennisetum* grasslands) and 56A (open grassland areas on clay plains - *Hyparrhenia - Pennisetum catabasis*).

In the Range Management Handbook of Kenya (RMHK; Schwartz *et al.* 1991; Shaabani *et al.* 1992abc; Herlocker *et al.* 1993, Herlocker *et al.* 1994abcd), one of the mapping units was "seasonally flooded grassland [and permanent] swamp" (mapping unit 29, see description for fresh-water swamp [X]). The RMHK further contained the physiognomic vegetation types of "grassland" and "annual grassland". Based on descriptions and map positions, we reclassified mapping units 27.10 (*Panicum - Sporobolus* [perennial] grassland; Turkana district) and 28.2 (*Aristida* annual grassland; Isiolo district; although the original documentation mentioned that this vegetation type was not flooded during the rains, we expected that its landscape position reflected an edaphic grassland type [11]) as edaphic grassland on drainage-impeded or seasonally flooded soils.

In Malawi, edaphic grassland areas consist mainly of floodplain grassland and dambo grasslands. The latter occur in local depresssions and shallow valley of Malawi's plateaux and are extremely numerous and intricately dispersed. They possibly form the most extensive and important grasslands of Malawi (C. Dudley, personal observations).

In Rwanda, we mapped edaphic grassland on drainage-impeded or seasonally flooded soils together with freshwater swamp in vegetation mosaics that are mapped as "g/X" (see Volume 6).

In Tanzania, Gillman (1949 p. 18) employed different mapping units for "valley grassland" and "ridge and slope grassland", using the criterion that "valley grasslands" are due to seasonal flooding and "ridge and slope grasslands" are not. The Central African Rail Link Development Survey (CARLDS 1952 p. 63) followed Gillman's classification system, using mapping symbol "Na" for valley grassland. They mentioned that this vegetation type comprises the seasonally inundated "mbuga" grasslands on dark, poorly-drained calcareous or non-calcareous clays. They are mainly devoid of trees except for small areas of *Acacia seyal* in more deeply flooded depressions within the grassland or *Acacia kirkii* on the grassland fringe. Gillman (1949 Fig. 30 p. 27) includes a photograph of the "valley grassland" to

11: an additional argument in favour of the classification of edaphic grassland is that the polygon corresponds with an area that is mapped as freshwater marsh or floodplain in the global wetland database (P. van Breugel)

which White (1983 p. 116) refers as one of the photographs for Somalia-Masai edaphic grassland.

In Uganda, edaphic grassland on drainage-impeded or seasonally flooded soils was originally mapped and described as "*Brachiaria - Hyparrhenia* grassland on soils with impeded drainage"; "*Echinochloa* grassland on soils with impeded drainage"; and "*Sorghastrum* grassland on soils with impeded drainage")

For Zambia, Fanshawe (1971 pp. 60 - 62) distinguishes between head water valley grassland, bogs (secondary formations that replaced the original swamp forests), riverine grasslands, flood plain grassland, pans (depressions that flood during the rains and dry out early in the dry season) and lake shore grasslands - and also includes descriptions of fresh water swamps (that remain flooded throughout the dry season) and alkaline swamps (shallow brackish lakes which periodically dry up completely) in his general treatment of Zambian "grasslands". In this country, edaphic grassland on drainage-impeded or seasonally flooded soils was always mapped as vegetation mosaics: (i) mosaics with *Termitaria* (T/g; see Volume 4); (ii) mosaics with Kalahari woodland (Wk/g; see Volume 3); and (iii) mosaics with fresh-water swamp (X/g; see above).

Investigation of environmental distribution of edaphic grassland on drainage-impeded or seasonally flooded soils in the VECEA region (Figure 12.5; limits are for areas of the VECEA map where this vegetation type is not mapped as mosaic) shows that more than 95% of samples occur at altitudes between 0 and 1500 m for this vegetation type. This range is a subset of the altitudinal range for freshwater swamp (X; > 95% of samples occur between 0 and 2000 m in this vegetation type; however, only 6.6% of samples occur between 1500 and 2000 m). The width of the altitudinal ranges agrees with edaphic reasons for the occurrence of both these vegetation types. More than 95% of the samples receive between 200 and 1400 mm annual rainfall for edaphic grassland on drainage-impeded or seasonally flooded soils. This interval is just smaller than the interval of 200 – 1600 m that contains more than 95% of samples for freshwater swamp.

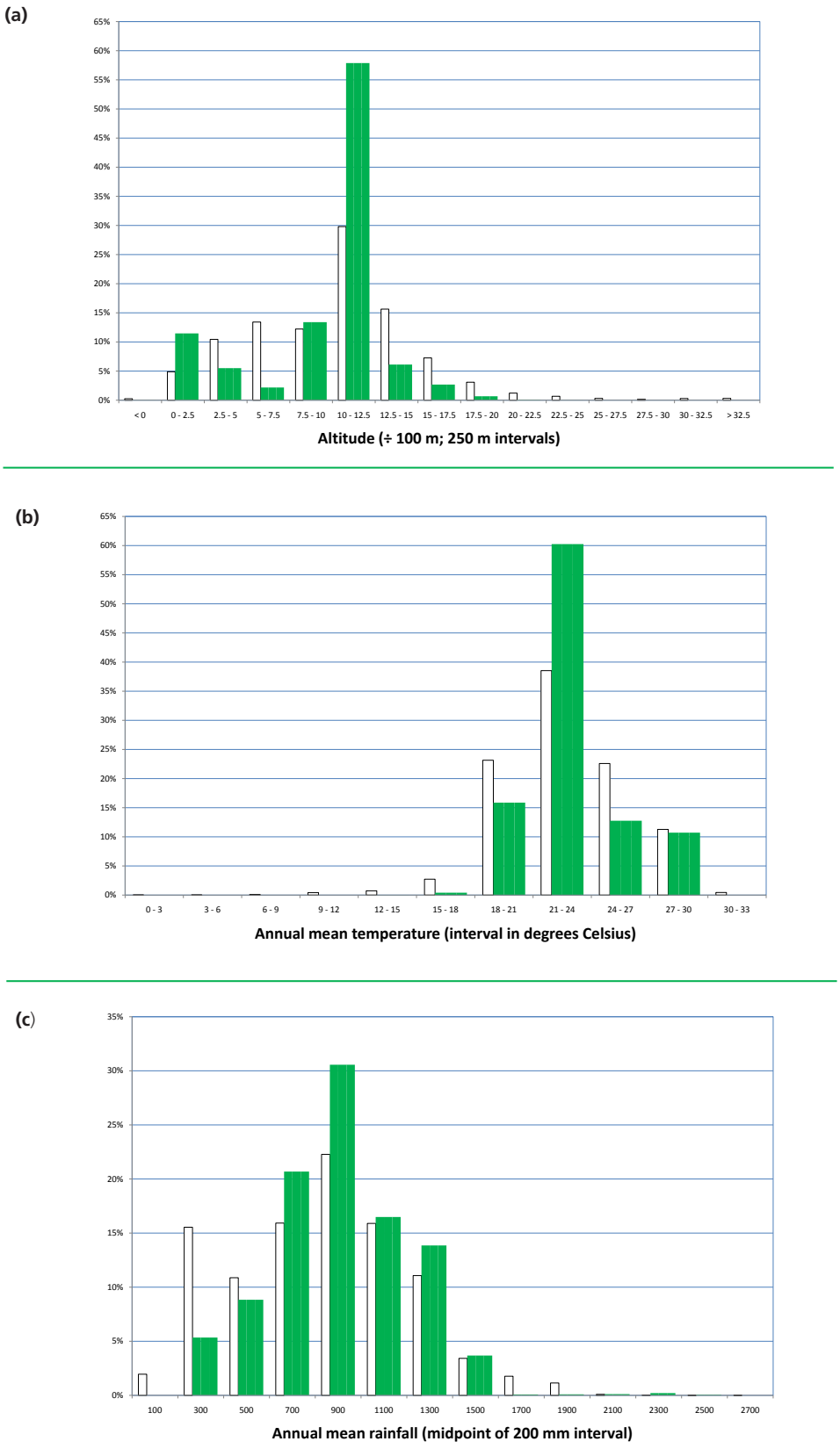


Figure 12.5. Histograms of the distribution of altitude (a), mean annual temperature (b) and mean annual rainfall (c). Bars at the centre of each interval show the percentage of samples within Edaphic grassland on drainage-impeded or seasonally flooded soils (g, *n* = 26,780). Bars on the left (open) show the overall percentage of samples (*n* = 740,047).

12.3. Species composition

Species assemblages were obtained from the following references:

- Kenya: Species associated with the names of mapping units of the Trapnell *et al.* (1966, 1969, 1976, 1986) map were coded "xt". Species listed for the grassland types of the Range Management Handbook of Kenya (RMHK; Schwartz *et al.* 1991; Shaabani *et al.* 1992abc; Herlocker *et al.* 1993, Herlocker *et al.* 1994abcd) that we expected to be mainly under edaphic control (see above) were coded "xn". Grass species listed for the mosaic mapping type from the RMHK of "seasonally flooded grassland (and permanent) swamp" (mapping unit 29; Herlocker *et al.* 1993 [Isiolo District] and Herlocker *et al.* 1994a [Baringo District]) were coded "xm".
- Malawi: Jackson (1969), Jackson and Wiehe (1958) and Howard-Williams (1977). Species listed to occur in "dambo grassland" were coded "xd" (unless they were characteristic species). Species listed to occur in "floodplain grassland" were coded "xp" (unless they were characteristic species).
- Tanzania (columns "gdT" and "gfT"): White (1983 pp. 99 - 100): Grass species that were listed for dambo grassland were coded "C" in column (gdT). In a separate column (gfT), grass species that were listed to occur in flood-plain grassland were coded "C".
- Uganda (columns "gbU", "geU" and "gsU"): Langdale-Brown *et al.* (1964). The dominant species mentioned in the appendix to occur in "*Echinochloa* grassland on soils with impeded drainage" (W1) were coded "x" in column "geU". In a separate column "gsU", the dominant species occurring in "*Sorghastrum* grassland on soils with impeded drainage" (W2) were coded "x". In a third separate column "gbU", the dominant species occurring in "*Brachiaria-Hyparrhenia* grassland on soils with impeded drainage" (W3) were coded "x".
- Zambia: Fanshawe (1971). Species listed for the species composition table for "grasslands" provided on pages 62 to 63 were coded "x". Species listed for fresh water swamp in the main text were coded "y". Species listed for alkaline swamps in the main text were coded "z".

Characteristic species were determined as:

- Kenya: Characteristic species were not determined.
- Malawi: Those species that were mentioned to be dominant were coded as "C".
- Uganda: Those species that were mentioned in the main text were coded as "C".
- Tanzania: Species listed for better-drained Zambezian flood-plain grasslands were coded "Cd". Species listed for wetter types of Zambezian flood-plain grasslands were coded "Cw".
- Zambia: Characteristic species were not determined (since Fanshawe usually listed genera when describing the grassland subtypes).

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 vegetation type in other countries (see section 2.3).

Table 12. Species composition of edaphic grassland on drainage-impeded or seasonally flooded soils (g)

Species	Regional status (see section 2.3)	(Kenya)	(Malawi)	gdT (Tanzania)	gfT (Tanzania)	gbU (Uganda)	geU (Uganda)	gsU (Uganda)	(Zambia)
Acroceras macrum	Zambezian edaphic grassland (wetter types of floodplain grasslands)	f		f	Cw	f	f	f	x
Alloteropsis cimicina	(grass)	f		f	f	f	f	f	x
Andropogon brazzae	Zambezian edaphic grassland (better-drained types of floodplain grasslands)			f	Cd				
Andropogon gayanus	(grass)			f	f	f	f	f	x
Andropogon schirensis	Zambezian edaphic grassland (dambo grasslands, suffrutex grasslands)	f		C	f	f	f	f	x
Aristida adscensionis	Somalia-Masai edaphic grassland (clays plains in Somalia)	xn							
Aristida junciformis	(grass)	f		f	f				x
Aristida stipitata	Zambezian edaphic grassland (suffrutex grasslands)								x
Arundinella nepalensis	(grass)	f		f	f				x
Bothriochloa bladhii	(grass)	f	xp	f	f	f	f	f	x
Bothriochloa radicans	(grass)	f		f	f	f	f	f	x
Brachiaria brizantha	(grass)	f	xp	f	f	f	f	f	x
Brachiaria humidicola	(grass)	f	xd	f	f				x
Brachiaria jubata	(grass)					C	f	f	
Chloris gayana	edaphic grasslands of the Serengeti plains	f	xp	f	f	f	f	f	x
Chloris virgata	(grass)	xn							
Cynodon dactylon	Somalia-Masai edaphic grasslands; edaphic grasslands of the Serengeti plains	xm	xp	f	f	f	f	f	x
Dichanthium annulatum	(grass)	f	xp	f	f				x
Digitaria diagonalis	(grass)	f		f	f	f	f	f	x
Digitaria milanjiana	(grass)	f		f	f	f	f	f	x
Digitaria sanguinalis	(grass)			f	f				x
Dinebra retroflexa	(grass)	f		f	f	f	f	f	x
Echinochloa colona	(grass)								x
Echinochloa crus-galli	(grass)								x
Echinochloa crus-pavonis	(grass)								x

Species	Regional status (see section 2.3)	(Kenya)	(Malawi)	gdT (Tanzania)	gfT (Tanzania)	gbU (Uganda)	geU (Uganda)	gsU (Uganda)	(Zambia)
Echinochloa haploclada	(grass)	xm	f	f	f	f	f	f	x
Echinochloa pyramidalis	Zambezian edaphic grassland (wetter types of floodplain grasslands)	f	xd	f	Cw	f	C	f	x
Echinochloa stagnina	Zambezian edaphic grassland (wetter types of floodplain grasslands)	f		f	Cw	f	f	f	x
Entolasia imbricata	Zambezian edaphic grassland (better-drained types of floodplain grasslands)	f	xd	f	Cd	f	f	f	x
Eragrostis atrovirens	(grass)	f	x	f	f				x
Eragrostis pallens	(grass)								x
Eragrostis plana	(grass)								x
Eriochloa fatmensis	(grass)								x
Eriochloa meyeriana	(grass)	f		f	f	f	f	f	x
Eustachys paspaloides	edaphic grasslands of the Serengeti plains	f		f	f	f	f	f	x
Hemarthria altissima	(grass)			f	f				x
Hyparrhenia bracteata	Zambezian edaphic grassland (dambo grasslands)	f	xp	C	f	f	f	f	x
Hyparrhenia collina	(grass)	f	f	f	f	f	f	f	x
Hyparrhenia cymbaria	(grass)	f		f	f	f	f	f	x
Hyparrhenia diplandra	Zambezian edaphic grassland (dambo grasslands)	f		C	f	f	f	f	x
Hyparrhenia filipendula	(grass)	f	xd	f	f	C	f	f	x
Hyparrhenia newtonii	Zambezian edaphic grassland (dambo grasslands)			C	f	f	f	f	x
Hyparrhenia nyassae	(grass)	f	xd	f	f	f	f	f	x
Hyparrhenia rufa	(grass)	f	xdp	f	f	f	f	C	x
Hyperthelia dissoluta	(grass)	f		f	f	f	f	f	x
Imperata cylindrica	(grass)	f	xd	f	f	f	f	f	x
Ischaemum afrum	(grass)	f	xp	f	f	f	f	f	
Leersia hexandra	Zambezian edaphic grassland (wetter types of floodplain grasslands)	f	xdp	f	Cw	f	C	f	y
Leptochloa fusca	alkaline swamp in the Lake Rukwa basin; Wembere depression south of Lake Eyasi	f	xp	f	f	f	f	f	z
Loudetia kagerensis	(grass)	f		f	f	f	f	C	

Species	Regional status (see section 2.3)	(Kenya)	(Malawi)	gdT (Tanzania)	gfT (Tanzania)	gbU (Uganda)	geU (Uganda)	gsU (Uganda)	(Zambia)
Loudetia simplex	Zambezian edaphic grassland (dambo grasslands, better-drained types of floodplain grasslands, suffrutex grassland)	f	xd	C	Cd	f	f	f	x
Microchloa kunthii	edaphic grasslands of the Serengeti plains	f		f	f	f	f	f	
Miscanthus teretifolius	Zambezian edaphic grassland (dambo grasslands)			C	f				
Monocymbium ceresiiforme	Zambezian edaphic grassland (dambo grasslands, better-drained types of floodplain grasslands, suffrutex grassland)		xd	C	Cd				x
Oryza barthii	(grass)		xp	f	f	f	C	f	
Oryza longistaminata	Zambezian edaphic grassland (wetter types of floodplain grasslands)	f		f	Cw	f	f	f	y
Panicum brazzavillense	(grass)								x
Panicum coloratum	Somalia-Masai edaphic grasslands; edaphic grasslands of the Serengeti plains	xn		f	f	f	f	f	
Panicum dregeanum	(grass)	f		f	f	f	f	f	x
Panicum maximum	(grass)	f		f	f	f	f	f	x
Panicum repens	Zambezian edaphic grassland (wetter types of floodplain grasslands)	f	x	f	Cw	f	f	f	x
Panicum subalbidum	(grass)		x						x
Paspalum scrobiculatum	Zambezian edaphic grassland (wetter types of floodplain grasslands)	f		f	Cw	f	f	f	x
Pennisetum macrourum	(grass)								y
Pennisetum mezianum	edaphic grasslands of the Serengeti plains	xt		f	f	f	f	f	
Pennisetum purpureum	(grass)	f		f	f	f	f	f	x
Phragmites mauritianus	common in silted areas and lakes of volcanic origin in East Africa	f		f	f	f	f	f	y
Rhytachne rottboellioides	(grass)	f		f	f	f	f	f	x
Sacciolepis africana	Zambezian edaphic grassland (wetter types of floodplain grasslands)	f	xp	f	Cw	f	f	f	x
Sacciolepis typhura	(grass)	f	xd	f	f	f	f	f	x
Setaria incrassata	Somalia-Masai edaphic grasslands	f	x	f	f	f	f	f	x
Setaria pumila	(grass)	f		f	f	f	f	f	x
Setaria sphacelata	Zambezian edaphic grassland (better-drained types of floodplain grasslands)	f	x	f	Cd	C	f	C	x
Sorghastrum stipoides	(grass)	f		f	f	f	f	C	
Sorghum arundinaceum	(grass)		xp						x
Sporobolus ioclados	edaphic grasslands of the Serengeti plains	f	xp	f	f	f	f	f	x

Species	Regional status (see section 2.3)	(Kenya)	(Malawi)	gdT (Tanzania)	gfT (Tanzania)	gbU (Uganda)	geU (Uganda)	gsU (Uganda)	(Zambia)
Sporobolus pyramidalis	(grass)	f	xp	f	f	f	f	f	x
Sporobolus sanguineus	(grass)	f		f	f				x
Sporobolus spicatus	chief plants around saline lakes in Kenya and Uganda; alkaline flats around Lake Rukwa	f		f	f	f	f	f	z
Themeda triandra	Somalia-Masai edaphic grasslands; edaphic grasslands of the Serengeti plains; Zambezian edaphic grassland (dambo grasslands, better-drained types of floodplain grasslands)	f	xdp	C	Cd	f	f	f	x
Trachypogon spicatus	Zambezian edaphic grassland (dambo grasslands)	f		C	f	f	f	f	x
Tragus berteronianus	(grass)	xn							
Tristachya superba	(grass)			f	f	f	f	f	x
Vetiveria nigritana	(grass)			f	f				x
Vossia cuspidata	Zambezian edaphic grassland (wetter types of floodplain grasslands)	f		f	Cw	f	f	f	y
Aeschynomene elaphroxylon	(woody)	f	f	f	f	f	x	f	f
Cyperus dives		f		f	f	f	C	f	
Cyperus latifolius						f	C	f	
Cyperus longus		f	Cp	f	f	f	f	f	
Cyperus papyrus	the main constituent of most of the shallower lakes (except those that are strongly saline) outside the Guineo-Congolian region (where swamp forests are more prominent); also in floating mats	x		f	f				y
Fimbristylis dichotoma						f	f	C	
Mimosa pigra	(woody)	f	f	f	f	f	x	f	f

13. Edaphic grassland on volcanic soils (edaphic subtype, gv)

13.1. Description

The grasslands of the Serengeti Plains grow on soils that are derived from volcanic ash. Outside the greater Serengeti region, grasslands occurring on volcanic ash are very restricted in Africa (White 1983 pp. 125 and 126). Huge quantities of fine whitish-grey ash were produced by eruptions around 150,000 years ago by the now extinct Kerimasi volcano (2 52' S, 35 56' E). The ashes fell over a wide area where it resulted in a relatively flat surface over a formerly undulating peneplain. The ash hardened to form grey and light-brown calcareous tuffs and almost continuous layers of calcitic hard-pan layers at successive layers (with the accumulation of lime through downward leaching; White 1983 p. 126).

More than 50 grass species are common among 100 grass species that occur. Different grassland types can be distinguished, including grassland types that are typical of juvenile ash soils (produced by the Oldoinyo Lengai volcano [2 46' S, 35 55' E] that formed after the Kerimasi volcano became extinct) in the drier eastern side of the Serengeti National Park (White 1983 p. 126).

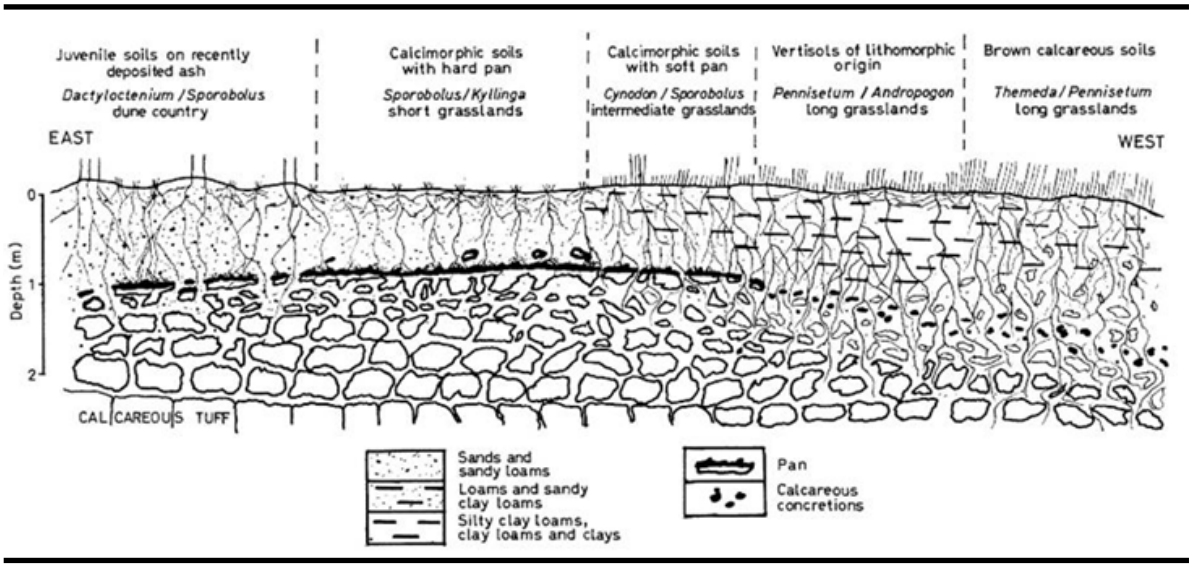


Figure 13.1Profile diagram of the soil – edaphic grassland associations running east to west across the Serengeti Plains. Surface topography is not drawn to scale. White (1983 p. 126) describes that the gradient from the juvenile ash soils in the east to the more mature brown calcareous soils in the west are paralleled by a climatic gradient as annual rainfall gradually increases from the 380 mm in the east to 780 mm in the west. Anderson and Talbot (1965, Figure 2). Image obtained from URL: *http://www.jstor.org/stable/2257564*

Figure 13.2 Edaphic grassland on volcanic soils along the Namanga – Arusha road (Tanzania). Altitude approximately 1700 m. Photograph by H. N. Moshi (2009).

13.2. VECEA region

Within the VECEA region, edaphic grassland on volcanic soils was only mapped for Kenya and Tanzania (Figure 13.3; see also Volume 6).

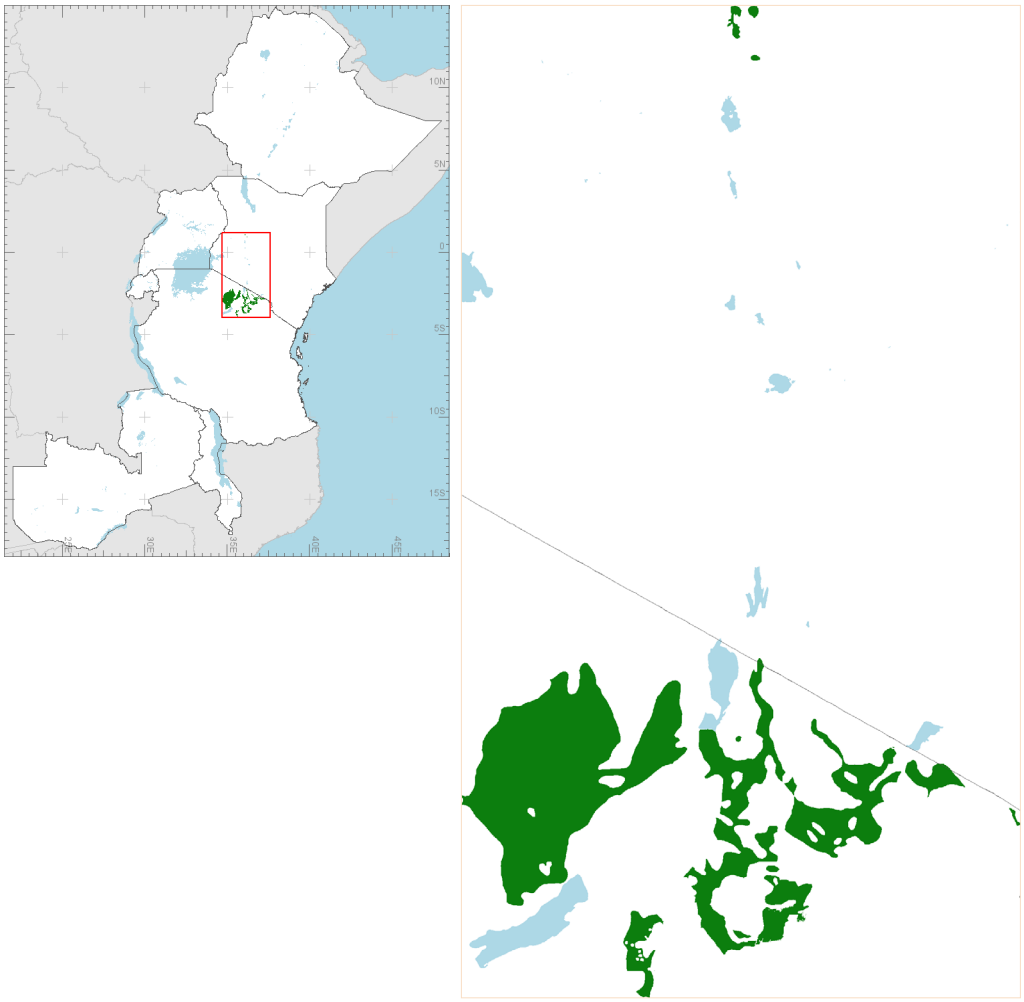


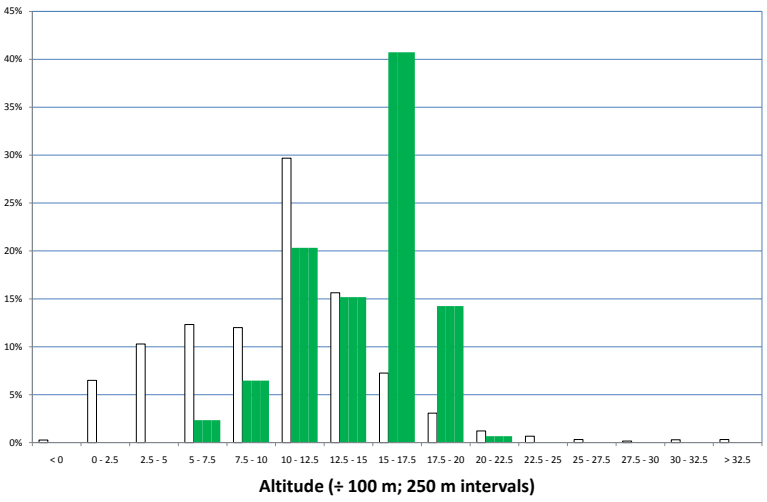
Figure 13.3. Mapped distribution of edaphic grassland on volcanic soils in the VECEA region (Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda and Zambia). Green polygons depict where we mapped this vegetation type

The Tanzanian manifestation of this vegetation type corresponds to the description given in section 13.1 (i.e. the description of this vegetation type for the greater Serengeti ecosystem [White 1983 pp. 125 and 126]).

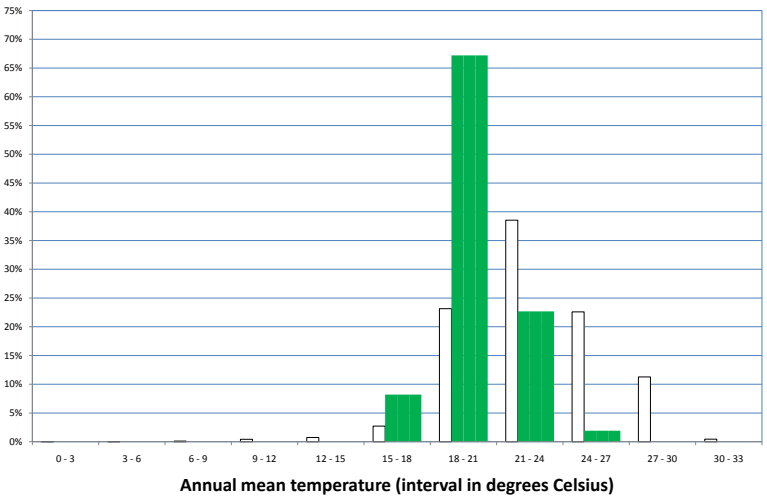
Mapping units 27.5 and 27.6 from the Range Management Handbook of Kenya (RMHK; Schwartz *et al.* 1991; Shaabani *et al.* 1992abc; Herlocker *et al.* 1993, Herlocker *et al.* 1994abcd) are perennial grasslands that occur in Baringo and Turkana districts on recent volcanic soils. The description of mapping unit 27.5 further specifies that "recent volcanic soils support a grassland here where soils more typical of the district would support deciduous shrubland", whereas the description of mapping unit 27.6 mentions that "ordinarily, some type of bushland would be expected to grow here (therefore) the occurrence of grassland is probably associated with recent volcanic soils although periodic burns by grass fires may also be influential" (mapping unit 27.6 was not visited in the field; RMHK Volume II.6 p. 58).

Investigation of environmental distribution of edaphic grassland on volcanic soils in the VECEA region (Figure 13.4) shows that more than 90% of the samples occur in an interval from 1000 – 1800 m. The altitude interval of 1500 – 1750 m contains the highest number of samples (40.8%); this is well above the altitude interval of 1000 – 1250 m that contains the highest number of samples of *Acacia-Commiphora* deciduous wooded grassland (Wd; this is another prominent vegetation type of the Serengeti ecosystem). Edaphic grassland on volcanic soils mainly receives between 400 and 1000 mm rainfall (> 95% of samples). This is a similar rainfall regime as the one that is experienced by most of *Acacia-Commiphora* deciduous wooded grassland areas (93.9% of samples). White (1983 p. 126) mentions that the Serengeti Plains receive from 380 mm in the east to 780 mm in the west, a gradient that also corresponds to a gradient of juveline ash soils in the west and more mature brown calcareous soils in the east.

(a)



(b)



(c)

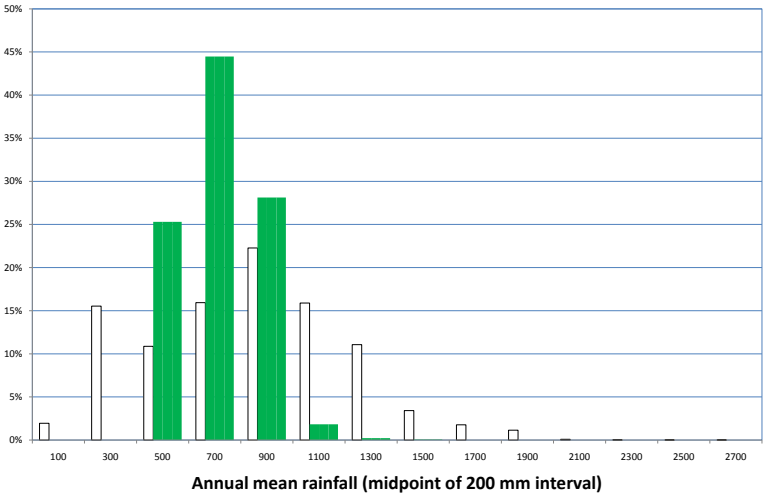


Figure 13.4. Histograms of the distribution of altitude (a), mean annual temperature (b) and mean annual rainfall (c). Bars at the centre of each interval show the percentage of samples within edaphic grassland on volcanic soils (gv, *n* = 3,459). Bars on the left (open) show the overall percentage of samples (*n* = 740,047).

13.3. 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 for original mapping units 27.5 and 27.6 were coded "x".
- Tanzania: White (1983): Those species that were listed for edaphic grasslands of the Serengeti plains were coded "x" (unless they were characteristic species)

Characteristic species were determined as:

- Kenya: characteristic species were not identified
- Tanzania: grass species were coded "C".

Floristic commitments (see section 2.3) were not made.

Table 13. Species composition of edaphic grassland on volcanic soils (subtype of edaphic grassland, gv)

Species	Regional status (see section 2.3)	(Kenya)	(Tanzania)
Andropogon greenwayi	edaphic grasslands of the Serengeti plains		C
Aristida adscensionis	Somalia-Masai Acacia-Commiphora deciduous bushland (ephemeral grass), Somalia-Masai edaphic grassland	x	
Aristida mutabilis	Somalia-Masai semi-desert grassland (dwarf shrublands on sandy alluvial plains near Lake Turkana)	x	
Chloris gayana	edaphic grasslands of the Serengeti plains		C
Cynodon dactylon	Somalia-Masai edaphic grasslands; edaphic grasslands of the Serengeti plains		C
Digitaria macroblephara	edaphic grasslands of the Serengeti plains		C
Enteropogon macrostachyus	(grass)	x	
Eragrostis superba	(grass)	x	
Eragrostis tenuifolia	edaphic grasslands of the Serengeti plains		C
Eustachys paspaloides	edaphic grasslands of the Serengeti plains		C
Heteropogon contortus	(grass)	x	
Indigofera spinosa	Somalia-Masai semi-desert grassland (dwarf shrub species, dwarf shrublands on sandy alluvial plains near Lake Turkana)	x	
Microchloa kunthii	edaphic grasslands of the Serengeti plains		C
Panicum coloratum	Somalia-Masai edaphic grasslands; edaphic grasslands of the Serengeti plains		C
Pennisetum mezianum	edaphic grasslands of the Serengeti plains		C
Pennisetum stramineum	edaphic grasslands of the Serengeti plains		C
Sporobolus ioclados	edaphic grasslands of the Serengeti plains		C
Sporobolus spicatus	Somalia-Masai semi-desert grassland (dwarf shrublands on sandy alluvial plains near Lake Turkana)	x	
Themeda triandra	Somalia-Masai edaphic grasslands; edaphic grasslands of the Serengeti plains; Zambezian edaphic grassland (dambo grasslands, better-drained types of floodplain grasslands)		C
Acacia mellifera	not characteristic (scattered bushes in edaphic grassland of the Serengeti plains, but also a characteristic species of Somalia-Masai Acacia-Commiphora deciduous bushland and thicket		x

14. Vegetation of sands (edaphic type, s)

14.1. Description

This vegetation type was not described in "the vegetation of Africa".

14.2. VECEA region

Within the VECEA region, vegetation of sands was only mapped in Malawi and the coastal areas of Kenya (where it was originally described as "sand dune and beach littoral"; Figure 14.1; see also Volume 6).

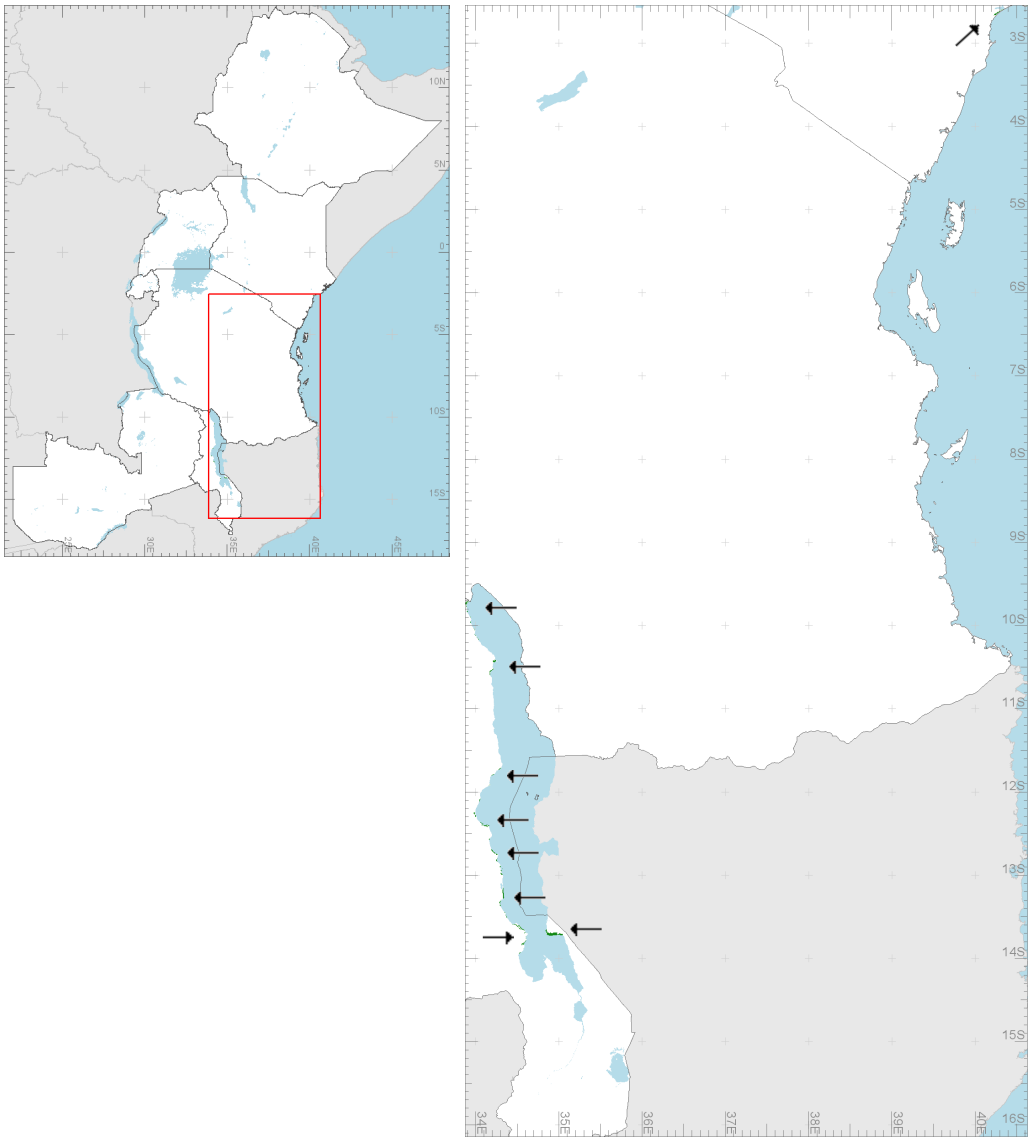


Figure 14.1. Mapped distribution of vegetation of sands in the VECEA region (Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda and Zambia). Arrows indicate where we mapped this vegetation type. Most likely there is a wider distribution along the coast than depicted here.

In Malawi, the areas are probably serial stages in the development of lake shore woodland (mapped in VECEA as Undifferentiated woodland [Wn]). The vegetation of sands vegetation type is extremely localized along the shoreline of Lake Malawi. Once the deposition of sand stops, the areas become stabilized by grasses. Later a woodland consisting principally of ***Terminalia sericea*** (Wt, see volume 3) becomes established (especially in central Malawi), whereas further successional stages lead to Undifferentiated woodland (Wn, see volume 3).

14.3. Species composition

Species assemblages were obtained from the following references:

- Malawi: Brown and Young (1964), Jackson and Wiehe (1958) and Young and Brown (1962). Species listed were coded "x" (unless they were characteristic species).
- Coastal areas of Kenya and Tanzania: Moomaw (1960). Species listed in the text for "Sand dune and beach littoral" (original mapping unit VII) were coded "x".

Characteristic species were determined as:

- Malawi: Those species that were mentioned to be dominant were coded as "C".
- Coastal areas of Kenya and Tanzania: no characteristic species were identified

Table 14. Species composition of vegetation of sands (edaphic type, s)

Species	**regional status** (see section 2.3)	(Malawi)	(coast)
Cadaba farinosa	*Acacia-Commiphora* deciduous bushland		x
Flacourtia indica	characteristic species in Zanzibar-Inhambane secondary grassland and wooded grassland	f	x
Garcinia livingstonei	characteristic species in Somalia-Masai riparian forest	f	x
Parinari curatellifolia	characteristic species in miombo woodland, Chipya woodland and Kalahari woodland	C	f
Salvadora persica	*Acacia-Commiphora* deciduous bushland, halophytic vegetation	f	x
Sterculia africana	*Acacia-Commiphora* deciduous bushland	f	x
Terminalia sericea	characteristic species in miombo woodland, north Zambezian undifferentiated woodland, chipya woodland and Kalahari woodland	C	

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Appendices

Appendix 1. Information on useful tree species

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

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

Species	Ethiopia	Kenya	Malawi	Rwanda	Tanzania	Uganda	Zambia
Acacia abyssinica	x	x	f	x	f	x	
Acacia bussei	x	f			f		
Acacia drepanolobium	f	x			f	f	
Acacia elatior		x				f	
Acacia gerrardii	f	x	f	x	f	x	f
Acacia hockii	f	f	f	x	x	x	f
Acacia mellifera	f	x			x	x	f
Acacia nilotica	x	x	f		x	x	f
Acacia oerfota	x	f			f	f	
Acacia polyacantha	x	x	x	x	x	f	x
Acacia senegal	x	x		x	x	x	f
Acacia seyal	x	x	f		x	x	f
Acacia tortilis	x	x			x	x	f
Acacia xanthophloea		x	f		x		
Adenium obesum	f	x				x	
Agauria salicifolia	f	f	f	x	w	f	f
Albizia adianthifolia		f	f	x	f	x	x
Albizia gummifera	x	f	x	x	x	x	
Allophylus abyssinicus	x	f	f	f	f	x	w
Allophylus africanus	f	f	f	x	f	f	f
Anthocleista grandiflora		f	x	x	f	f	
Avicennia marina	w	x			f		
Balanites aegyptiaca	x	x		f	x	x	x
Balanites rotundifolia	f	x				x	
Berberis holstii	x	f	f		f	f	
Bersama abyssinica	x	x	f	x	x	x	f
Boscia angustifolia	f	f	w	x	f	f	w
Boscia coriacea	f	x			f	f	
Boswellia rivae	x	f					
Bridelia micrantha	x	x	x	x	x	x	x

Species	Ethiopia	Kenya	Malawi	Rwanda	Tanzania	Uganda	Zambia
Bruguiera gymnorhiza		x			f		
Cadaba farinosa	w	x		f	x	f	
Calotropis procera	x	f			f	f	
Cassipourea ruwensoriensis	w	f		x	f	f	
Combretum aculeatum	x	x			f	f	
Commiphora africana	x	x	f	x	x	x	x
Commiphora erythraea	x						
Commiphora habessinica	x	f		f	f	f	f
Commiphora myrrha	f	x					
Cordeauxia edulis	x	x					
Cordia sinensis	f	x			x	x	f
Cordyla africana		x	x		x		x
Cornus volkensii		x	f	x	f	f	
Crotalaria agatiflora	f	x	f	f	f	f	
Croton macrostachyus	x	x	f	f	x	x	f
Delonix elata	f	x		x	f	f	f
Dichrostachys cinerea	x	x	x	x	x	x	x
Discopodium penninervium	x	f	f	f	f	x	
Dobera glabra	x	x				f	
Dodonaea viscosa	x	x	f	x	x	x	f
Dombeya torrida	x	x	w	x	f	x	
Dovyalis abyssinica	x	x	w		f	x	
Dovyalis macrocalyx		x	f	f	f	x	f
Ehretia cymosa	x	x	f	f		x	
Ekebergia capensis	x	x	f	x	x	x	f
Embelia schimperi	x	x	f	f	f	f	f
Erica arborea	x	f		f	f	f	
Erythrina abyssinica	x	x	x	x	x	x	x
Euclea divinorum	f	x	f	f	x	f	f
Faurea saligna		x	x	x	f	x	x
Ficalhoa laurifolia			f	x	f	x	f
Flacourtia indica	x	x	f	x	x	x	x
Galiniera saxifraga	x	f	w	x	f	f	
Garcinia livingstonei	f	x	f		x	f	f
Grewia similis	f	f		x	x	f	
Grewia tenax	f	x			f	f	
Hagenia abyssinica	x	x	f	x	x	x	f
Hibiscus diversifolius	f	f	f	x	f	f	f
Hypericum revolutum	x	f	f	x	f	f	f
Hyphaene thebaica	x						
Ilex mitis	x	x	f	x	f	x	f
Juniperus procera	x	x	x		x	x	
Lannea triphylla	f	x			f	f	
Lawsonia inermis	x	x			x	f	
Lepidotrichilia volkensii	x	f	f	f	f	f	w
Leptadenia hastata	f	x					
Macaranga capensis	f	x	f	x	f	x	f
Maesa lanceolata	x	f	x	x	f	x	f
Maytenus acuminata		f	f	x	f	f	f

Species	Ethiopia	Kenya	Malawi	Rwanda	Tanzania	Uganda	Zambia
Maytenus undata	f	f	f	f	f	x	f
Myrsine africana	f	x	f	f	f	f	f
Neoboutonia macrocalyx		f	f	x	f	x	f
Nuxia congesta	x	x	x	x	f	x	f
Nuxia floribunda		f	f	x	f	f	f
Oreobambos buchwaldii		f	x		f	f	f
Oxytenanthera abyssinica	x		x		x	x	x
Parinari curatellifolia		x	x	x	x	x	x
Parkinsonia aculeata	x	x			x	x	
Pavetta oliveriana	x	f		f	f	f	
Peddiea fischeri		f		x	f	x	
Phoenix reclinata	x	x	w	x	x	x	x
Phytolacca dodecandra	x	f	f	f	f	x	f
Pittosporum viridiflorum	x	f	f	f	f	x	f
Podocarpus latifolius		x	x	x	x	x	f
Polyscias fulva	x	x	f	x	x	x	f
Pouteria adolfi-friedericii	x	x	f	f	f	x	f
Pouteria altissima	x	f		f	f	x	f
Prunus africana	x	x	x	x	x	x	f
Pseudospondias microcarpa		f		f	f	x	f
Psychotria mahonii		f	f	x	f	f	f
Rapanea melanophloeos	f	f	f	x	f	x	f
Raphia farinifera		x	x		f	x	
Rhamnus prinoides	x	f	f	x	f	f	f
Rhizophora mucronata	w	x			f		
Rhus natalensis	x	x	f	x	f	f	f
Rhus vulgaris	x	x	f	f	f	f	f
Rubus apetalus	f	x	f	f	f	f	f
Rubus volkensii	f	x			f	f	
Salvadora persica	x	x	f		x	f	f
Sambucus ebulus		f			f	x	
Schefflera volkensii	f	f			f	x	
Scutia myrtina	f	x	f	x	f	f	f
Senna alexandrina	x	f					
Senna didymobotrya	x	f	f	x	f	x	f
Sesbania bispinosa		x			f		
Sesbania macrantha		f	f	f	f	f	x
Sesbania sesban	x	x	f	x	x	x	x
Sinarundinaria alpina	x	x	x	x	f	x	
Solanecio mannii	f	x	w	f	f	x	w
Sterculia africana	x	x	f		x		x
Syzygium cordatum		x	x	f	x	x	x
Syzygium guineense	x	x	x	x	x	x	x
Tabernaemontana stapfiana		f	f	x	f	f	
Tamarindus indica	x	x	x		x	x	x
Tamarix aphylla	x	f					
Tamarix nilotica	f	x			f		
Terminalia sericea			x		x		x

Species	Ethiopia	Kenya	Malawi	Rwanda	Tanzania	Uganda	Zambia
Vangueria apiculata	f	x	f	x	f	f	f
Voacanga thouarsii		f	f			x	f
Xymalos monospora		f	x	x	f	f	
Zanthoxylum usambarense	f	x		f	f		
Ziziphus spina-christi	x	f			f	f	

Appendix 2. Information on synonyms

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

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

Synonym	Species in VECEA
Acacia brichettiana	*Acacia edgeworthii*
Acacia nubica	*Acacia oerfota*
Acacia oliveri	*Acacia senegal*
Aerva persica	*Aerva javanica*
Afrocrania volkensii	*Cornus volkensii*
Agarista salicifolia	*Agauria salicifolia*
Albizia fastigiata	*Albizia adianthifolia*
Andropogon ravus	*Andropogon schirensis*
Aningeria adolfi-friedericii	*Pouteria adolfi-friedericii*
Aningeria altissima	*Pouteria altissima*
Anthocleista zambesiaca	*Anthocleista grandiflora*
Arundinaria alpina	*Sinarundinaria alpina*
Asparagus asiaticus	*Asparagus africanus*
Asthenatherum glaucum	*Centropodia glauca*
Balanites orbicularis	*Balanites rotundifolia*
Boscia patens	*Boscia angustifolia*
Bothriochloa glabra	*Bothriochloa bladhii*
Brachiaria soluta	*Brachiaria jubata*
Canthium gueinzii	*Keetia gueinzii*
Cassia didymobotrya	*Senna didymobotrya*
Cephaelis peduncularis	*Psychotria peduncularis*
Chrysopogon aucheri	*Chrysopogon plumulosus*
Commiphora coronillifolia	*Commiphora gileadensis*
Commiphora flaviflora	*Commiphora kua*
Commiphora gowlello	*Commiphora kua*
Commiphora madagascariensis	*Commiphora habessinica*
Commiphora subsessilifolia	*Commiphora kua*
Commiphora terebinthina	*Commiphora samharensis*
Commiphora tubuk	*Commiphora africana*
Cordia rothii	*Cordia sinensis*
Crassocephalum mannii	*Solanecio mannii*
Cynanchum lennewtonii	*Cynanchum gerrardii*
Cyperus immensus	*Cyperus dives*
Dendrosenecio amblyphyllus	*Dendrosenecio elgonensis*
Dichanthium papillosum	*Dichanthium annulatum*
Diplachne fusca	*Leptochloa fusca*
Dissotis incana	*Heterotis canescens*
Dodonaea angustifolia	*Dodonaea viscosa*

Synonym	Species in VECEA
Dombeya goetzenii	*Dombeya torrida*
Dombeya leucoderma	*Dombeya torrida*
Dovyalis engleri	*Dovyalis abyssinica*
Echinochloa holubi	*Echinochloa pyramidalis*
Echinochloa scabra	*Echinochloa stagnina*
Ekebergia rueppelliana	*Ekebergia capensis*
Ekebergia senegalensis	*Ekebergia capensis*
Eragrostis haraensis	*Eragrostis mahrana*
Eriochloa meyerana	*Eriochloa meyeriana*
Eriochloa nubica	*Eriochloa fatmensis*
Erythrina tomentosa	*Erythrina abyssinica*
Euphorbia spinescens	*Euphorbia cuneata*
Festuca schimperiana	*Festuca abyssinica*
Grumilea megistosticta	*Psychotria mahonii*
Hagenia anthelmintica	*Hagenia abyssinica*
Helichrysum fruticosum	*Helichrysum forskahlii*
Helichrysum guilelmi	*Helichrysum formosissimum*
Hyparrhenia dissoluta	*Hyperthelia dissoluta*
Hyparrhenia lecomtei	*Hyparrhenia newtonii*
Hypericum keniense	*Hypericum revolutum*
Hypericum lanceolatum	*Hypericum revolutum*
Impatiens eminii	*Impatiens burtonii*
Kelleronia quadricornuta	*Kelleronia splendens*
Lasiocorys argyrophylla	*Leucas abyssinica*
Lobelia achrochilus	*Lobelia rhynchopetalum*
Lobelia elgonensis	*Lobelia deckenii*
Lobelia lanuriensis	*Lobelia stuhlmannii*
Macaranga kilimandscharica	*Macaranga capensis*
Mikania cordata	*Mikania capensis*
Miscanthidium violaceum	*Miscanthus violaceus*
Myrsine melanophloeos	*Rapanea melanophloeos*
Nuxia usambarensis	*Nuxia floribunda*
Nymphaea caerulea	*Nymphaea nouchali*
Nymphaea capensis	*Nymphaea nouchali*
Panicum glabrescens	*Panicum subalbidum*
Panicum ianthum	*Panicum brazzavillense*
Paspalum orbiculare	*Paspalum scrobiculatum*
Peddiea orophila	*Peddiea rapaneoides*
Pennisetum davyi	*Pennisetum macrourum*
Pennisetum glaucocladum	*Pennisetum macrourum*
Pennisetum schimperi	*Pennisetum sphacelatum*
Pittosporum malosanum	*Pittosporum viridiflorum*
Pittosporum mildbraedii	*Pittosporum viridiflorum*
Pittosporum rhodesicum	*Pittosporum viridiflorum*
Pittosporum spathicalyx	*Pittosporum viridiflorum*
Podocarpus milanjianus	*Podocarpus latifolius*
Polygonum salicifolium	*Persicaria decipiens*
Polyscias kikuyuensis	*Polyscias fulva*
Pygeum africanum	*Prunus africana*
Rapanea pulchra	*Rapanea melanophloeos*

Synonym	Species in VECEA
Rubus rigidus	*Rubus apetalus*
Sacciolepis scirpoides	*Sacciolepis typhura*
Sambucus africana	*Sambucus ebulus*
Scutia commersonii	*Scutia myrtina*
Senecio cottonii	*Dendrosenecio kilimanjari*
Senecio friesiorum	*Dendrosenecio adnivalis*
Senecio kilimanjari	*Dendrosenecio kilimanjari*
Senecio mannii	*Solanecio mannii*
Setaria angustifolia	*Setaria sphacelata*
Setaria holsti	*Setaria incrassata*
Setaria homblei	*Setaria sphacelata*
Setaria pallide-fusca	*Setaria pumila*
Setaria phragmitoides	*Setaria incrassata*
Setaria trinervia	*Setaria sphacelata*
Sorghum verticilliflorum	*Sorghum arundinaceum*
Sporobolus kentrophyllus	*Sporobolus ioclados*
Sporobolus marginatus	*Sporobolus ioclados*
Syzygium parvifolium	*Syzygium guineense*
Tabernaemontana johnstonii	*Tabernaemontana stapfiana*
Trichilia volkensii	*Lepidotrichilia volkensii*
Vallisneria aethiopica	*Vallisneria spiralis*
Zygophyllum hildebrandtii	*Melocarpum hildebrandtii*

Appendix 3. Information on botanical families

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

Family or subfamily	Species
Acanthaceae	*Barleria prionitis*
	Barleria proxima
	Blepharis linariifolia
	Duosperma eremophilum
Amaranthaceae	*Aerva javanica*
	Sericocomopsis hildebrandtii
	Sericocomopsis pallida
Anacardiaceae	*Lannea triphylla*
	Pseudospondias microcarpa
	Rhus natalensis
	Rhus vulgaris
Apocynaceae	*Adenium obesum*
	Tabernaemontana stapfiana
	Voacanga africana
	Voacanga thouarsii
	Wrightia demartiniana
Aquifoliaceae	*Ilex mitis*
Araceae	*Pistia stratiotes*
Araliaceae	*Polyscias fulva*
	Schefflera volkensii
Arecaceae	*Hyphaene thebaica*
	Phoenix reclinata
	Raphia farinifera
Asclepiadaceae	*Calotropis procera*
	Caralluma edithae
	Caralluma penicillata
	Cynanchum clavidens
	Cynanchum gerrardii
	Kanahia laniflora
	Leptadenia arborea
	Leptadenia hastata
	Leptadenia pyrotechnica
	Sarcostemma viminale
	Tacazzea apiculata
Asteraceae	*Conyza newii*
	Dendrosenecio adnivalis
	Dendrosenecio elgonensis
	Dendrosenecio kilimanjari
	Helichrysum formosissimum
	Helichrysum forskahlii
	Helichrysum glumaceum
	Inula confertiflora
	Melanthera scandens
	Mikania capensis
	Pluchea ovalis

Family or subfamily	Species
Asteraceae	*Senecio johnstonii*
	Senecio keniodendron
	Senecio myriocephalus
	Senecio subsessilis
	Solanecio mannii
	Triplocephalum holstii
	Vernonia cinerascens
Avicenniaceae	*Avicennia marina*
Balanitaceae	*Balanites aegyptiaca*
	Balanites pedicellaris
	Balanites rotundifolia
Balsanrinaceae	*Impatiens burtonii*
Berberidaceae	*Berberis holstii*
Boraginaceae	*Cordia sinensis*
	Cordia suckertii
	Ehretia cymosa
Brassicaceae	*Farsetia longisiliqua*
Burseraceae	*Boswellia rivae*
	Commiphora africana
	Commiphora erlangeriana
	Commiphora erythraea
	Commiphora gileadensis
	Commiphora guidottii
	Commiphora habessinica
	Commiphora incisa
	Commiphora kua
	Commiphora myrrha
	Commiphora samharensis
	Commiphora sphaerocarpa
Capparidaceae	*Boscia angustifolia*
	Boscia coriacea
	Cadaba farinosa
	Cadaba glandulosa
	Cadaba mirabilis
	Cadaba rotundifolia
	Capparis cartilaginea
	Capparis decidua
	Maerua crassifolia
	Maerua oblongifolia
Caprifoliaceae	*Sambucus ebulus*
Celastraceae	*Maytenus acuminata*
	Maytenus heterophylla
	Maytenus undata
Ceratophyllaceae	*Ceratophyllum demersum*
Chenopodiaceae	*Suaeda monoica*
Chrysobalanaceae	*Parinari curatellifolia*
Clusiaceae	*Garcinia livingstonei*
	Hypericum revolutum
Combretaceae	*Combretum aculeatum*
	Combretum constrictum

Family or subfamily	Species
	Lumnitzera racemosa
	Terminalia brevipes
	Terminalia sericea
Commelinaceae	*Commelina diffusa*
Convolvulaceae	*Ipomoea aquatica*
	Ipomoea donaldsonii
	Ipomoea rubens
	Ipomoea sultani
Cornaceae	*Cornus volkensii*
Cucurbitaceae	*Momordica sessilifolia*
	Momordica spinosa
Cupressaceae	*Juniperus procera*
Cyperaceae	*Cyperus dives*
	Cyperus laevigatus
	Cyperus latifolius
	Cyperus longus
	Cyperus papyrus
	Fimbristylis dichotoma
	Pycreus mundtii
Ebenaceae	*Euclea divinorum*
Ericaceae	*Agauria salicifolia*
	Erica arborea
Euphorbiaceae	*Alchornea cordifolia*
	Bridelia micrantha
	Croton macrostachyus
	Euphorbia columnaris
	Euphorbia cuneata
	Euphorbia mosaica
	Euphorbia multiclava
	Euphorbia sepulta
	Jatropha pelargoniifolia
	Macaranga capensis
	Macaranga schweinfurthii
	Neoboutonia macrocalyx
	Phyllanthus reticulatus
	Phyllanthus sepialis
	Phyllanthus somalensis
Flacourtiaceae	*Dovyalis abyssinica*
	Dovyalis macrocalyx
	Flacourtia indica
Geraniaceae	*Pelargonium christophoranum*
Hemandiaceae	*Gyrocarpus hababensis*
Hydrocharitaceae	*Vallisneria spiralis*
Lamiaceae	*Leonotis nepetifolia*
	Leonotis ocymifolia
	Leucas abyssinica
	Leucas tomentosa
Leguminosae: Caesalpinioideae	*Cordeauxia edulis*
	Cordyla africana
	Delonix elata

Family or subfamily	Species
Leguminosae: Caesalpinioideae	*Parkinsonia aculeata*
	Senna alexandrina
	Senna didymobotrya
	Senna longiracemosa
	Senna sophera
	Tamarindus indica
Leguminosae: Mimosoideae	*Acacia abyssinica*
	Acacia bussei
	Acacia drepanolobium
	Acacia edgeworthii
	Acacia ehrenbergiana
	Acacia elatior
	Acacia etbaica
	Acacia gerrardii
	Acacia hockii
	Acacia horrida
	Acacia mellifera
	Acacia nilotica
	Acacia oerfota
	Acacia polyacantha
	Acacia reficiens
	Acacia senegal
	Acacia seyal
	Acacia tortilis
	Acacia xanthophloea
	Acacia zanzibarica
	Albizia adianthifolia
	Albizia gummifera
	Dichrostachys cinerea
	Mimosa pigra
Leguminosae: Papilionoideae	*Abrus precatorius*
	Adenocarpus mannii
	Aeschynomene abyssinica
	Aeschynomene cristata
	Aeschynomene elaphroxylon
	Aeschynomene pfundii
	Aeschynomene schimperi
	Crotalaria agatiflora
	Erythrina abyssinica
	Indigofera oblongifolia
	Indigofera spinosa
	Kotschya africana
	Pseudarthria hookeri
	Sesbania bispinosa
	Sesbania keniensis
	Sesbania macrantha
	Sesbania sericea
	Sesbania sesban
	Vigna luteola
Liliaceae	*Aloe breviscapa*

Family or subfamily	Species
Liliaceae	*Aloe rigens*
	Aloe scobinifolia
	Asparagus africanus
Lobeliaceae	*Lobelia deckenii*
	Lobelia rhynchopetalum
	Lobelia stuhlmannii
	Lobelia telekii
	Lobelia wollastonii
Loganiaceae	*Anthocleista grandiflora*
	Nuxia congesta
	Nuxia floribunda
Lythraceae	*Lawsonia inermis*
	Pemphis acidula
Malvaceae	*Hibiscus diversifolius*
Melastomataceae	*Dissotis rotundifolia*
	Heterotis canescens
Meliaceae	*Ekebergia capensis*
	Lepidotrichilia volkensii
	Xylocarpus granatum
	Xylocarpus moluccensis
Melianthaceae	*Bersama abyssinica*
	Chasmanthera dependens
	Cissampelos mucronata
	Cocculus hirsutus
Monimiaceae	*Xymalos monospora*
Moraceae	*Ficus verruculosa*
Moringaceae	*Moringa peregrina*
Myrsinaceae	*Embelia schimperi*
	Maesa lanceolata
	Myrsine africana
	Rapanea melanophloeos
Myrtaceae	*Syzygium cordatum*
	Syzygium guineense
Nymphaeaceae	*Nymphaea lotus*
	Nymphaea nouchali
Ochnaceae	*Campylospermum vogelii*
Onagraceae	*Ludwigia leptocarpa*
	Ludwigia octovalvis
	Ludwigia stenorraphe
	Ludwigia stolonifera
Pandanaceae	*Pandanus kirkii*
Pedaliaceae	*Sesamothamnus busseanus*
Phytolaccaceae	*Phytolacca dodecandra*
Pittosporaceae	*Pittosporum viridiflorum*
Poaceae	*Acroceras macrum*
	Alloteropsis cimicina
	Andropogon amethystinus
	Andropogon brazzae
	Andropogon gayanus
	Andropogon greenwayi

Family or subfamily	Species
Poaceae	*Andropogon schirensis*
	Aristida adscensionis
	Aristida junciformis
	Aristida mutabilis
	Aristida stipitata
	Arundinella nepalensis
	Bothriochloa bladhii
	Bothriochloa radicans
	Brachiaria brizantha
	Brachiaria humidicola
	Brachiaria jubata
	Cenchrus pennisetiformis
	Centropodia glauca
	Chloris gayana
	Chloris virgata
	Chrysopogon aucheri
	Chrysopogon plumulosus
	Cynodon dactylon
	Dactyloctenium aegyptium
	Dichanthium annulatum
	Digitaria diagonalis
	Digitaria macroblephara
	Digitaria milanjiana
	Digitaria sanguinalis
	Dinebra retroflexa
	Drake-brockmania somalensis
	Echinochloa colona
	Echinochloa crus-galli
	Echinochloa crus-pavonis
	Echinochloa haploclada
	Echinochloa pyramidalis
	Echinochloa stagnina
	Enteropogon macrostachyus
	Entolasia imbricata
	Eragrostis atrovirens
	Eragrostis mahrana
	Eragrostis pallens
	Eragrostis plana
	Eragrostis superba
	Eragrostis tenuifolia
	Eriochloa fatmensis
	Eriochloa meyeriana
	Eustachys paspaloides
	Festuca abyssinica
	Hemarthria altissima
	Heteropogon contortus
	Hyparrhenia bracteata
	Hyparrhenia collina
	Hyparrhenia cymbaria
	Hyparrhenia diplandra

Family or subfamily	Species
Poaceae	*Hyparrhenia filipendula*
	Hyparrhenia newtonii
	Hyparrhenia nyassae
	Hyparrhenia rufa
	Hyperthelia dissoluta
	Imperata cylindrica
	Ischaemum afrum
	Leersia hexandra
	Leptochloa fusca
	Leptothrium senegalense
	Loudetia kagerensis
	Loudetia phragmitoides
	Loudetia simplex
	Microchloa kunthii
	Miscanthus teretifolius
	Miscanthus violaceus
	Monocymbium ceresiiforme
	Odyssea jaegeri
	Oreobambos buchwaldii
	Oropetium capense
	Oryza barthii
	Oryza longistaminata
	Oxytenanthera abyssinica
	Panicum brazzavillense
	Panicum coloratum
	Panicum dregeanum
	Panicum maximum
	Panicum repens
	Panicum subalbidum
	Panicum turgidum
	Paspalum scrobiculatum
	Pennisetum macrourum
	Pennisetum mezianum
	Pennisetum purpureum
	Pennisetum sphacelatum
	Pennisetum stramineum
	Phragmites mauritianus
	Rhytachne rottboellioides
	Sacciolepis africana
	Sacciolepis typhura
	Setaria incrassata
	Setaria pumila
	Setaria sphacelata
	Sinarundinaria alpina
	Sorghastrum stipoides
	Sorghum arundinaceum
	Sporobolus helvolus
	Sporobolus ioclados
	Sporobolus pellucidus
	Sporobolus pyramidalis

Family or subfamily	Species
Poaceae	*Sporobolus robustus*
	Sporobolus sanguineus
	Sporobolus spicatus
	Tetrapogon cenchriformis
	Themeda triandra
	Trachypogon spicatus
	Tragus berteronianus
	Trichoneura mollis
	Tristachya superba
	Vetiveria nigritana
	Vossia cuspidata
Podocarpaceae	*Podocarpus latifolius*
Polygonaceae	*Persicaria decipiens*
	Rumex usambarensis
Pontederiaceae	*Eichhornia crassipes*
Proteaceae	*Faurea saligna*
Resedaceae	*Ochradenus baccatus*
Rhamnaceae	*Rhamnus prinoides*
	Scutia myrtina
	Ziziphus spina-christi
Rhizophoraceae	*Bruguiera gymnorhiza*
	Cassipourea ruwensoriensis
	Ceriops tagal
	Rhizophora mucronata
Rosaceae	*Alchemilla argyrophylla*
	Alchemilla elgonensis
	Alchemilla johnstonii
	Hagenia abyssinica
	Prunus africana
	Rubus apetalus
	Rubus volkensii
Rubiaceae	*Galiniera saxifraga*
	Keetia gueinzii
	Oxyanthus speciosus
	Pavetta oliveriana
	Pavetta subcana
	Pseudosabicea arborea
	Psychotria mahonii
	Psychotria peduncularis
	Vangueria apiculata
Rutaceae	*Zanthoxylum usambarense*
Salvadoraceae	*Azima tetracantha*
	Dobera glabra
	Salvadora persica
Sapindaceae	*Allophylus abyssinicus*
	Allophylus africanus
	Allophylus kivuensis
	Dodonaea viscosa
Sapotaceae	*Pouteria adolfi-friedericii*
	Pouteria altissima

Family or subfamily	Species
Solanaceae	*Discopodium eremanthum*
	Discopodium penninervium
	Lycium europaeum
	Lycium shawii
Sonneratiaceae	*Sonneratia alba*
Sterculiaceae	*Dombeya torrida*
	Heritiera littoralis
	Sterculia africana
Tamaricaceae	*Tamarix aphylla*
	Tamarix nilotica
Theaceae	*Ficalhoa laurifolia*
Thymelaeaceae	*Peddiea fischeri*
	Peddiea rapaneoides
Tiliaceae	*Grewia similis*
	Grewia tenax
Typhaceae	*Typha domingensis*
	Typha latifolia
Vitaceae	*Cissus rotundifolia*
Zygophyllaceae	*Kelleronia splendens*
	Melocarpum hildebrandtii

FOREST & LANDSCAPE

FOREST & LANDSCAPE WORKING PAPERS 65 / 2011

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

Volume 5

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