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ORCID
IF: 0000-0002-2438-1528
SD: 0000-0002-0123-9596

The species of Burseraceae in Ethiopia – their distribution patterns, association with major vegetation types, species richness, and extinction risks

Ib Friis[1], Sebsebe Demissew[2]

[1] *Natural History Museum of Denmark, University of Copenhagen, Universitetsparken 15, DK-2100 Copenhagen Ø, Denmark*
[2] *The National Herbarium, Department of Plant Biology and Biodiversity Management, College of Natural Sciences, Addis Ababa University, P.O. Box 3434, Addis Ababa, Ethiopia*
Email: ibf@snm.ku.dk; sebsebe.demissew@aau.edu.et

Abstract. The Burseraceae in Ethiopia comprises six species of *Boswellia* and 42 of *Commiphora*, producing frankincense or myrrh. This work aims to study the distribution and ecology of all 48 species, although some *Commiphora*-species are poorly documented. *Boswellia* species form two distinct geographic groups: one northwestern and one southeastern. Most *Commiphora* species are confined to the southern and eastern lowlands, with a few also occurring in river valleys in highlands. Distributions are analysed against vegetation types and climate models. Ranges vary from widespread in climatically suitable areas to highly localized. *Commiphora* species are linked to *Acacia-Commiphora* bushland on limestone and sand (mostly calcareous), though specific ecological preferences are still unclear. Species richness on degree squares correlates with collection intensity, indicating gaps in knowledge beyond well-sampled areas. Assessed IUCN categories of extinction risks range from Least concern to Critically endangered.

Keywords: *Acacia-Commiphora* woodland and bushland, *Combretum-Terminalia* woodlands, conservation, modelled distributions, observed distributions.

INTRODUCTION

The commonly known aromatic resins used as incense, frankincense and myrrh, are obtained from the dried sap of shrubs or small, deciduous trees of the genera *Boswellia* and *Commiphora* in the plant family Burseraceae. The genus is known to occur in nearly all tropical African countries, but almost always restricted to lowland areas with one or several prominent dry seasons. The species are all adapted to a dry season by being deciduous. In the countries that harbour most *Boswellia* and *Commiphora* species, frankincense and myrrh provide a unique resource that supplements the limited incomes among the local rural population. However, many species of *Com-*

miphora are affected by the increasing size and necessities of the human population in their natural habitats, causing destruction of the habitats, and the as yet not well understood effects of climate change. In Ethiopia, two species have been assessed as critically endangered, seven species as near threatened, six species as vulnerable, sixteen species as least concern, while the status of fifteen species is still unsettled on the Red List of the IUCN, where the different levels of extinction risks are presented (https://www.iucnredlist.org/).

The use of incense, almost certainly from species of Burseraceae, has been documented by the presence of incense burners found in archaeological sites in Ethiopia and Yemen from the pre-Aksumite period, and incense has been an important commercial good since the Antiquity. The ancient Egyptians imported incense from the areas around the southern part of the Red Sea and the Gulf of Aden (Bulakh and Fiaccadori 2007).

In Ethiopia, incense is still much in use, being burnt with charcoal to produce perfumed smoke, either in censers for church use or on open burners of clay for private use. Recently, the production of incense in Ethiopia has been estimated at over 30,000 tons annually, though the largest part is consumed internally and only (in 1995–2000) between 800 and 1800 tons were exported (Volker-Saad 2007). Incense from species of Burseraceae has been important in the rites of the Ethiopian Orthodox Church since the beginning of the 4th Century; currently, the use of incense is compulsory during every service except at the rites of penance (Fritsch 2007). The resins from species of *Boswellia* and *Commiphora* seem also to play an increasing role in the pharmaceutical industry (Eltigani et al. 2025).

There are no longer difficulties with the taxonomy and distribution of *Boswellia* in Ethiopia, but there are still problems with the taxonomy and distribution patterns of *Commiphora*. In the Flora of Ethiopia, Vollesen (1989) provided a detailed account of six species of *Boswellia* and 52 species of *Commiphora*. In his account for the Flora of Tropical East Africa (Burseraceae), Gillett (1991) provided an account of four species of *Boswellia* and ca. 44 species of *Commiphora* recorded from Kenya, mainly in the part of the country closest to Ethiopia and Somalia. In the Flora of Somalia, Thulin (1999) provided the taxonomy of three species of *Boswellia* and 52 species of *Commiphora* of which seventeen species did not occur in Ethiopia. Despite the presence of these good accounts, taxonomic problems persisted, and it is never easy for users to identify or collect good material of the species because leaves, flowers, and fruits are needed for certain identification, and they are rarely available on the same shrub or tree at the same time.

It is worth mentioning that the theme of this work follows in the tradition of the journal Webbia, providing both taxonomic and phytogeographical works on the Horn of Africa. Already the first detailed vegetation map of Ethiopia (Pichi Sermolli 1957) documented the importance of species of Burseraceae in the Ethiopian lowland vegetation in a long and detailed paper in Webbia. This has been further emphasised on the two recent vegetation maps of Ethiopia (Friis et al. 2010, 2022), published as monographs for which precursory studies have appeared in Webbia. Another Italian botanist, Emilio Chiovenda, published most of his important studies on the flora of the Horn of Africa, mainly Somalia, in other outlets than Webbia, but here we should mention his main work on the Burseraceae, the Flora Somala 2 (Chiovenda 1932), which together with his other publications on the family is frequently cited here.

As part of the preparation of a new Field Guide to species that produce frankincense and myrrh in Ethiopia (Demissew and Friis in preparation), the present authors have collected data of all *Boswellia* and *Commiphora* species from Ethiopia, concluding on a moderately modified taxonomy in relation to that of Vollesen (1989), with the number of species of *Commiphora* in Ethiopia reduced to 42.

Although the genus *Boswellia* occurs in both the western and the eastern lowlands of Ethiopia, the genus *Commiphora* is almost entirely restricted to the south-eastern and adjacent lowlands with very variable patterns of distribution, ranging from widespread species in many habitats to local endemics probably found only on a narrow range of geological formations. A few species penetrate into the highlands along the deep river valleys of the Tacazze, Abay, Gibe, Didessa, and Omo. This work is intended to summaries what we currently know and can conclude about the distributions of the species of Burseraceae in Ethiopia, which may help attempts at their conservation.

MATERIALS AND METHODS; PRESENTATION OF DATA

Extensive data gathered by the authors from the Burseraceae collections in the herbaria at C, ETH, FT, and K, as well as from our own field observations, all based on carefully identified specimens. Ca. 910 identified collections were listed and their sites of collection georeferenced, using all available sources to identify the coordinates of the localities of the collections. We used the GIS software ArcGis 9 / ArcMap 9.3 to map the collections and produce the maps with the

distribution of the collections superimposed on a map of vegetation types of Ethiopia. The layers and the legend of these vegetation types (Fig. 1A & 1B) have been adapted from Friis et al. (2022, Fig. 4-1) and are used for all the distribution maps with direct observations in this work.

The modelling in this work of suitability of habitats was based on the sample of the ca. 910 identified and georeferenced collections and was made with MaxEnt, vers. 3.4.4 (Phillips 2017). The results produced with the MaxEnt-analyses were further treated with DivaGis 7.5.0 (Hijmans et al. 2012) to adjust the classes of climatic suitability to five intervals: from not suitable (0) to highly suitable (1), represented in this paper with suitability 0–0.2 (dark green), 0.2–0.4 (light green), 0.4–0.6 (yellow), 0.6–0.8 (orange), and 0.8–1.0 (dark red). The files used for climatic parameters were derived from the internet database in WorldClim (2020–2025), representing the years 1970-2000, and with a spatial resolution of 30 seconds, which is comparable to a pixel size of ca. 1 km^2. The parameters are: 1 = Annual Mean Temperature; 2 = Mean Diurnal Range (Mean of monthly max temp - min temp); 3 = Isothermality (parameters 2 / parameters 7 ×100); 4 = Temperature Seasonality (standard deviation ×100); 5 = Max Temperature of Warmest Month; 6 = Min Temperature of Coldest Month; 7 = Temperature Annual Range (parameter 5 - parameter 6); 8 = Mean Temperature of Wettest Quarter; 9 = Mean Temperature of Driest Quarter; 10 = Mean Temperature of Warmest Quarter; 11 = Mean Temperature of Coldest Quarter; 12 = Annual Precipitation; 13 = Precipitation of Wettest Month; 14 = Precipitation of Driest Month; 15 = Precipitation Seasonality (Coefficient of Variation); 16 = Precipitation of Wettest Quarter; 17 = Precipitation of Driest Quarter; 18 = Precipitation of Warmest Quarter; 19 = Precipitation of Coldest Quarter.

Species with only one record are mapped but cannot be modelled with MaxEnt. The reliability of the modelled distributions of species with more than one record relies strongly on the number of observed occurrence points (locations of collections with documented occurrence) and the relevant environmental parameters that are involved in the analyses (Merow et al. 2013; Phillips 2017; Lissovsky and Dudov 2021). The minimum number of observed occurrence points varies with their geographical distribution and the reliability of the environmental parameters. As suggested by Paulo van Breugel (pers. com.) in connection with discussions of how to draw conclusions of this study, results of modelling may not be expected to reliably model species with below approximately 12–13 observed occurrence points. However, for endemic Ethiopian species the number of observed occurrence points must of necessity be lower, and we have for example used a limit of 5–6 of observed occurrence points. Nevertheless, for the sake of completion, we have run models for all species with two or more observed occurrence points, but we have not offered special comments on the reliability of the result based on modelled omission rates in relation to the expected values in cases with fewer than 12–13 observed occurrence points (Ethiopian endemics excepted). For species with sufficient number of occurrence points, we suggest if the model is performing as intended or not, based on the curve showing the modelled omission rate, in other cases we simply present the model without commenting on how reliably it may function.

We are fully aware that MaxEnt, as pointed out by Lissovsky and Dudov (2021), does not provide a "magic wand" that in all cases will provide a correct modelled range map. Nevertheless, we hope that our study presents useful steps forward both with regard to observations, modelling, understanding of relation to vegetation types and distribution patterns of the Burseraceae in Ethiopia.

For both the distribution maps on vegetation types and for the maps showing modelled suitability, the outlines of the lakes of Ethiopia have been superimposed with blue colour and a black border-line. Likewise, the borders of the floristic regions of the Flora of Ethiopia and Eritrea have been superimposed both on the maps showing observed distributions (with thin black border-lines), and on the maps showing modelled potential distributions (with bold black border-lines). A map with the border lines of these floristic regions is published opposite the title page of the first published volume of the Flora of Ethiopia [and Eritrea] and republished in all subsequent volumes. The floristic regions are: AF (Afar region, below and to the east of the 1000 m contour to the Eritrean border in the east and to the Harerge border in the south); TU (abbreviation of Tigray Uplands, area within the former outline of the Tigray region above and to the west of the 1000 m contour); GD (the former Gonder region); GJ (the former Gojam region); WU (abbreviation of Welo Uplands, area within the former Welo region above and to the west of the 1000 m contour); SU (abbreviation of Shewa Uplands, area within the former Welo region above and to the west of the 1000 m contour); AR (the former Arsi region); WG (the former Welega region); IL (the former Illubabor region); KF (the former Kefa region); GG (the former Gamo Gofa region); SD (the former Sidamo region); HA (the former Harerge region).

DivaGis 7.5.0 was also used as a tool to analyse the distributions of the data on one-degree squares. This included indication of number of observed positive presence locations on one-degree squares of all records used in this paper, estimation of richness of Burseraceae species on one-degree squares with direct observation, and rearranged richness with Jackknife cross-validation technique (Hijmans et al. 2012: 35–36) to reduce bias in parameter estimates, as well as estimation of diversity of Burseraceae on one-degree squares measured with the Shanon-Wiener Index (Hijmans et al. 2012: 38), applying both richness (number of species) and evenness (how evenly individuals are distributed among species). We have also tried to perform the analyses with quarter-degree squares but found that the very uneven distribution of the occurrence points observed made it even more difficult to find a pattern of richness that would make sense with the topography and climate.

Although geological suitability would also have represented important environmental parameters to use for this study, perhaps as important as the climatic parameters we were able to use, we were only able to find traditional geological maps (Tefera et al. 1996; Last 2009), but no high-resolution digital data sets suitable for incorporating geological formations in our analyses. Instead, we have summarized the information about substrates and vegetation types from available sources, including Flora of Ethiopia, Flora of Tropical East Africa, and Flora of Somalia and attempted to make a verbal summary in our conclusions.

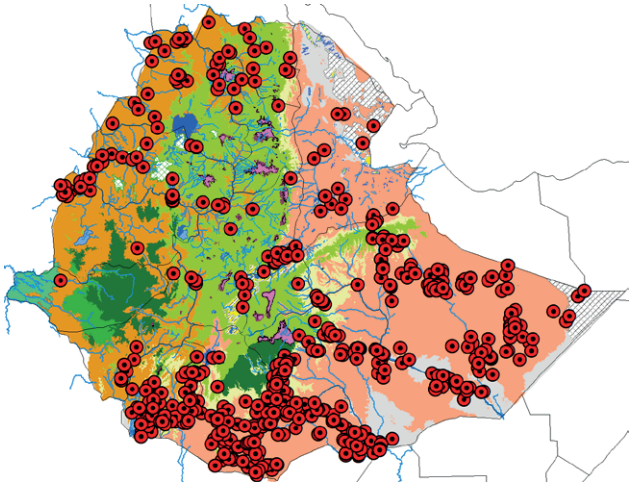

Figure 1A. Distribution of all ca. 910 records of Ethiopian Burseraceae studied for this work and superimposed on the vegetation types defined in Friis et al. (2022). The same classification of vegetation types is used on the left-hand maps in the Figs. 3–50. For legend to the vegetation types, see Fig. 1B.

Both because of the small number of occurrence points for many species and the non-random distribution of occurrence points in geographical space, often densely clustered in well-collected areas but perhaps erroneously absent in poorly collected areas, the results of our modelling will for many species require data correction from future collections.

The assessed extinction risk is cited where available and is available for species endemic to Ethiopia. We have not attempted to assess EOO (Extent of Occurrence) and AOO (Area of Occupancy) with GeoCAT (https://geocat.iucnredlist.org/) for species that occur outside Ethiopia due to our lack of information about their entire distribution, and therefore not indicate more about general threat of these species. A summary is given in our conclusions and in Table 4.

The taxonomy and sequence of species in this work follows the manuscript of our drafted Field Guide (Demissew and Friis in preparation). A number of synonyms have been cited in this work to ensure the option for reliable comparison with the regional floras (Vollesen 1989; Gillett 1991; Thulin 1999; 2020).

GENERAL DISTRIBUTION OF BURSERACEAE IN ETHIOPIA

The distribution of the total number of species of Burseraceae in Ethiopia is mapped on Fig. 1A, based on data from this study. The distribution of the species is modelled on the suitability of climatic parameters as presented in Fig. 2, with the use of DIVA-GIS. It appears from Fig. 1A that most records studied have been found growing in *Acacia-Commiphora* woodland and bushland proper in southern and southeast-

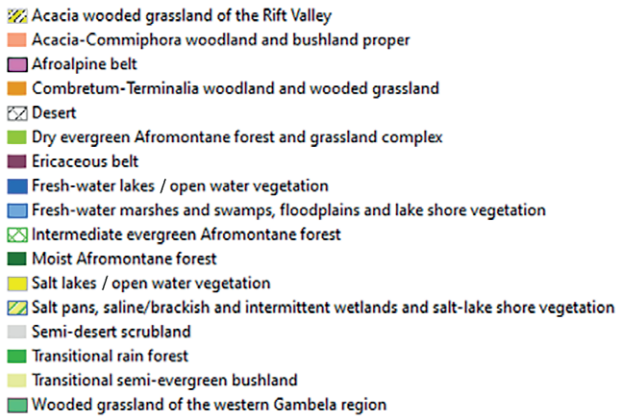

Figure 1B. Legend to vegetation types defined in Friis et al. (2022) and used for all distribution maps in this paper.

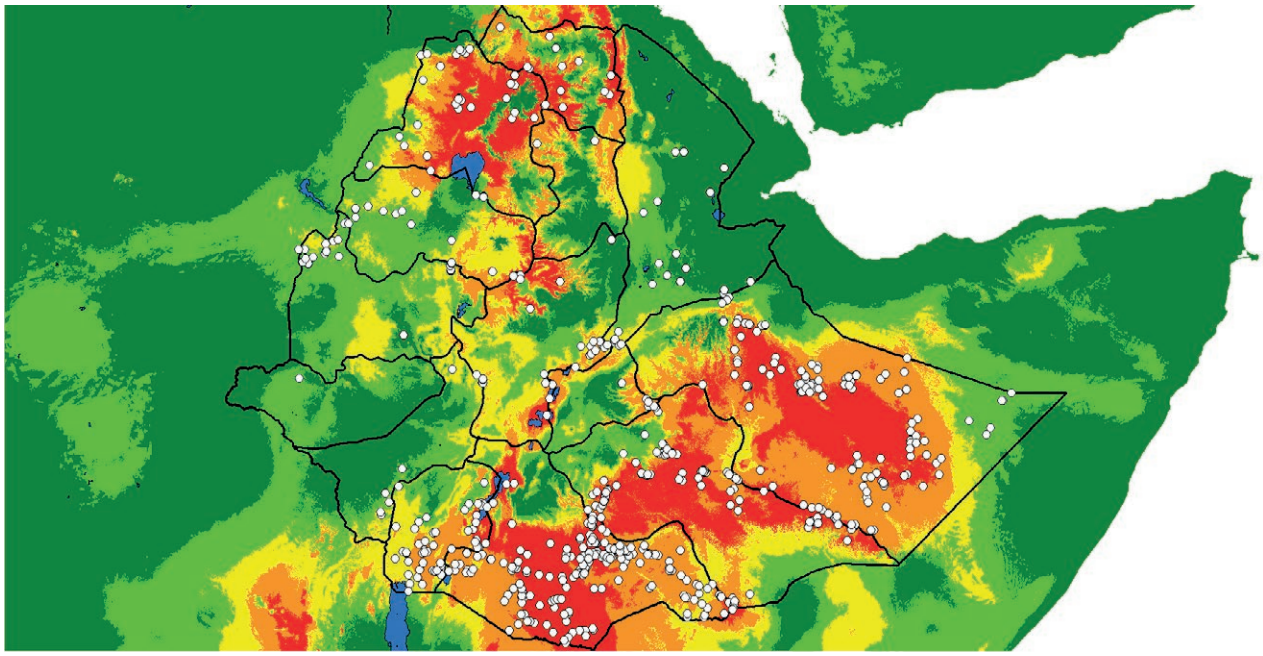

Figure 2. Map showing modelled suitability of potential distribution areas of the species of Burseraceae in Ethiopia, based on climatic parameters. The legend to the colouring is the same as for all maps in this paper showing potential vegetation: Dark green: Suitability 0–0.2. Pale green: Suitability 0.2–0.4. Yellow: Suitability 0.4–0.6. Orange: Suitability 0.6–0.8. Red: Suitability 0.8–1.0.

ern Ethiopia, but many records have also been made in transitional semi-evergreen bushland, which represents the transition zone between lowland and highland vegetation (Friis et al. 2010, 2022). A number of species in these two areas of distribution belong to the genus *Boswellia*, but many more to the genus *Commiphora*. Although most species grow in *Acacia-Commiphora* woodland and bushland proper, some may also grow in *Combretum-Terminalia* woodland and wooded grassland on the western side of the Ethiopian highlands and in the deep river valleys.

The modelled map in Fig. 2 shows that most of our records of Burseraceae occur in areas with the highest category of suitability, dark red, but a number of records have been collected from areas with the two lowest categories of suitability, pale green and dark green, the latter is most often the case with records from AF, the Afar region.

STUDY OF HABITATS AND DISTRIBUTION OF INDIVIDUAL SPECIES

In the following, mapping and modelling of each of the six species of *Boswellia* and the forty-two species *Commiphora* are dealt with as represented by ca. 910 collections we have studied. If possible, the treatment for each species includes, as for the two separate maps showing all species in Fig. 1A and Fig. 1B, figures with a combination of two maps, to the left a map of observed distribution on vegetation types and to the right a map showing a combination of observed records and modelled distribution based on climatic parameters. The number of observed occurrence points are cited in the text for each species. Collections of *Boswellia* and *Commiphora* that could not be identified to species are not included, and data relating to infraspecific taxa, except for the subspecies *C. edulis* subsp. *boiviniana*, are not accounted for here. For all species we have tried to add the general distribution and, according to the latest Red List of IUCN (https://www.iucnredlist.org/), the extinction risk of the species.

B01. ***Boswellia papyrifera*** (Caill.) Hochst., Flora 26: 81. 1843.

Fifty occurrence points studied, which we consider sufficient for reliable modelling. The species is distributed in *Combretum-Terminalia* woodland and wooded grassland on the western side of the Ethiopian highlands as far south as the northern part of WG but the species does also occur in the deep valleys of the rivers running both westwards towards the Abay and eastwards towards the Awash rivers. In the latter, an isolated population is

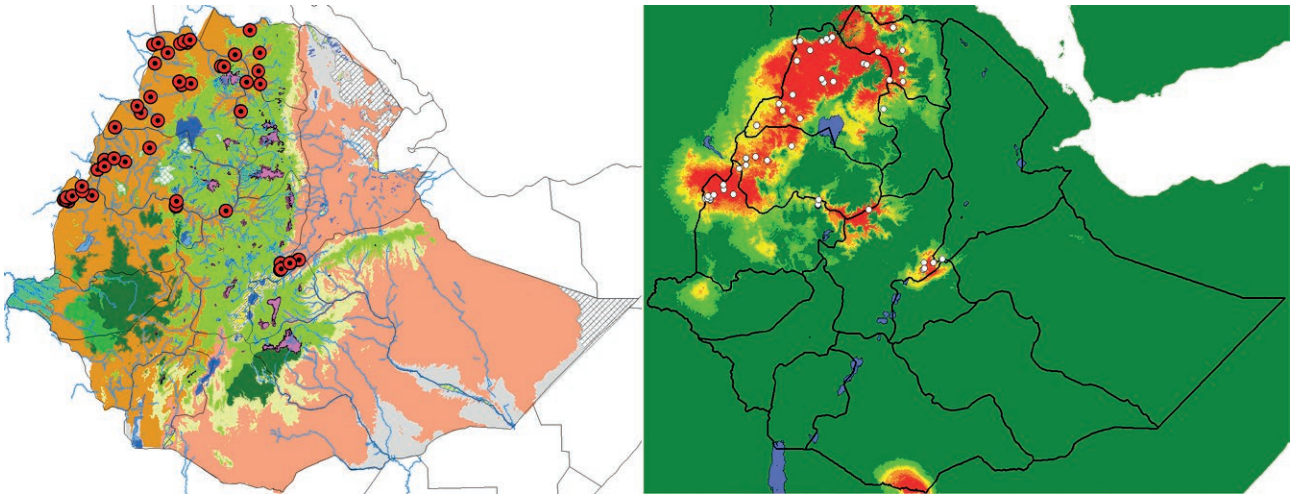

Figure 3. *Boswellia papyrifera* (Caill.) Hochst. in Ethiopia. Left hand map showing distribution of observed records on the vegetation types in Fig. 1B; right hand map showing modelled suitability of potential distribution areas of the species as defined in Fig. 2, based on climatic parameters. For text about species, see B01.

found in vegetation recorded as *Acacia-Commiphora* woodland and bushland (Fig. 3).

There is good agreement between the areas of the actual and the modelled distribution, and the modelled omission rates of *B. papyrifera* are close to the expected values, suggesting that the model performs as intended. The highest contribution to the model is provided by Bio19 (precipitation of coldest quarter).

In Ethiopia, the species has been reported to grow in dry *Acacia-Commiphora* woodland and wooded grassland [but this is not the typical habitat], in *Pterocarpus* woodland, a northern subtype of *Combretum-Terminalia* woodland, often as the dominant species on steep rocky slopes, also on lava flows (Vollesen 1989). In Tropical East Africa (Uganda), it has been found growing on stony hillsides in dry wooded grassland (Gillett 1991). Thulin (2020) cites that in Ethiopia this is a characteristic species of the northern half of the vegetation types designated as *Combretum-Terminalia* woodland and wooded grassland, which is confirmed by studies of Friis et al. (2022) and here.

The species is widespread in deciduous woodlands of northern tropical Africa from Nigeria to Sudan (Darbyshire et al. 2015), Eritrea and Ethiopia, reaching southwards to Uganda. The species is of economic importance, and population studies have been made of mature trees and their regeneration (Abiyu et al. 2010).

Thulin (2020) assessed the extinction risk as Vulnerable A2cd + 3cd. Despite the evidence cited by Thulin (2020), *B. papyrifera* is not currently red-listed by IUCN. Previous IUCN information can be found at https://doi.org/10.2305/IUCN.UK.2018-2.RLTS.T34394A128137387.en.

B02. ***Boswellia pirottae*** Chiov., Ann. Bot. (Rome) 9: 53. 1911.

Twenty-nine occurrence points studied, which we consider sufficient for reliable modelling. The species is mainly found below and near the upper limit of *Combretum-Terminalia* woodland and wooded grassland on the western side of the Ethiopian highlands from GD in the north to the northernmost part of WG and KF in the south. The river valleys in the highlands with *B. pirottae* comprise the Abay Valley, running to the west, and an apparently isolated population in the upper part of the Omo Valley, running to the south. There seems to be no population in rivers running to the east (Fig. 4).

There is good agreement between actual and modelled distributions, and the modelled omission rates of *B. pirottae* are close to the expected values, suggesting that the model performs as intended. The highest contribution to the model is provided by Bio19 (precipitation of coldest quarter).

The species has been reported to grow in *Commiphora-Boswellia*, *Combretum* and *Acacia-Lannea* woodland on steep rocky slopes (Vollesen 1989), and more generally in variants of *Combretum-Terminalia* woodland (Thulin 2020; Friis et al 2022). The substrate is according to our own observations usually derived from basaltic rocks, usually where these rocks form steep slopes.

The species is endemic to Ethiopia. The extinction risk of the species is considered Vulnerable C1 by Awas T, Belay B, Demissew S, Nemomissa S, Mekbib E, Atnafu H, Alemu S, Alemu S. 2021. *Boswellia pirottae* (errata version published in 2022). The IUCN Red

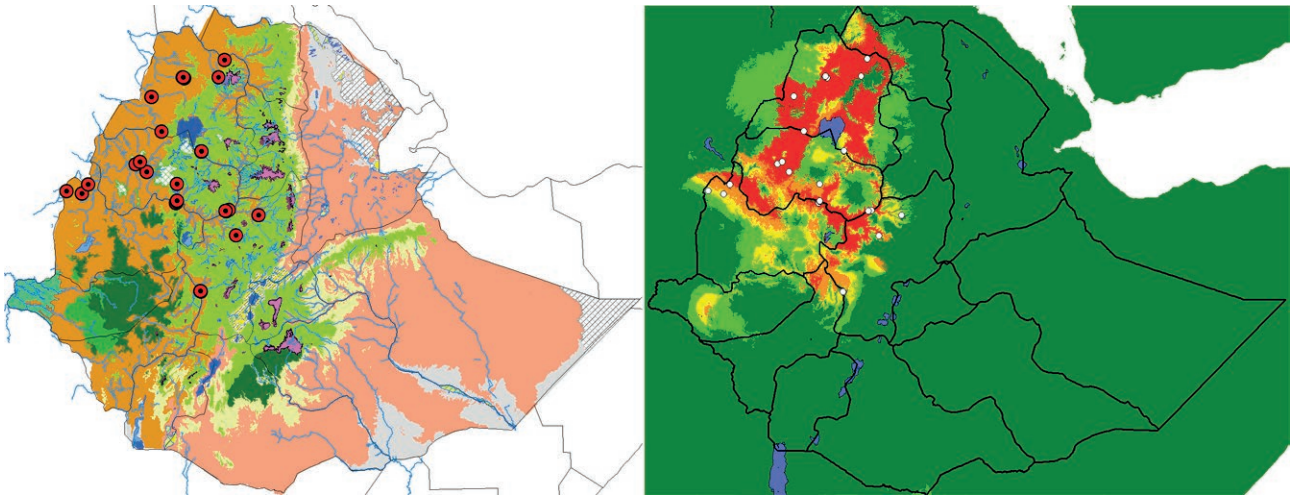

Figure 4. *Boswellia pirottae* Chiov. in Ethiopia. Left hand map showing distribution of observed records on the vegetation types in Fig. 1B; right hand map showing modelled suitability of potential distribution areas of the species as defined in Fig. 2, based on climatic parameters. For text about species, see B02.

List of Threatened Species 2021: e.T34394A223071850. https://doi.org/10.2305/IUCN.UK.2021-3.RLTS.T34394A223071850.en. The species is assessed to have a continuing decline of mature individuals and a continuing decline in area, extent and/or quality of habitat. Thulin (2020) suggested the same assessment extinction risk.

B03. ***Boswellia rivae*** Engl., Ann. Bot. (Rome) 7: 16. 1897.

(=) *B. boranensis* Engl., Bot. Jahrb. Syst. 34: 316. 1904.

Twenty occurrence points studied, which we consider sufficient for reliable modelling. The species is restricted to *Acacia-Commiphora* woodland and bushland proper in southern and southeastern Ethiopia, with slight transgression into transitional semi-evergreen bushland, semi-desert scrubland, desert, and saline wetlands (Fig. 5).

There is good agreement between the recorded distribution and area of highest suitability, and the modelled omission rates of *B. rivae* are close to the expected value, suggesting that the model performs as intended. The highest contribution to the model is provided by Bio11 (mean temperature of coldest quarter).

In Ethiopia, it has been reported to grow in *Acacia-Commiphora* wooded grassland and bushland on red sandy soil overlying limestone (Vollesen 1987). In Tropical East Africa (Kenya), it has been found growing in open *Acacia-Commiphora* bushland on limestone hills (Gillett 1991). In Somalia, it has been reported from both the northern, central and southern parts, growing in open *Acacia-Commiphora* bushland, often on hills or rocky ridges, usually on limestone, occasionally on gypsum (Thulin 1999, 2020).

Restricted to Ethiopia, Somalia, northeastern Kenya. The extinction risk of the species is considered Least Concern by Alemu S, Alemu S, Atnafu H, Awas T, Bahdon J, Belay B, Demissew S, Luke WRQ, Mekbib E, Musili P, Nemomissa S. (2021). *Boswellia rivae* (errata version published in 2022). The IUCN Red List of Threatened Species 2021: e.T128044164A223074935. https://doi.org/10.2305/IUCN.UK.2021-3.RLTS.T128044164A223074935.en. Although considered Least Concern, the species is assessed to have a continuing decline in area, extent and/or quality of habitat. Thulin (2020) has suggested the same assessment.

B04. ***Boswellia ogadensis*** Vollesen, Kew Bull. 40: 39. 1985.

Two occurrence points studied. Although this is a species endemic to Ethiopia, two records are not sufficient for reliable modelling, but as far as known, the species is restricted to a part of semi-desert scrubland, desert, and saline wetlands along the lower reach of the Webe Shebele River (Fig. 6).

The species is reported to grow in *Acacia-Commiphora* bushland on rocky limestone slopes (Vollesen 1989), where, according to Thulin (2020), it is restricted to gypseous ground.

Endemic to Ethiopia.

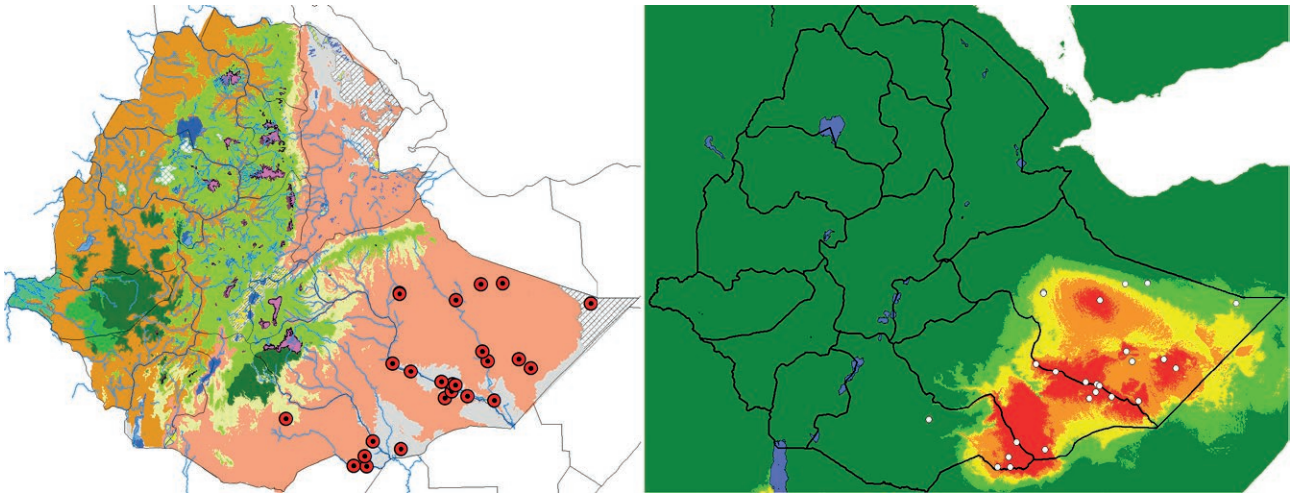

Figure 5. *Boswellia rivae* Engl. in Ethiopia. Left hand map showing distribution of observed records on the vegetation types in Fig. 1B; right hand map showing modelled suitability of potential distribution areas of the species as defined in Fig. 2, based on climatic parameters. The westernmost outlying collection in SD was included in the modelling but is not in the predicted area. For text about species, see B03.

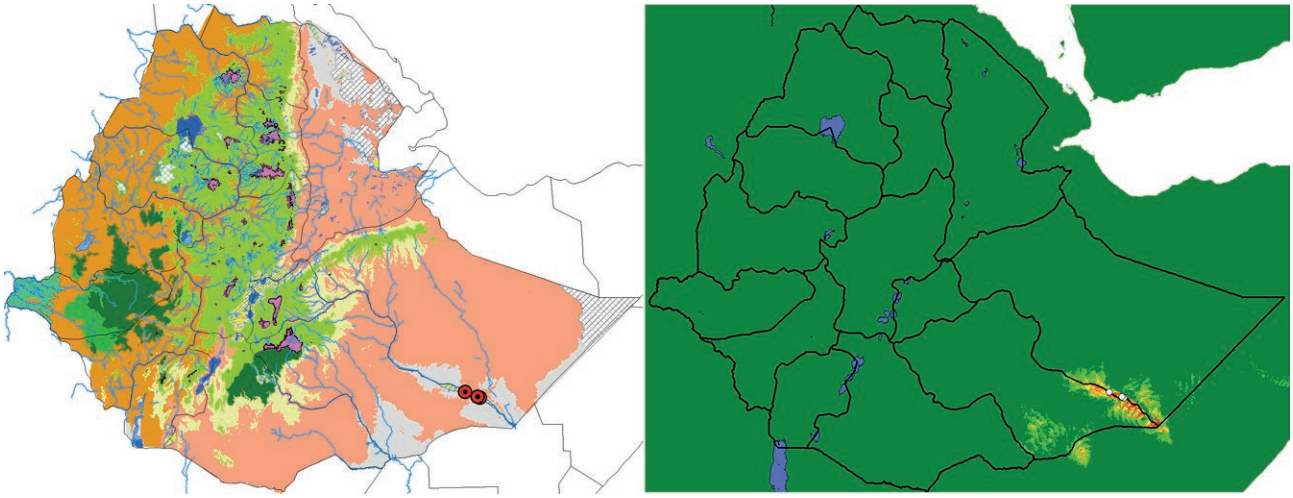

Figure 6. *Boswellia ogadensis* Vollesen in Ethiopia. Left hand map showing distribution of observed records on the vegetation types in Fig. 1B; right hand map showing modelled suitability of potential distribution areas of the species as defined in Fig. 2, based on climatic parameters. For text about species, see B04.

The extinction risk of the species is considered Critically Endangered B1ab(iii) by Alemu S, Alemu S, Atnafu H, Awas T, Belay B, Demissew S, Luke WRQ, Mekbib E, Nemomissa S, Bahdon J. 2021. *Boswellia ogadensis* (errata version published in 2022). The IUCN Red List of Threatened Species 2021: e.T34385A223070932. https://doi.org/10.2305/IUCN.UK.2021-3.RLTS.T34385A223070932.en. The populations are severely fragmented and there is a continuing decline of mature individuals. Thulin (2020) has suggested the same assessment.

B05. ***Boswellia neglecta*** S.Moore, J. Bot. 15: 67. 1877.

Sixty occurrence points studied, which we consider sufficient for reliable modelling. The species is restricted to *Acacia-Commiphora* woodland and bushland proper in southern and southeastern Ethiopia, with slight transgression into semi-desert scrub and transitional semi-evergreen bushland; it has not been recorded from the Afar region (Fig. 7).

There is good agreement between the recorded distribution and area of highest suitability, and the mod-

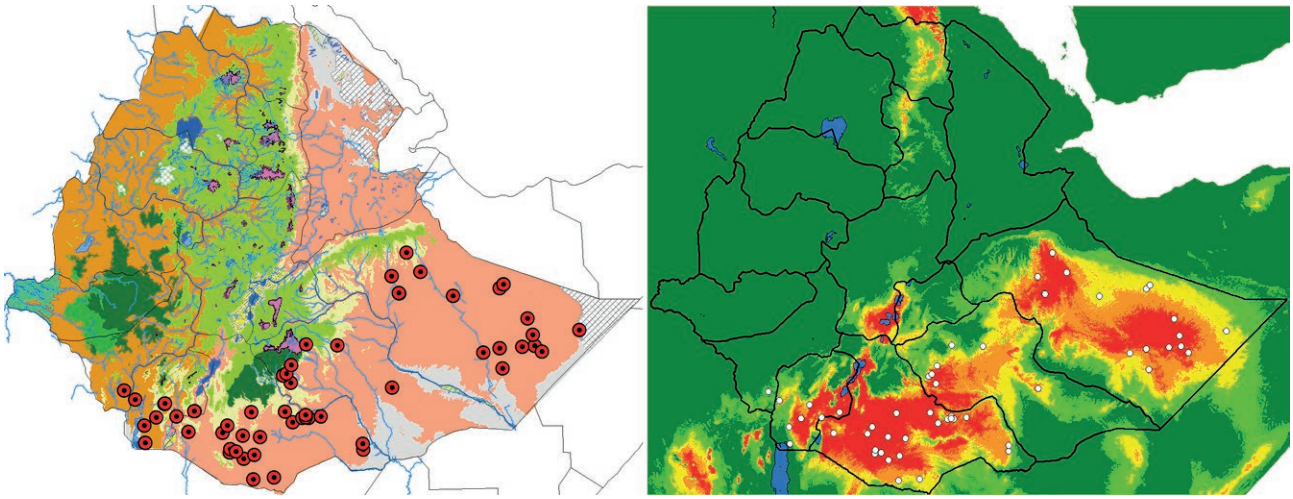

Figure 7. *Boswellia neglecta* S. Moore in Ethiopia. Left hand map showing distribution of observed records on the vegetation types in Fig. 1B; right hand map showing modelled suitability of potential distribution areas of the species as defined in Fig. 2, based on climatic parameters. For text about species, see B05.

elled omission rates of *B. neglecta* are close to the expected value, suggesting that the model performs as intended. The highest contribution to the model is provided by Bio3 (isothermality).

In Ethiopia, the species has been reported to grow in *Acacia-Commiphora* woodland, wooded grassland and bushland, *Acacia-Boswellia-Terminalia* woodland or wooded grassland, often on red sandy soil overlying limestone but also on basement rocks (Vollesen 1989). In Tropical East Africa (Uganda, Kenya, Tanzania), it has been found growing in *Acacia-Commiphora* bushland on basement complex or lava and red sandy soil (Gillett 1991).

Thulin (1999) considered *B. neglecta* and *B. microphylla* as one variable species, but kept them distinct in Thulin (2020), according to which it has been known from both the northern, central and southern parts, growing in *Acacia-Commiphora* bushland, usually on red sandy soil overlying limestone but also on basement rocks and on lava.

In Ethiopia, Somalia, northeastern Uganda, northern and eastern Kenya, northeastern Tanzania. Not red-listed by IUCN. Thulin (2020) has preliminarily suggested an assessment of the extinction risk as Least Concern.

B06. ***Boswellia microphylla*** Chiov., Ann. Bot. (Rome) 13: 404. 1915.

Twenty-five occurrence points studied, which we consider sufficient for reliable modelling. The species is restricted to *Acacia-Commiphora* woodland and bushland proper in southern and southeastern Ethiopia, with slight transgressions into transitional semi-evergreen bushland, semi-desert scrubland and desert, and also into saline wetlands (Fig. 8).

There is good agreement between the recorded distribution and areas of highest suitability. The modelled omission rates of *B. microphylla* deviate from the expected values, and the model may not perform as intended. The highest contribution to the model is provided by Bio4 (temperature seasonality).

In Ethiopia, the species has been reported to grow in *Acacia-Commiphora* wooded grassland and bushland, usually on red sandy to gravelly soil overlying limestone (Vollesen 1989). In Tropical East Africa (Kenya), it has been found growing in open or dense *Acacia-Commiphora* bushland on stony ridges or slopes or on red sandy soil (Gillett 1991). Thulin (1999) considered *B. neglecta* and *B. microphylla* as one variable species, but kept them distinct in Thulin (2020), stating that it grows in *Acacia-Commiphora* woodland and bushland, usually on red sandy soil overlying limestone, but sometimes on rocky ridges or in gypseous or silty soils.

Restricted to Ethiopia, Somalia, and northeastern Kenya. Not red-listed by IUCN. Thulin (2020) preliminarily suggested an assessment of the extinction risk as Least Concern.

C01. ***Commiphora erlangeriana*** Engl., Bot. Jahrb. Syst. 34: 311. 1904.

Seven occurrence points studied. This is not sufficient for reliable modelling, but as far as known, the

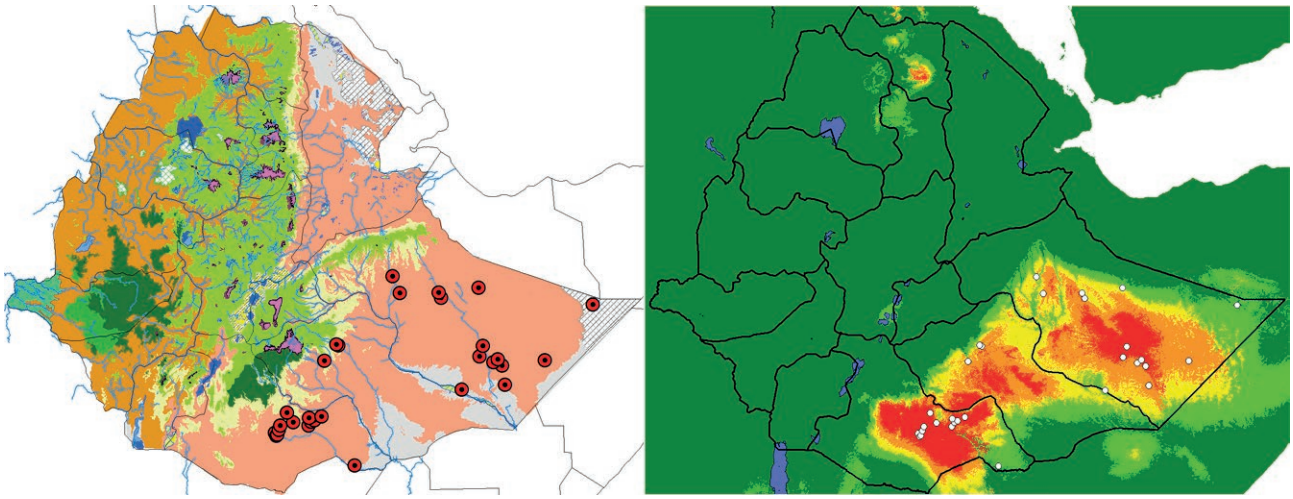

Figure 8. *Boswellia microphylla* Chiov. in Ethiopia. Left hand map showing distribution of observed records on the vegetation types in Fig. 1B; right hand map showing modelled suitability of potential distribution areas of the species as defined in Fig. 2, based on climatic parameters. For text about species, see B06.

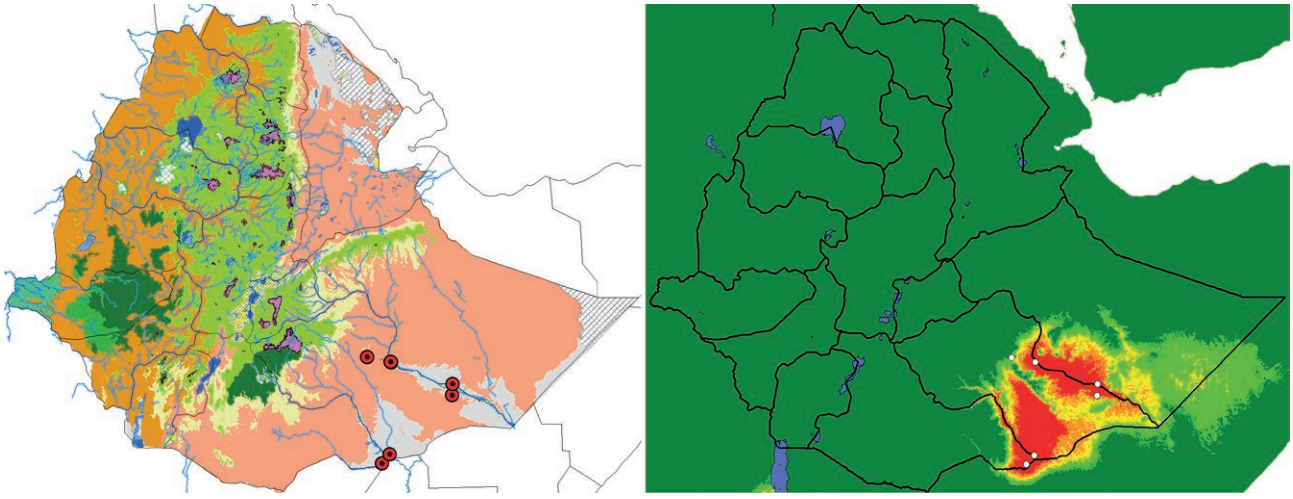

Figure 9. *Commiphora erlangeriana* Engl. in Ethiopia. Left hand map showing distribution of observed records on the vegetation types in Fig. 1B; right hand map showing modelled suitability of potential distribution areas of the species as defined in Fig. 2, based on climatic parameters. For text about species, see C01.

species is restricted to semi-desert scrublands along or near the lower reach of the Webe Shebele and the Genale rivers, with some transgression into *Acacia-Commiphora* woodland and bushland proper (Fig. 9).

In Ethiopia, the species has been reported to grow in *Acacia-Commiphora* bushland on rocky limestone and gypsum slopes (Vollesen 1989). In Tropical East Africa, it was not yet found when the flora was published but it had been collected from hills near the Kenya-Somalia border (Gillett 1991). In Somalia, it has been known from both the northern, central and southern parts, growing in open *Acacia-Commiphora* bushland, usually on gypseous ground (Thulin 1999).

Restricted to Ethiopia and Somalia. The extinction risk of the species is considered Vulnerable B2ab(iii) by Harvey-Brown Y. 2024. *Commiphora erlangeriana*. The IUCN Red List of Threatened Species 2024: e.T231498882A231498888. https://doi.org/10.2305/IUCN.UK.2024-1.RLTS.T231498882A231498888.en. There is a continuing decline in area, extent and/or quality of habitat, and the tree is used for logging and wood harvesting.

C02. ***Commiphora staphyleifolia*** Chiov., Fl. Somala 2: 97. 1932.

One occurrence point studied, and hence the species is not modelled. The only record is from semi-desert scrublands along or near the lower reach of the Genale River (Fig. 10).

In Ethiopia, the species has been reported to grow in open *Acacia-Commiphora* bushland on yellowish alluvium overlying limestone (Vollesen 1989). In Somalia, it has been known from the central and southern part, growing in open bushland on silt plains and on limestone hills (Thulin 1999).

Restricted to Ethiopia and Somalia. This extinction risk of this species is considered Data Deficient by IUCN SSC Global Tree Specialist Group & Botanic Gardens Conservation International (BGCI). 2023. *Commiphora staphyleifolia*. The IUCN Red List of Threatened Species 2023: e.T198161143A198161145. https://doi.org/10.2305/IUCN.UK.2023-1.RLTS.T198161143A198161145.en.

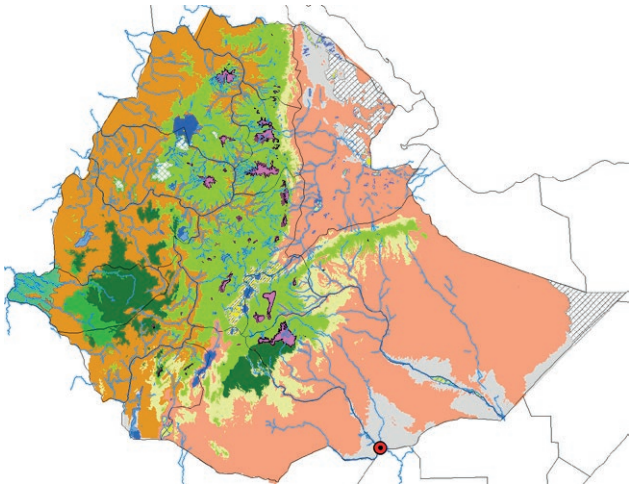

Figure 10. *Commiphora staphyleifolia* Chiov. in Ethiopia. Map showing distribution of observed records on the vegetation types in Fig. 1B. Modelling is not possible based on only one occurrence point. For text about species, see C02.

C03. ***Commiphora unilobata*** J.B.Gillett & Vollesen, Kew Bull. 40: 73. 1985.

Two occurrence points with nearly identical locations have been studied. This is not sufficient for reliable modelling, but as far as is known, the species is restricted to semi-desert scrubland along or near the lower reach of the Genale River (Fig. 11).

In Ethiopia, the species has been reported to grow in open *Acacia-Commiphora* bushland on yellowish alluvium overlying limestone (Vollesen 1989). In Tropical East Africa (Kenya), it has been found in open *Acacia-Commiphora* bushland, chiefly on alluvium (Gillett 1991).

In Somalia, it has been known from the central and southern part, growing in *Acacia-Commiphora* bushland or on silt plains (Thulin 1999).

In Ethiopia, Somalia, northern and eastern Kenya. The extinction risk of the species is considered Near Threatened by Thulin M. 1998. *Commiphora unilobata*. The IUCN Red List of Threatened Species 1998: e.T35166A9915779. https://doi.org/10.2305/IUCN.

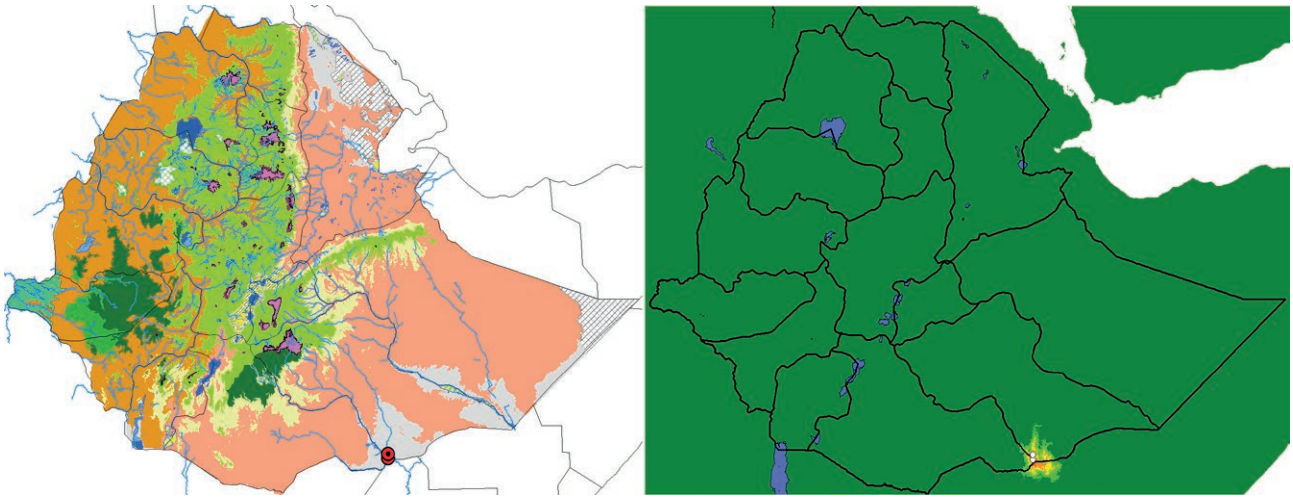

Figure 11. *Commiphora unilobata* Gillett & Vollesen in Ethiopia. Left hand map showing distribution of observed records on the vegetation types in Fig. 1B; right hand map showing modelled suitability of potential distribution areas of the species as defined in Fig. 2, based on climatic parameters. For text about species, see C03.

UK.1998.RLTS.T35166A9915779.en. There is a continuing decline in area, extent and/or quality of habitat, and the tree is used for logging and wood harvesting.

C04. ***Commiphora guidottii*** Chiov., Fl. Somala 2: 91. 1932.

(-) *Commiphora guidottii* Chiov. ex Guid., Rivista Ital. Essenze e Profumi 13: 232. 1931, not validly published.

(=) *C. sessiliflora* Vollesen, Kew Bull. 40: 71. 1985.

Eleven occurrence points studied. This is not sufficient for reliable modelling, and the records studied do far from fill the climatic model. Most records are from semi-desert scrublands or *Acacia-Commiphora* bushland along or near the lower reaches of the Genale and Webe Shebele rivers; one record has transgressed into transitional semi-evergreen bushland (Fig. 12).

In Ethiopia, the species has been reported to grow in open to dense *Acacia-Commiphora-Boswellia rivae* bushland on stony slopes with gypseous soils or yellowish alluvium overlying limestone (Vollesen 1989). In Tropical East Africa it was not yet found when the flora was published but it had been collected from hills near the Kenya-Somalia border (Gillett 1991). In Somalia, it has been known from both the northern, central and southern parts, growing in open *Acacia-Commiphora* bushland on gypsum (Thulin 1999).

Restricted to Ethiopia and Somalia. The extinction risk of the species is considered Vulnerable A2c; C1 by Alemu S, Alemu S, Atnafu H, Awas T, Bahdon J, Belay B, Demissew S, Luke WRQ, Mekbib E, Nemomissa S. 2021. *Commiphora guidottii* (errata version published in 2022). The IUCN Red List of Threatened Species 2021: e.T35815A223073528. https://doi.org/10.2305/IUCN.UK.2021-3.RLTS.T35815A223073528.en. There is a continuing decline of mature individuals, a continuing decline in area, extent and/or quality of habitat, and material of the plant is gathered.

In some nomenclatural databases (for example https://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:127676-1) the name of this species is stated to have been validly published as the name of a new species by Guidotti (1931: 232) with the intended diagnostic statement "*Pianta a portamento cespuglioso, caratteristica per i rami rivolti verso terra nella parte terminale*." Being published before 1 January 1935, a diagnosis in Italian is sufficient for valid publication of the name for a new species, but Guidotti's statement cannot be a diagnosis distinguishing the new species from other taxa, as required by Turland et. al. (2018: Art. 38.2), because several other shrubs of *Commiphora* in that paper have "branches pointing towards the ground at the end", a fact which in the same paper is documented with habitat photographs of other species of *Commiphora*. We consider Chiovenda's publication from 1932 as the correct place of validation of this name.

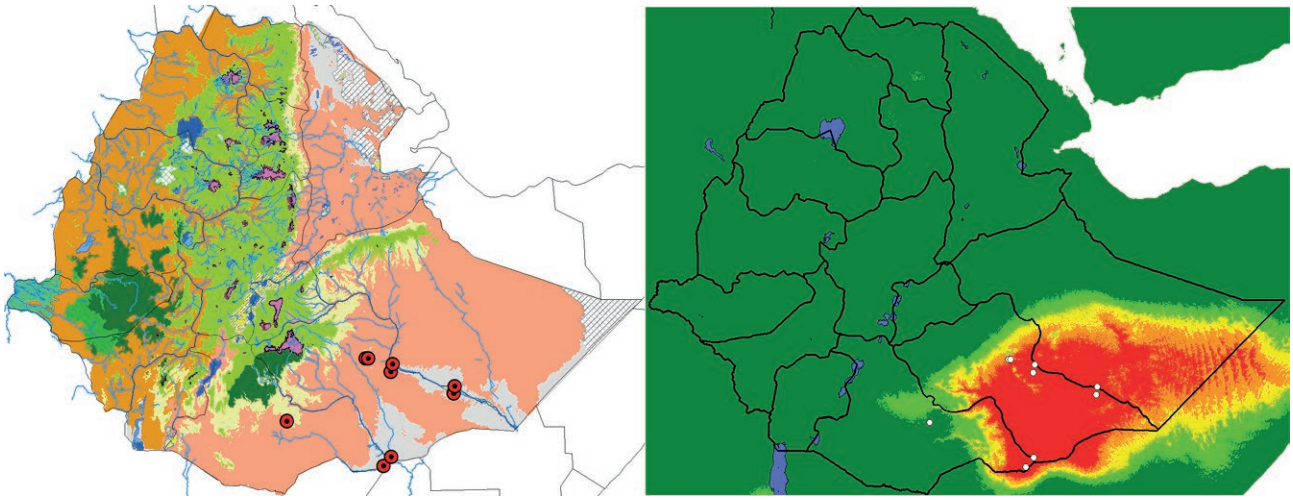

Figure 12. *Commiphora guidottii* Chiov. ex Guid. in Ethiopia. Left hand map showing distribution of observed records on the vegetation types in Fig. 1B; right hand map showing modelled suitability of potential distribution areas of the species as defined in Fig. 2, based on climatic parameters. The westernmost outlying collection in SD was included in the modelling but is not in the predicted area. For text about species, see C04.

C05. ***Commiphora paolii*** Chiov., Res. Sci. Somalia Ital. 1: 46. 1916.

(=) *C. longipedicellata* Vollesen, Kew Bull. 40: 69. 1985.

Four occurrence points studied. This is not sufficient for reliable modelling, and the few records do not fill the climatic model. The records studied are from semi-desert scrublands or *Acacia-Commiphora* bushland along or near the lower reach of the Webe Shebele River and a tributary (Fig. 13).

In Ethiopia, the species has been reported to grow in *Acacia-Commiphora* bushland on rocky limestone slopes (Vollesen 1989). In Tropical East Africa (Kenya), it has been found growing in *Acacia-Commiphora* bushland and coastal thickets on sand dunes (Gillett 1991). In Somalia, it has been known from the central and southern parts, growing in *Acacia-Commiphora* bushland (Thulin 1999).

Restricted to Ethiopia, Somalia, and northeastern Kenya. Not red-listed by IUCN.

C06. ***Commiphora edulis*** (Klotzsch) Engl. subsp. ***boiviniana*** (Engl.) J.B.Gillett, Fl. Trop. E. Africa, Burserac.: 65. 1991.

(≡) *C. boiviniana* Engl. in A.L.P.P. de Candolle & A.C.P. de Candolle, Monogr. Phan. 4: 21. 1883.

Twelve occurrence points studied. This is not fully sufficient for reliable modelling. The records studied are from varied vegetation around the northern end of Lake Turkana, including *Combretum-Terminalia* woodland, *Acacia-Commiphora* bushland proper, and transitional semi-evergreen bushland (Fig. 14).

There is good agreement between the recorded distribution in Ethiopia and area of highest suitability. However, one southeastern record is far outside the predicted area of distribution. The modelled omission rates of subsp. *boiviniana* are deviating from the expected value, suggesting that the model may not perform as intended. The highest contribution to the model is provided by Bio4 (temperature seasonality).

In Ethiopia, subsp. *boiviniana* has been reported to grow in *Acacia-Commiphora* bushland, in *Combretum-Terminalia* wooded grassland and in dry riverine forest (in the western part of the distribution area), and also on rocky slopes or sandy soil derived from basement rocks, and apparently not in limestone areas (Vollesen 1989). In Tropical East Africa (Uganda, Kenya, Tanzania), it (subsp. *boiviniana*) has been found growing in *Acacia-Commiphora* bushland and semi-evergreen bushland (Gillett 1991). In Somalia, subsp. *boiviniana* is known from the southern parts, growing in *Acacia-Commiphora* bushland and deciduous woodland (Thulin 1999).

Subsp. *boiviniana* is restricted to Ethiopia, Somalia, northeastern Uganda, Kenya, Tanzania. Subsp. *edulis* occurs from Tanzania south to Transvaal. Subsp. *holosericea* is restricted to Kenya. The species is not red-listed as a whole, nor is the status of subsp. *boiviniana* assessed as a distinct taxon. The extinction risk of the species *C. edulis* (as subsp. *edulis*) is considered Least Concern by Botanic Gardens Conservation International (BGCI) &

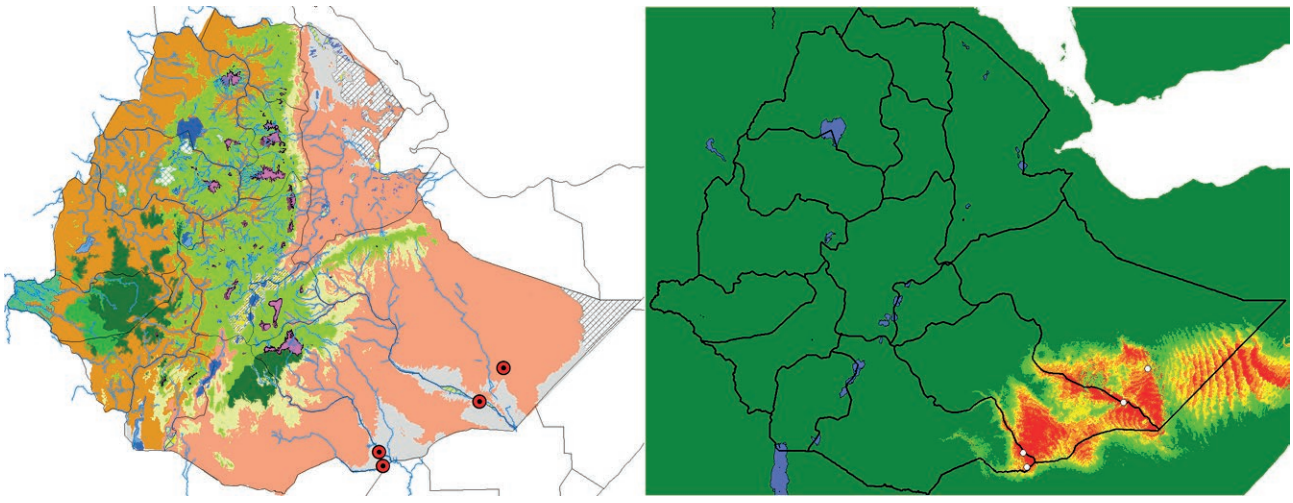

Figure 13. *Commiphora paolii* Chiov. in Ethiopia. Left hand map showing distribution of observed records on the vegetation types in Fig. 1B; right hand map showing modelled suitability of potential distribution areas of the species as defined in Fig. 2, based on climatic parameters. For text about species, see C05.

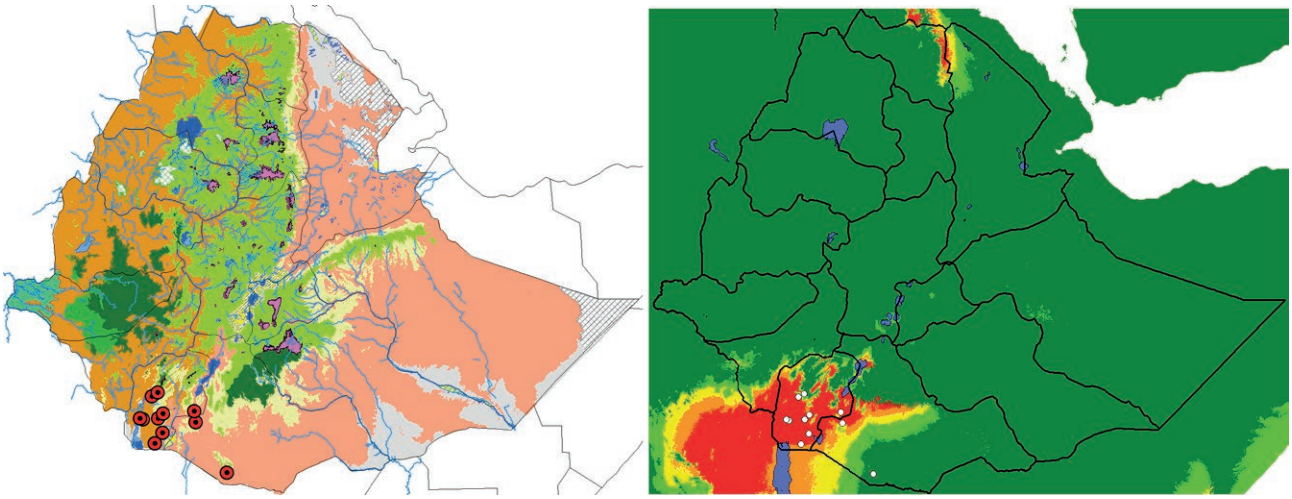

Figure 14. *Commiphora edulis* subsp. *boiviniana* (Engl.) Gillett in Ethiopia. Left hand map showing distribution of observed records on the vegetation types in Fig. 1B; right hand map showing modelled suitability of potential distribution areas of the species as defined in Fig. 2, based on climatic parameters. For text about species, see C06.

IUCN SSC Global Tree Specialist Group. 2019. *Commiphora edulis*. The IUCN Red List of Threatened Species 2019: e.T146209364A146209366. https://doi.org/10.2305/IUCN.UK.2019-2.RLTS.T146209364A146209366.en.

C07. ***Commiphora sphaerophylla*** Chiov., Fl. Somala 2: 119. 1932.

(=) *C. ellisiae* Vollesen, Kew Bull. 40: 67. 1985.

Six occurrence points studied. This is not sufficient for reliable modelling, and the six known occurrence points are far apart and do not fill the climatic model. The records studied are from *Acacia-Commiphora* bushland, especially the drier parts of this vegetation type, and a few records are from near semi-desert scrubland at a tributary of the Webe Shebele River (Fig. 15).

In Ethiopia, the species has been reported to grow in *Acacia-Commiphora* wooded grassland and bushland on red to brownish sandy soil overlying limestone, and on rocky slopes (Vollesen 1989). In Somalia, it has been known from both northern, central and southern parts, growing in *Acacia-Commiphora* bushland (Thulin 1999).

Restricted to Ethiopia and Somalia. The extinction risk of the species is considered Near Threatened by Thulin M. 1998. *Commiphora sphaerophylla*. The IUCN Red List of Threatened Species 1998: e.T35825A9960461. https://doi.org/10.2305/IUCN.UK.1998.RLTS.T35825A9960461.en.

C08. ***Commiphora myrrha*** (T.Nees) Engl. in A.L.P.P. de Candolle & A.C.P. de Candolle, Monogr. Phan. 4: 10. 1883.

(=) *C. coriacea* Engl., Bot. Jahrb. Syst. 26: 369. 1899.

(=) *C. molmol* (Engl.) Engl. ex Tschirch, Handb. Pharmakogn. 3: 1117. 1925.

(=) *C. cuspidata* Chiov., Bull. Misc. Inform. Kew 1941: 134. 1941.

(=) *C. habessinica* var. *grossedentata* Chiov., Atti Reale Accad. Italia, Mem. Cl. Sci. Fis. 11: 22. 1941.

Thirty-seven occurrence points studied, which we consider sufficient for reliable modelling, and the model has a large distribution area in HA, with smaller areas in SD and BA. However, the records studied are scattered within the areas of highest suitability, including in the southern part of the Afar region. Most records are from *Acacia-Commiphora* bushland proper, but also often collected in semi-desert scrubland along the Genale and the Webe Shebele rivers. Some records have transgressed into transitional semi-evergreen bushland (Fig. 16).

The modelled omission rates of *C. myrrha* agree with the expected values, suggesting that the model may perform as intended. The highest contribution to the model is provided by Bio12 (annual precipitation).

In Ethiopia, the species has been recorded to grow in *Acacia-Commiphora* woodland and bushland on sandy to loamy soil overlying limestone and granite, and

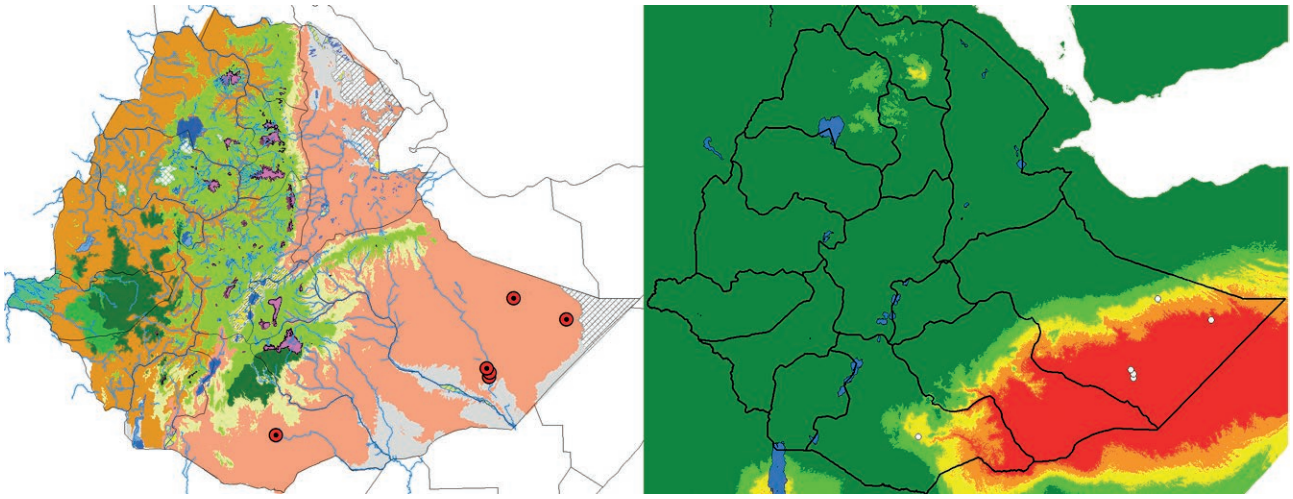

Figure 15. *Commiphora sphaerophylla* Chiov. in Ethiopia. Left hand map showing distribution of observed records on the vegetation types in Fig. 1B; right hand map showing modelled suitability of potential distribution areas of the species as defined in Fig. 2, based on climatic parameters. For text about species, see C07.

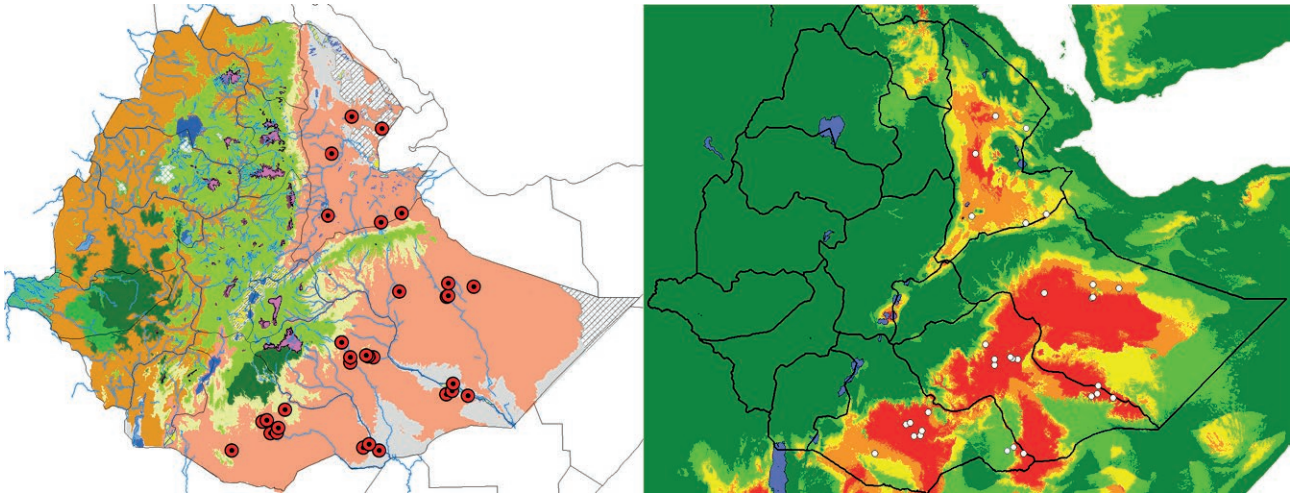

Figure 16. *Commiphora myrrha* (Nees) Engl. in Ethiopia. Left hand map showing distribution of observed records on the vegetation types in Fig. 1B; right hand map showing modelled suitability of potential distribution areas of the species as defined in Fig. 2, based on climatic parameters. For text about species, see C08.

rocky lava hills (Vollesen 1989). In Tropical East Africa (Kenya), it has been found growing in open *Acacia-Commiphora* bushland in shallow soil over limestone (Gillett 1991). In Somalia, it has been known from both northern, central and southern parts, growing in *Acacia-Commiphora* bushland (Thulin 1999).

In Ethiopia, Somalia, northeastern Kenya, Arabia. Not red-listed by IUCN.

C09. ***Commiphora samharensis*** Schweinf., Bull. Herb. Boisser 7 (App. 2): 290. 1899.

(=) *C. terebinthina* Vollesen, Kew Bull. 40: 45. 1985.

(=) *C. samharensis* subsp. *terebintha* (Vollesen) J.B.Gillett, Fl. Trop. E. Africa, Burserac.: 40. 1991.

Thirty-one occurrence points studied, which we consider sufficient for reliable modelling. However, in spite of the species occurring in Eritrea, the records

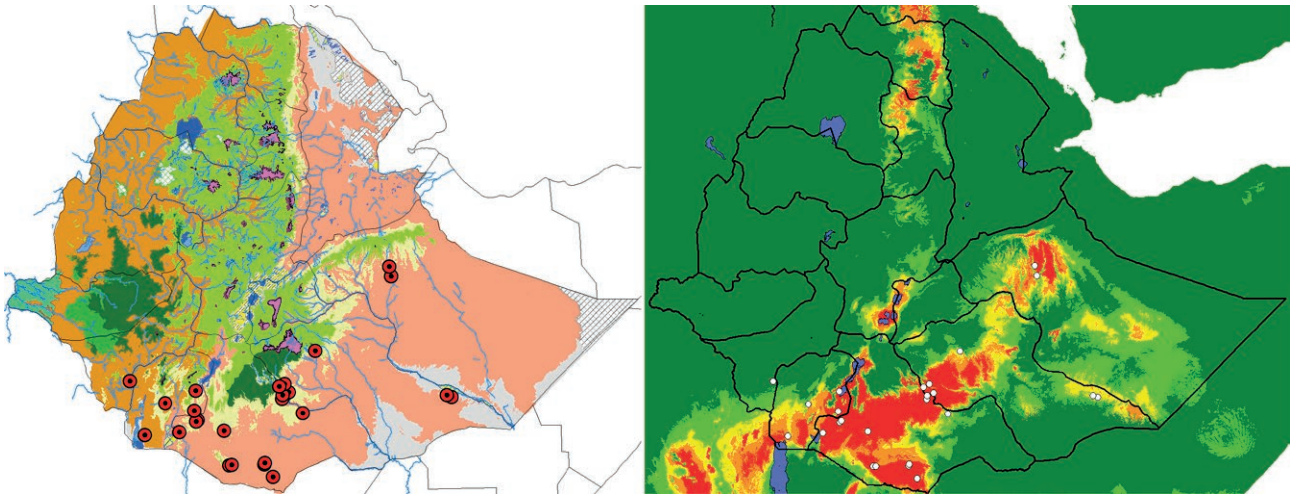

Figure 17. *Commiphora samharensis* Schweinf. in Ethiopia. Left hand map showing distribution of observed records on the vegetation types in Fig. 1B; right hand map showing modelled suitability of potential distribution areas of the species as defined in Fig. 2, based on climatic parameters. For text about species, see C09.

studied from Ethiopia are scattered within the southern areas with highest suitability, with no records from northern Ethiopia near the long-established records from Eritrea. The species does not fill the suitable climatic area well and has not been recorded from the suitable areas on the eastern escarpment of the Ethiopian highlands in the north. The records are most prominent in GG, SD, and BA, less prominent in HA. Most records are from *Acacia-Commiphora* bushland proper, but the species has also been collected from semi-desert scrubland along the Webe Shebele River, and some records have transgressed into transitional semi-evergreen bushland (Fig. 17).

The modelled omission rates of *C. samharensis* agree with the expected values, suggesting that the model performs as intended. The highest contribution to the model is provided by Bio3 (isothermality).

In Ethiopia, *C. samharensis* has been recorded to grow on rocky hills (Vollesen 1989), but these records are mainly from Eritrea, while the plants from Ethiopia, called *C. terebinthina*, are found widespread in *Acacia-Commiphora* woodland and bushland in southern Ethiopia, as well as in wooded grassland, *Combretum-Terminalia* wooded grassland, all on whitish to red sandy to stony soil overlying limestone or basement rocks, on rocky slopes and on black cotton soil (Vollesen 1989). In Tropical East Africa (Uganda, Kenya, Tanzania), it has been found growing in *Acacia-Commiphora* bushland and bushed grassland (Gillett 1991). In Somalia, it has been known from both northern, central and southern parts, growing in *Acacia-Commiphora* bushland and wooded grassland (Thulin 1999).

The species is widespread in eastern Sudan (Darbyshire et al. 2015), Eritrea, Ethiopia, Somalia, northeastern Uganda, Kenya, and northeastern Tanzania. Not red-listed by IUCN.

C10. ***Commiphora schimperi*** (O.Berg) Engl. in A.L.P.P. de Candolle & A.C.P. de Candolle, Monogr. Phan. 4: 13. 1883.

(=) *C. arussensis* Engl., Bot. Jahrb. Syst. 34(3): 305. 1904.

Forty-three occurrence points studied, which we consider sufficient for reliable modelling. Most records are from *Acacia-Commiphora* bushland proper, but the species also occur in *Combretum-Terminalia* woodland in the deep values of rivers running westwards towards the Nile, as well as in *Acacia* wooded grassland of the Rift Valley (Fig. 18).

The records studied are widely scattered within the southern areas with highest suitability, particularly in southern Ethiopia, but the records only fill the suitable climatic areas moderately well outside southern Ethiopia. The modelled omission rates of *C. schimperi* agree with the expected values, suggesting that the model performs as intended. The highest contribution to the model is provided by Bio14 (precipitation of driest month).

In Ethiopia, the species has been reported to grow in *Acacia-Commiphora*, *Acacia-Combretum* and *Combretum-Terminalia* woodland and bushland, on red sandy to stony soil overlying limestone and basement rocks, also on rocky slopes, on black cotton soil and ter-

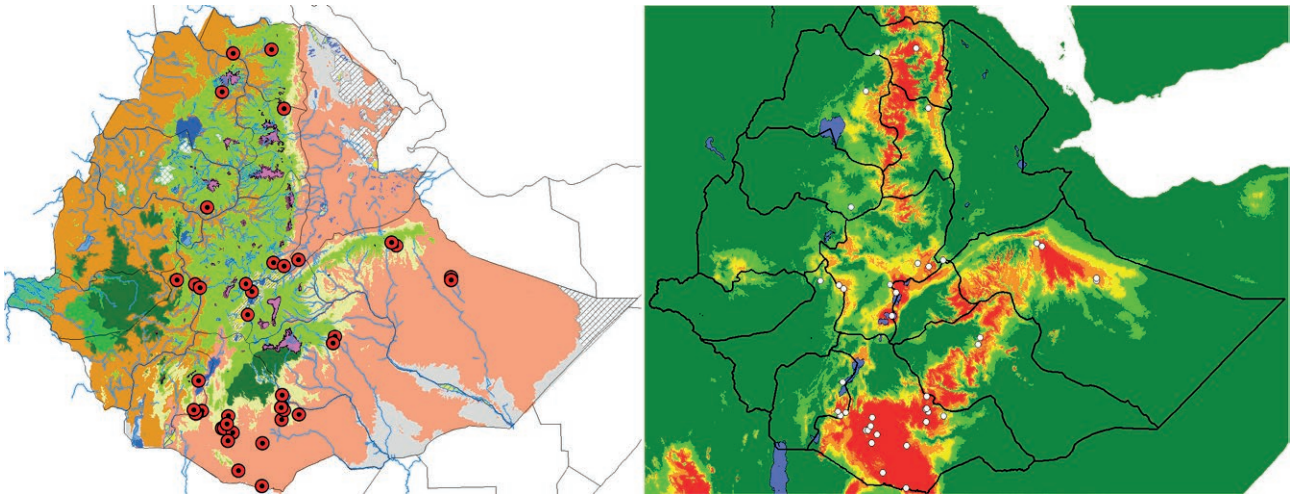

Figure 18. *Commiphora schimperi* (Berg) Engl. in Ethiopia. Left hand map showing distribution of observed records on the vegetation types in Fig. 1B; right hand map showing modelled suitability of potential distribution areas of the species as defined in Fig. 2, based on climatic parameters. For text about species, see C10.

mite mounds (Vollesen 1989). In Tropical East Africa (Uganda, Kenya, Tanzania), it has been found growing in bushed grassland and *Acacia-Commiphora* bushland (Gillett 1991). In Somalia, it has been known from both northern, central and southern parts, growing in *Acacia-Commiphora* bushland and woodland (Thulin 1999).

The species is widespread in Sudan (Darbyshire et al. 2015), Somalia, Uganda, Kenya, Tanzania, and southwards to South Africa; also in Arabia. The extinction risk of the species is considered Least Concern by Botanic Gardens Conservation International (BGCI) & IUCN SSC Global Tree Specialist Group. 2021. *Commiphora schimperi* (amended version of 2020 assessment). The IUCN Red List of Threatened Species 2021: e.T88322531A208439214. https://doi.org/10.2305/IUCN.UK.2021-3.RLTS.T88322531A208439214.en. The status of the species is considered stable.

C11. ***Commiphora obovata*** Chiov., Bull. Misc. Inform. Kew 1941: 136. 1941.

Four occurrence points studied. This is not sufficient for reliable modelling, and the few records do far from fill the climatic model. The records studied are widely scattered in *Acacia-Commiphora* bushland, and some are transgressing into transitional semi-evergreen bushland (Fig. 19).

In Ethiopia, the species has been reported to grow in *Acacia-Commiphora* bushland on rocky limestone slopes (Vollesen 1989). In Tropical East Africa (Kenya), it has been found growing in broken and scattered semi-evergreen coastal bushland (Gillette 1991). In Somalia, it has been known from the northern and central parts, growing in *Acacia-Commiphora* bushland (Thulin 1999).

Restricted to Ethiopia, Somalia, and Kenya. The extinction risk of the species is considered Near Threatened by Thulin M. 1998. *Commiphora obovata*. The IUCN Red List of Threatened Species 1998: e.T34799A9885922. https://doi.org/10.2305/IUCN.UK.1998.RLTS.T34799A9885922.en. The status is considered in need of updating.

C12. ***Commiphora africana*** (A.Rich.) Engl. in A.L.P.P. de Candolle & A.C.P. de Candolle, Monogr. Phan. 4: 14. 1883.

(=) *C. tubuk* Sprague in Hooker's Icon. Pl. 32: t. 3108. 1927.

Ninety-five occurrence points have been studied, which we consider sufficient for reliable modelling. In particular, the records studied are scattered within the southern areas with highest suitability but are widely scattered in other parts of the areas predicted to be suitable, including in the deep valley of rivers in the south running towards the Nile in the northwest and west, towards Lake Turkana in the south, to the Webe Shebele in the southeast, and to the Awash River basin in the east.

Most records are from *Acacia-Commiphora* bushland proper, but the species has also been collected from *Combretum-Terminalia* woodland in the southwest and the northeast, as well as close to semi-desert scrubland

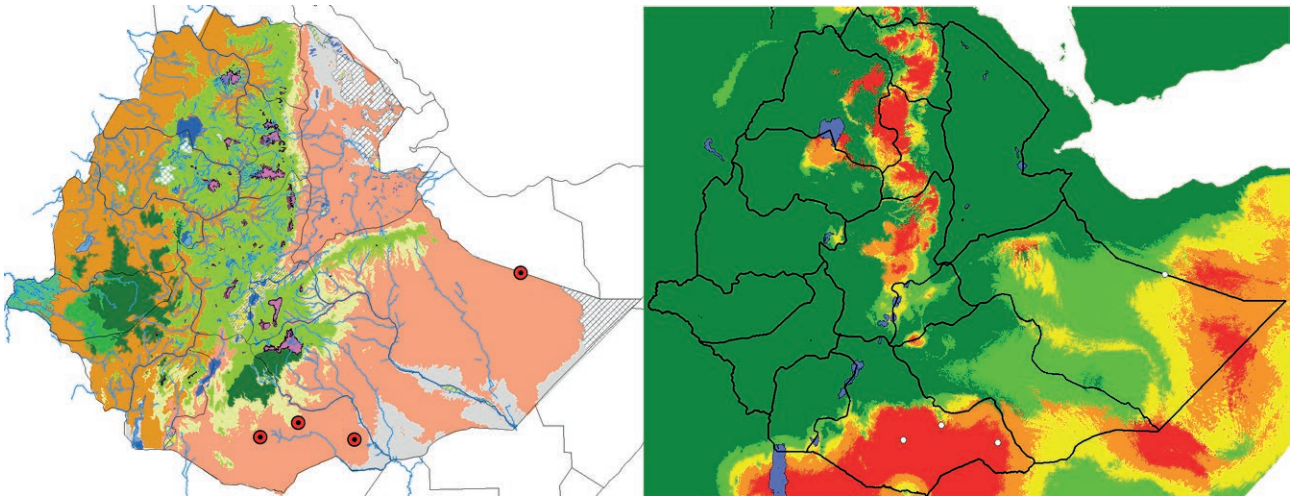

Figure 19. *Commiphora obovata* Chiov. in Ethiopia. Left hand map showing distribution of observed records on the vegetation types in Fig. 1B; right hand map showing modelled suitability of potential distribution areas of the species as defined in Fig. 2, based on climatic parameters. Large areas in northern Ethiopia are predicted to have climatically suitable areas for the species, but it has not been found there. For text about species, see C11.

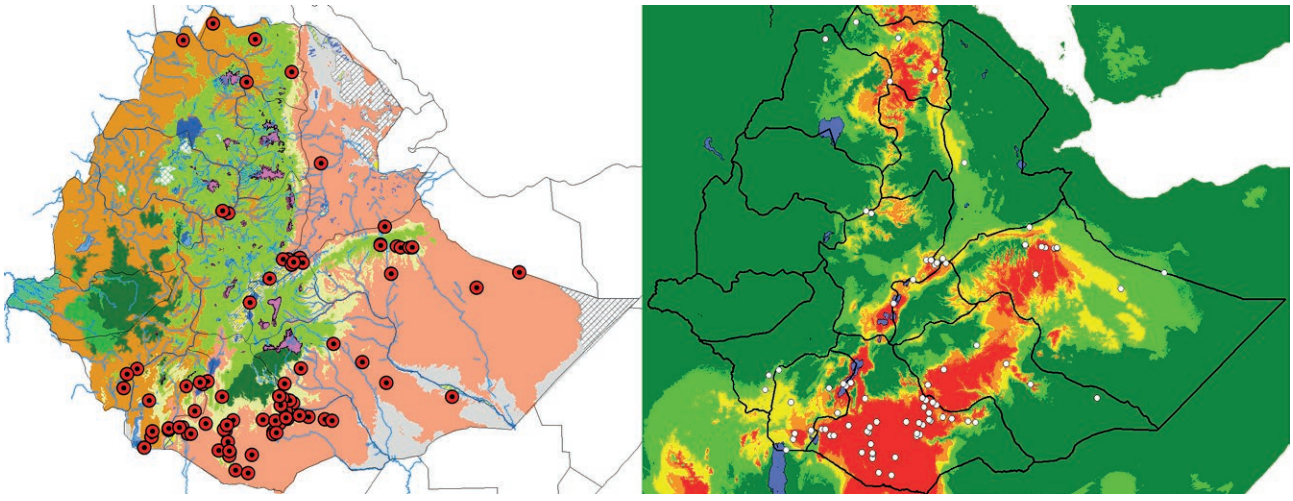

Figure 20. *Commiphora africana* (A. Rich.) Engl. in Ethiopia. Left hand map showing distribution of observed records on the vegetation types in Fig. 1B; right hand map showing modelled suitability of potential distribution areas of the species as defined in Fig. 2, based on climatic parameters. One southeastern record is outside the predicted area. For text about species, see C12.

at the Webe Shebele River, and it transgresses into transitional semi-evergreen bushland (Fig. 20).

The modelled omission rates of *C. africana* agree with the expected values, suggesting that the model performs as intended. The highest contribution to the model is provided by Bio3 (isothermality).

In Ethiopia, the species has been reported to grow in *Acacia* and *Acacia-Commiphora* bushland, *Commiphora-Boswellia*, *Acacia-Terminalia*, *Acacia-Balanites*, and *Combretum-Terminalia* woodland, wooded grassland and bushland, often on rocky slopes in areas with basement rocks but also on level sandy to loamy soil and recent lava flows. This summary is based on the combined information about *C. africana* and *C. tubuk* in Vollesen (1989).

In Tropical East Africa (Uganda, Kenya, Tanzania), it has been found to be very variable and reported to grow in bushed grassland, *Acacia-Commiphora* bushland, in dry open *Acacia-Commiphora* bushland and in coastal semi-evergreen thickets (Gillett 1991). In Somalia, it has been known from northern, central and south-

ern parts, growing in *Acacia-Commiphora* bushland or woodland, also on sand of coastal dunes (Thulin 1999).

The species is widespread in drier parts of Africa from Senegal to Sudan (Darbyshire et al. 2015) and Ethiopia and south to Namibia, Zimbabwe, and Mozambique. The extinction risk of the species is considered Least Concern by Botanic Gardens Conservation International (BGCI) & IUCN SSC Global Tree Specialist Group. 2019. *Commiphora africana*. The IUCN Red List of Threatened Species 2019: e.T146216386A146216388. https://doi.org/10.2305/IUCN.UK.2019-2.RLTS.T146216386A146216388.en. The status of the species is considered stable.

C13. ***Commiphora monoica*** Vollesen, Kew Bull. 40: 62. 1985.

Seven occurrence points in three locations studied. The species is endemic to Ethiopia, and we have to consider seven records sufficient for modelling. These few records do far from fill the climatic model, with a much smaller recorded distribution in the south than predicted, and there are no records in highly suitable areas in the north (Fig. 21).

The records studied are all from transitional semi-evergreen bushland in the south. In its restricted area the species has been recorded from dense *Commiphora* woodland on rocky limestone slopes and *Acacia-Commiphora* bushland on black cotton soil (Vollesen 1989).

The species is endemic to Ethiopia. The extinction risk of the species is considered Critically Endangered B1ab(i,ii,iii,iv,v); C2a(i,ii) by D. Alemu S, Alemu S, Atnafu H, Awas T, Belay B, Demissew S, Luke WRQ, Mekbib E, Nemomissa S. 2021. *Commiphora monoica* (errata version published in 2022). The IUCN Red List of Threatened Species 2021: e.T34389A223071378. https://doi.org/10.2305/IUCN.UK.2021-3.RLTS.T34389A223071378.en. There is a continuing decline in number of mature individuals, in area, extent and/or quality of habitat, and material is being collected from the wild.

C14. ***Commiphora pedunculata*** (Kotschy & Peyr.) Engl. in A.L.P.P. de Candolle & A.C.P. de Candolle, Monogr. Phan. 4: 23. 1883.

Eleven occurrence points studied. This is not sufficient for reliable modelling, but the few records from the western border of Ethiopia fill one of two highly suitable areas in *Combretum-Terminalia* woodland in western Ethiopia, forming the eastern end of the total distribution area of the species (Fig. 22).

In Ethiopia, according to Vollesen (1989), the species was expected to grow in *Combretum-Terminalia* woodland and wooded grassland, but this was not based on material from inside Ethiopia. However, the information has been confirmed from detailed studies in the field by Friis et al. (2022). In Tropical East Africa (southwestern Tanzania), it has been found growing in *Brachystegia* woodland and in mixed deciduous woodland (Gillett 1991).

The species is widespread from Mali to Sudan, South Sudan (Darbyshire et al. 2015), and W Ethiopia, south to southern Tanzania, Malawi and Zambia. The

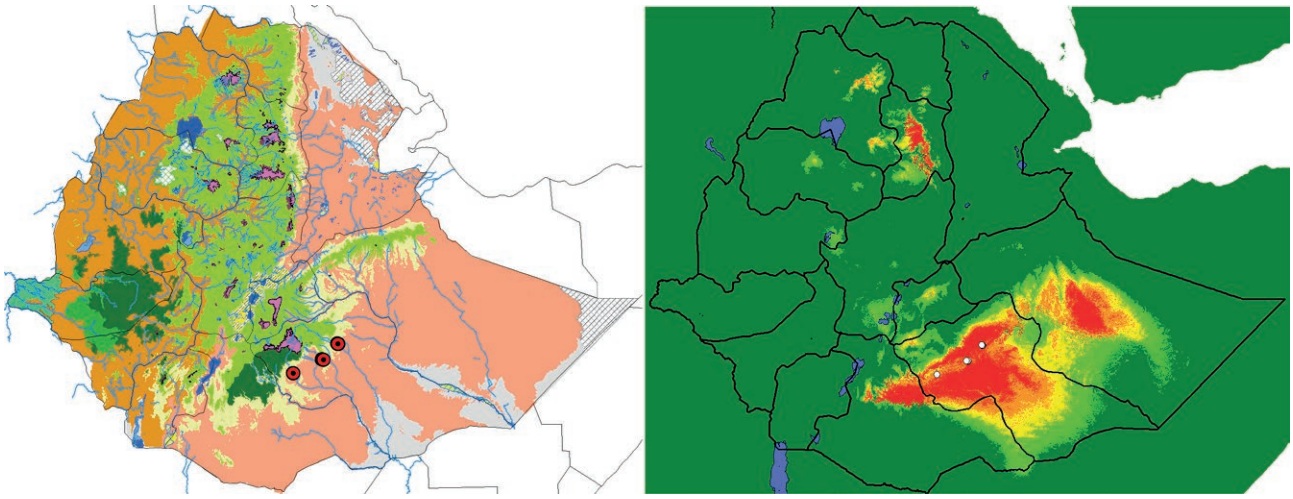

Figure 21. *Commiphora monoica* Vollesen in Ethiopia. Left hand map showing distribution of observed records on the vegetation types in Fig. 1B; right hand map showing modelled suitability of potential distribution areas of the species as defined in Fig. 2, based on climatic parameters. For text about species, see C13.

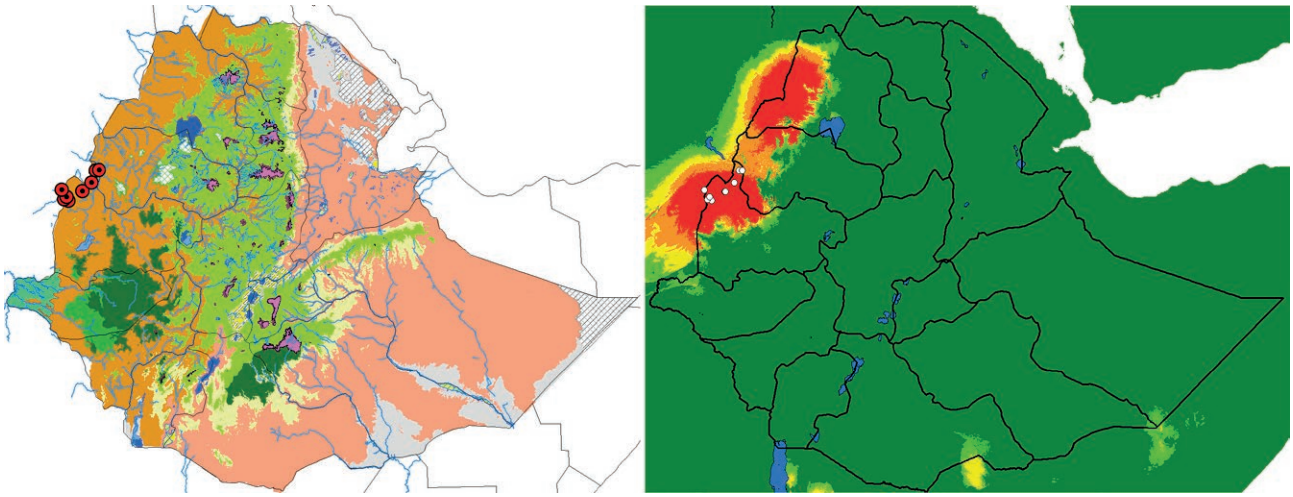

Figure 22. *Commiphora pedunculata* (Kotschy & Peyr.) Engl. in Ethiopia. Left hand map showing distribution of observed records on the vegetation types in Fig. 1B; right hand map showing modelled suitability of potential distribution areas of the species as defined in Fig. 2, based on climatic parameters. For text about species, see C14.

extinction risk of the species is considered Least Concern by Botanic Gardens Conservation International (BGCI) & IUCN SSC Global Tree Specialist Group. 2018. *Commiphora pedunculata*. The IUCN Red List of Threatened Species 2018: e.T128045009A135814518. https://doi.org/10.2305/IUCN.UK.2018-2.RLTS.T128045009A135814518.en. The status of the species and habitat is considered stable.

C15. ***Commiphora hildebrandtii*** Engl. in A.L.P.P. de Candolle & A.C.P. de Candolle, Monogr. Phan. 4: 15. 1883.

Nine occurrence points studied. This is not sufficient for reliable modelling, and the few records do far from fill the climatic model, with a scattered recorded distribution in the south that does not fill the highly suitable areas as predicted, and there are no records in the highly suitable area in the north. The records studied are all scattered in *Acacia-Commiphora* bushland proper, but marginal to transitional semi-evergreen bushland (Fig. 23).

In Ethiopia, the species has been reported to grow in *Acacia-Commiphora* woodland, wooded grassland and bushland on rocky limestone slopes and ridges (Vollesen 1989). In Thulin (1999) *C. hildebrandtii* and *C. ogadensis* were considered conspecific, and therefore no information was given other than the species grow in *Acacia-Commiphora* bushland.

Restricted to Ethiopia and Somalia. The extinction risk of the species is considered Least Concern by Alemu S, Alemu S, Atnafu H, Awas T, Belay B, Demissew S, Luke WRQ, Mekbib E, Nemomissa S. 2021. *Commiphora hildebrandtii* (errata version published in 2022). The IUCN Red List of Threatened Species 2021: e.T128044736A223075194. https://doi.org/10.2305/IUCN.UK.2021-3.RLTS.T128044736A223075194.en. The trends in population size and habitat are unknown.

C16. ***Commiphora ogadensis*** Chiov., Fl. Somala 2: 103. 1932.

Eight occurrence points studied. This is not sufficient for reliable modelling, and the few records do far from filling the climatic model, with a very scattered distribution recorded in the south. The species has been recorded from the *Acacia-Commiphora* bushland proper, but more records are from the transitional semi-evergreen bushland (Fig. 24).

No records have been observed from the areas with high or highest suitability in northern Ethiopia.

In Ethiopia, the species has been recorded to grow in *Acacia-Commiphora* woodland and bushland, on red sandy soil overlying limestone, on black cotton soil and, and on soil derived from granitic rocks (Vollesen 1989). In Tropical East Africa (Kenya), it has been found growing in *Acacia-Commiphora* bushland on alluvial soil, usually near base of mountains (Gillett 1991).

In Thulin (1999), *C. hildebrandtii* and *C. ogadensis* were considered conspecific, and therefore no information was given other than that the species grows in *Acacia-Commiphora* bushland.

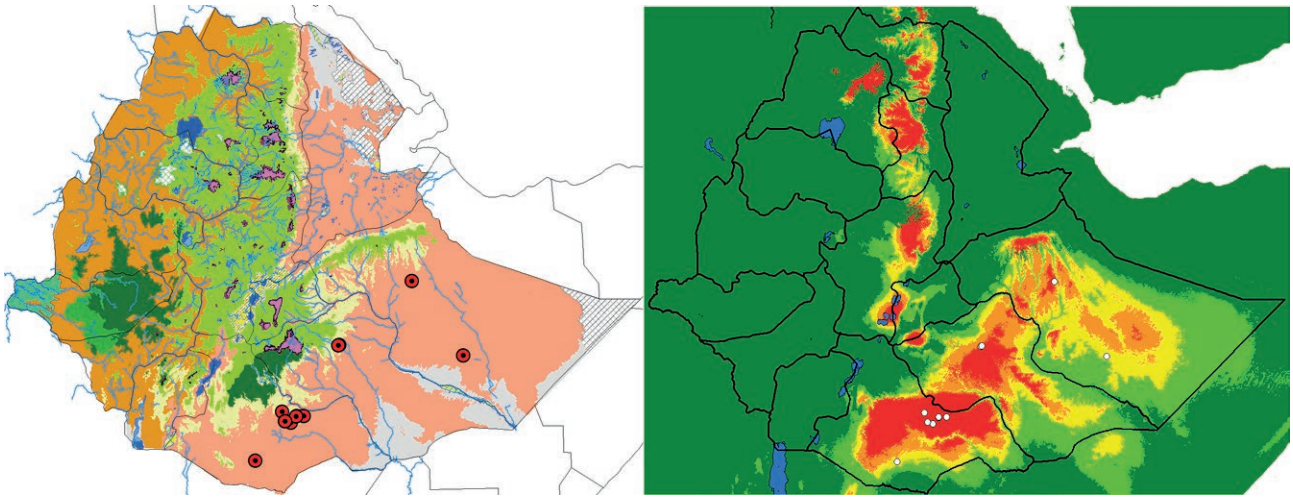

Figure 23. *Commiphora hildebrandtii* (Engl.) Engl. in Ethiopia. Left hand map showing distribution of observed records on the vegetation types in Fig. 1B; right hand map showing modelled suitability of potential distribution areas of the species as defined in Fig. 2, based on climatic parameters. For text about species, see C15.

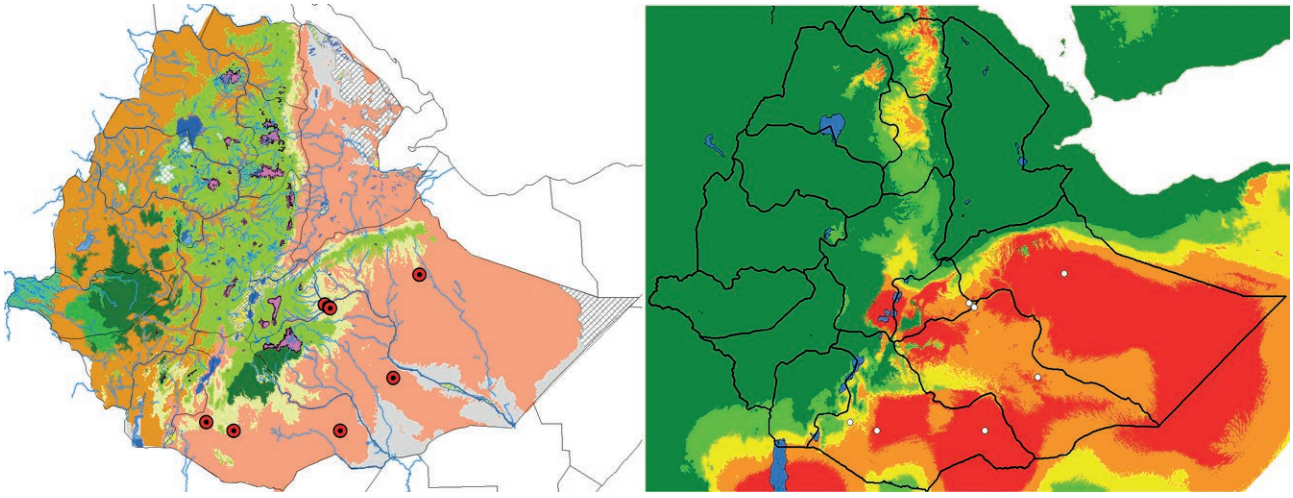

Figure 24. *Commiphora ogadensis* Chiov. in Ethiopia. Left hand map showing distribution of observed records on the vegetation types in Fig. 1B; right hand map showing modelled suitability of potential distribution areas of the species as defined in Fig. 2, based on climatic parameters. For text about species, see C16.

Restricted to Ethiopia, Somalia, and northeastern Kenya. The extinction risk of the species is considered Data Deficient by Alemu S, Alemu S, Atnafu H, Awas T, Belay B, Demissew S, Luke WRQ, Musili P, Nemomissa S, Bahdon J, Mekbib E. 2021. *Commiphora ogadensis* (errata version published in 2022). The IUCN Red List of Threatened Species 2021: e.T133268514A223078443. https://doi.org/10.2305/IUCN.UK.2021-3.RLTS.T133268514A223078443.en. The trends in population size and habitat are unknown.

C17. ***Commiphora corrugata*** J.B.Gillett & Vollesen, Kew Bull. 40: 59. 1985.

Twenty-seven occurrence points studied, which we consider sufficient for reliable modelling. The recorded distribution is scattered within the southeastern parts of Ethiopia with most records from *Acacia-Commiphora* bushland proper, but the species also transgresses into transitional semi-evergreen bushland (Fig. 25).

No records have been observed from the areas with high or highest suitability in northern Ethiopia. The

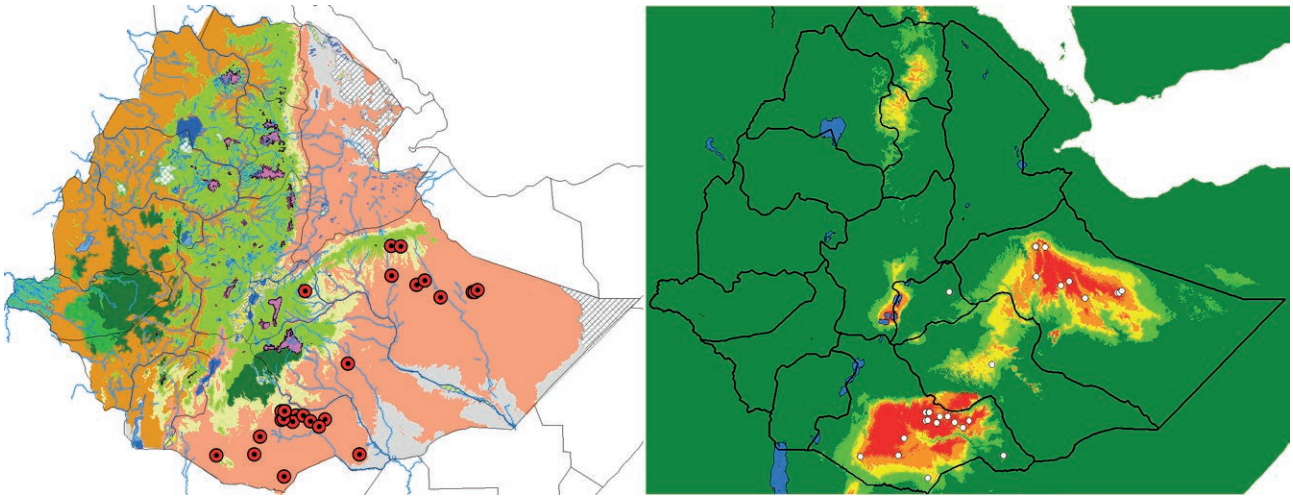

Figure 25. *Commiphora corrugata* Gillett & Vollesen in Ethiopia. Left hand map showing distribution of observed records on the vegetation types in Fig. 1B; right hand map showing modelled suitability of potential distribution areas of the species as defined in Fig. 2, based on climatic parameters. For text about species, see C17.

modelled omission rates of *C. corrugata* agree with the expected values, suggesting that the model performs as intended. The highest contribution to the model is provided by Bio3 (isothermality).

In Ethiopia, the species has been recorded to grow in *Acacia-Commiphora* woodland, wooded grassland and bushland on rocky limestone slopes and ridges (Vollesen 1989). In Tropical East Africa (Kenya), it has been found growing in *Acacia-Commiphora* bushland on limestone slopes (Gillett 1991). In Somalia, it is known from the central and southern parts, growing in *Acacia-Commiphora* bushland, usually on limestone (Thulin 1999).

In Ethiopia, Somalia, northeastern Kenya. The extinction risk of the species is considered Near Threatened C1 by Alemu S, Alemu S, Atnafu H, Awas T, Belay B, Demissew S, Luke WRQ, Mekbib E, Nemomissa S. 2021. *Commiphora corrugata* (errata version published in 2022). The IUCN Red List of Threatened Species 2021: e.T35164A223073349. https://doi.org/10.2305/IUCN.UK.2021-3.RLTS.T35164A223073349.en. The population size is declining.

C18. ***Commiphora truncata*** Engl., Bot. Jahrb. Syst. 34: 309. 1904.

Four occurrence points studied. This is not sufficient for reliable modelling, and the few records do far from fill the large area occupied by the climatic model. Three records are from drier parts of *Acacia-Commiphora* bushland proper, while one record is from near semi-desert scrubland at a tributary to the Webe Shebele River (Fig. 26).

In Ethiopia, the species has been reported to grow in *Acacia-Commiphora* bushland on red sandy soil to stony soil overlying limestone (Vollesen 1989). In Somalia, it has been found both in the northern, central and southern parts, growing in *Acacia-Commiphora* bushland and semi-desert scrub (Thulin 1999).

Restricted to Ethiopia and Somalia. The extinction risk of the species is considered Near Threatened by Thulin M. 1998. *Commiphora truncata*. The IUCN Red List of Threatened Species 1998: e.T35831A9961055. https://doi.org/10.2305/IUCN.UK.1998.RLTS.T35831A9961055.en. The trends in population size and habitat are unknown.

C19. ***Commiphora confusa*** Vollesen, Kew Bull. 40: 54. 1985.

Twenty-four occurrence points studied, which we consider sufficient for reliable modelling. Most records studies are from *Acacia-Commiphora* bushland proper in southern Ethiopia, but the species also transgresses into *Combretum-Terminalia* woodland to the west of the Omo River and transitional semi-evergreen bushland further to the east; one record is from near the semi-desert scrubland at the Webe Shebele River (Fig. 27).

The records fill the suitable climatic areas in southern Ethiopia, but no records have been observed from the areas with high or highest suitability in northern Ethiopia, and it is striking that such a fairly common species does not seem to have been found in southeastern Ethiopia when it is also common in eastern Kenya.

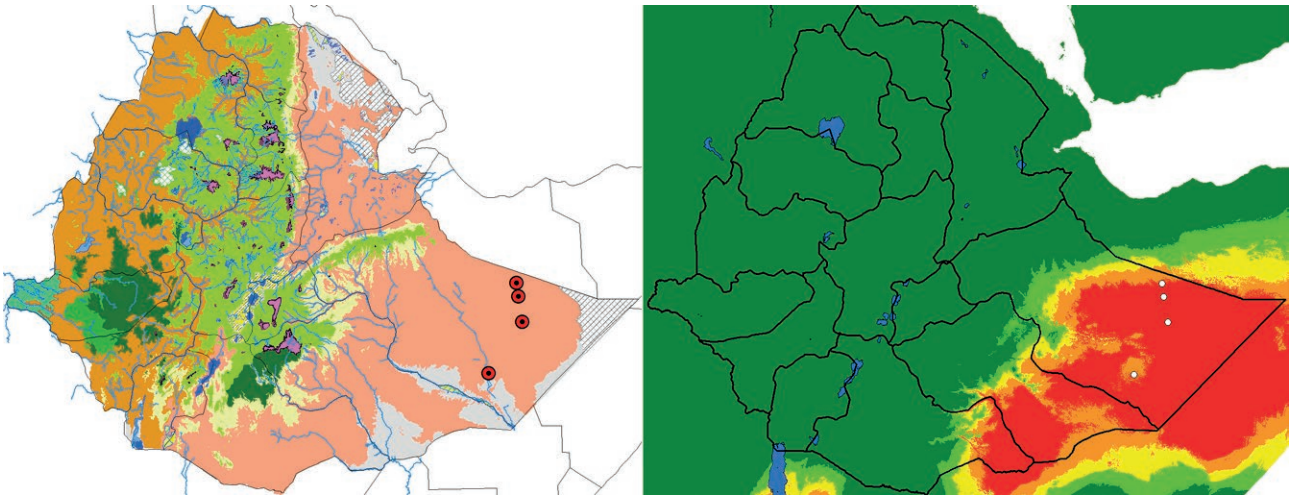

Figure 26. *Commiphora truncata* Engl. in Ethiopia. Left hand map showing distribution of observed records on the vegetation types in Fig. 1B; right hand map showing modelled suitability of potential distribution areas of the species as defined in Fig. 2, based on climatic parameters. For text about species, see C18.

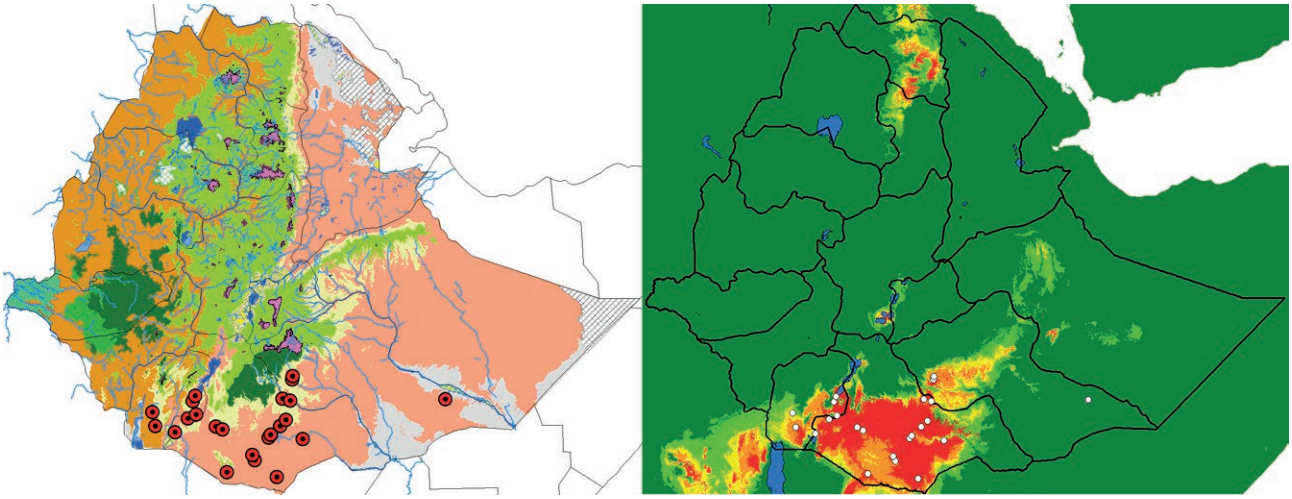

Figure 27. *Commiphora confusa* Vollesen in Ethiopia. Left hand map showing distribution of observed records on the vegetation types in Fig. 1B; right hand map showing modelled suitability of potential distribution areas of the species as defined in Fig. 2, based on climatic parameters. One southeastern record is outside the predicted area. For text about species, see C19.

The modelled omission rates of *C. confusa* agree partly with the expected values, suggesting that the model may perform as intended.

The highest contribution to the model is provided by Bio3 (isothermality).

In Ethiopia, the species has been reported to grow in dense *Acacia-Commiphora* bushland on rocky slopes or grey sandy soil over basement rocks (Vollesen 1989). In Tropical East Africa (Kenya, Tanzania), it has been found growing in *Acacia-Commiphora* bushland (Gillett 1991).

The species is widespread in Ethiopia, recorded from South Sudan (Darbyshire et al. 2015), northern and eastern Kenya, and northeastern Tanzania. The extinction risk of the species is considered Least Concern by Kamau P. 2022. *Commiphora confusa*. The IUCN Red List of Threatened Species 2022: e.T215410196A215570173. https://doi.org/10.2305/IUCN.UK.2022-2.RLTS.T215410196A215570173.en. The population size is declining.

C20. ***Commiphora alaticaulis*** J.B.Gillett & Vollesen, Kew Bull. 40: 52. 1985.

Six occurrence points studied. This is not sufficient for reliable modelling. The Ethiopian records are from localities at different altitudes, and it is best known from the area around Sof Omar in BA. We must conclude that the potential vegetation types, in which *C. alaticaulis* occurs, are *Acacia-Commiphora* bushland proper, transitional semi-evergreen bushland and semi-desert scrub. The potentially modelled area based on climatic parameters is large, and the observed records only fill a small area inside large areas with potentially suitable climate. It seems relevant to study other environmental parameters that might restrict the distribution of this species (Fig. 28).

No records have been observed from the areas with high or highest suitability in northern Ethiopia.

In Ethiopia, the species has been recorded to grow in *Acacia-Commiphora* woodland and bushland on red sandy soil overlying limestone and on rocky limestone slopes (Vollesen 1989). In Tropical East Africa (Kenya), it has been found growing in open *Acacia-Commiphora* bushland (Gillett 1991). In Somalia, it has been found both in northern, central and southern parts, growing in *Acacia-Commiphora* bushland (Thulin 1999).

Restricted to Ethiopia, Somalia, and northeastern Kenya. The extinction risk of the species is considered Vulnerable B2ab(iii) by Harvey-Brown Y. 2022. *Commiphora alaticaulis*. The IUCN Red List of Threatened Species 2022: e.T183102075A183102077. https://doi.org/10.2305/IUCN.UK.2022-2.RLTS.T183102075A183102077.en. The trend in population size is unknown, but there is continuing decline in area, extent and/or quality of habitat.

C21. ***Commiphora kataf*** (Forssk.) Engl. in A.L.P.P. de Candolle & A.C.P. de Candolle, Monogr. Phan. 4: 19. 1883.

(=) *C. erythraea* (Ehrenb.) Engl. in A.L.P.P. de Candolle & A.C.P. de Candolle, Monogr. Phan. 4: 20. 1883.

(=) *C. gallaensis* Engl. Engl., Bot. Jahrb. Syst. 48: 487. 1912.

(=) *C. kataf* (Forssk.) Engl. subsp. *turkanensis* J.B.Gillett, Fl. Trop. E. Africa, Burserac.: 81. 1991.

(=) *C. baluensis* Engl., Bot. Jahrb. Syst. 34: 313. 1904.

(=) *C. holtziana* Engl., Bot. Jahrb. Syst. 34: 310. 1904.

Forty-five occurrence points studied, which we consider sufficient for reliable modelling. The records studied are scattered within the areas with highest suitability and the highest density is in southern Ethiopia. Some isolated records are from the southern part of the Afar region. Most records occur in *Acacia-Commiphora* bushland proper, but also often collected in the semi-desert scrubland at the Genale and Webe Shebele rivers, and some records have transgressed into transitional semi-evergreen bushland (Fig. 29).

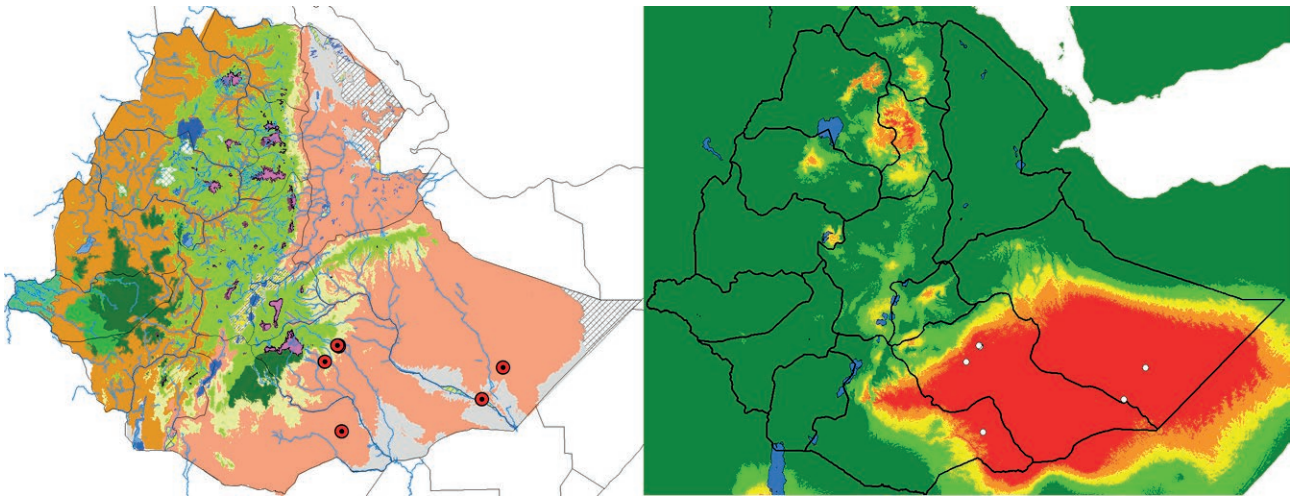

Figure 28. *Commiphora alaticaulis* Gillett & Vollesen in Ethiopia. Left hand map showing distribution of observed records on the vegetation types in Fig. 1B; right hand map showing modelled suitability of potential distribution areas of the species as defined in Fig. 2, based on climatic parameters. For text about species, see C20.

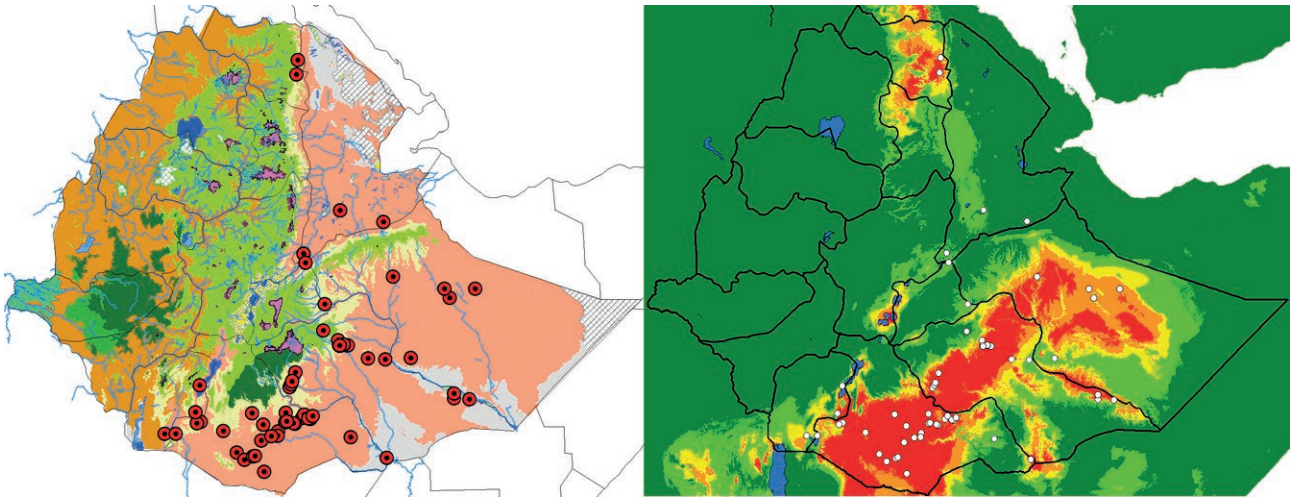

Figure 29. *Commiphora kataf* (Forssk.) Engl. in Ethiopia. Left hand map showing distribution of observed records on the vegetation types in Fig. 1B; right hand map showing modelled suitability of potential distribution areas of the species as defined in Fig. 2, based on climatic parameters. For text about species, see C21.

No records have been observed from the areas with highest suitability in northern Ethiopia. The modelled omission rates of *C. kataf* agree with the expected values, suggesting that the model performs as intended. The highest contribution to the model is provided by Bio3 (isothermality).

In Ethiopia, the species has been reported to grow in *Acacia-Commiphora* woodland and bushland, in *Combretum-Terminalia* wooded grassland [in western part of the distribution area], and on rocky slopes of basement rocks as well as limestone. In Tropical East Africa (Uganda, Kenya, Tanzania), it has been recorded as variable and has been found growing in deciduous woodland, dry forest, *Acacia-Commiphora* bushland on well drained and sandy soils, and on hillsides (Gillett 1991). In Somalia, it has been found to be widespread in northern, central and southern parts, growing in deciduous woodland (Thulin 1999).

The species is widespread in Ethiopia, Eritrea, northeastern Sudan (Darbyshire et al. 2015), Somalia, Kenya, and northern Tanzania; also in Arabia. It has not been red-listed as a species of this name, but the extinction risk of the taxon carrying the synonym *C. baluensis* is considered Least Concern by Beentje HJ. 2022. *Commiphora baluensis*. The IUCN Red List of Threatened Species 2022: e.T214701672A214702915. https://doi.org/10.2305/IUCN.UK.2022-2.RLTS.T214701672A214702915.en. The extinction risk of the taxon carrying the synonym *C. holtziana* is also considered Least Concern by Beentje HJ, Gereau RE, Hilton-Taylor C, Howard G, Kindeketa W, Luke WRQ, Maunder M, Mwachala G, Mwangoka M, Ndangalasi H, Njau E-F, Schatz GE, Siro Masinde P, Wilkins VL. 2020. *Commiphora holtziana*. The IUCN Red List of Threatened Species 2020: e.T158137A762492. https://doi.org/10.2305/IUCN.UK.2020-3.RLTS.T158137A762492.en.

C22. ***Commiphora rostrata*** Engl., Ann. Bot. (Rome) 7: 17. 1897.

Seventeen occurrence points studied. This would seem sufficient for reliable modelling, but the observed records are very scattered and do not fill the areas with the highest suitability. Most records occur in *Acacia-Commiphora* bushland proper, but some records have transgressed into transitional semi-evergreen bushland (Fig. 30).

No records have been observed from the areas with high or highest suitability in northern Ethiopia.

In Ethiopia, the species has been reported to grow in *Acacia-Commiphora* woodland, wooded grassland and bushland, often on red sandy soil overlying limestone but also on black cotton soil and on rocky slopes (Vollesen 1989). In Tropical East Africa (Kenya), it has been found growing in *Acacia-Commiphora* open bushland on eluvial soil (Gillett 1991). In Somalia, it has been known from both northern, central and southern parts of the country, growing in *Acacia-Commiphora* bushland (Thulin 1999).

Restricted to Ethiopia, Somalia, and northeastern Kenya. Not red-listed by IUCN.

C23. ***Commiphora ciliata*** Vollesen, Kew Bull. 40: 50. 1985.

Seven occurrence points studied. This is not sufficient for reliable modelling; the observed records are scattered and far from fill the areas with the highest suitability. Most of the few records occur in *Acacia-Commiphora* bushland proper, but one has been collected in transitional semi-evergreen bushland (Fig. 31).

No records have been observed from the areas with highest suitability in northern Ethiopia.

In Ethiopia, the species has been reported to grow in *Commiphora*, *Acacia-Commiphora* and *Acacia-Commiphora-Delonix* woodland and bushland on rocky limestone slopes (Vollesen 1989). In Tropical East Africa (Kenya), it has been found growing in *Acacia-Commiphora* bushland (Gillett 1991). In Somalia, it has been known from the central and southern parts, growing in *Acacia-Commiphora* bushland (Thulin 1999). In Ethiopia, Somalia, and northeastern Kenya. The extinction risk of the species is considered Near Threatened C1 by Alemu S, Alemu S, Atnafu H, Awas T, Belay B,

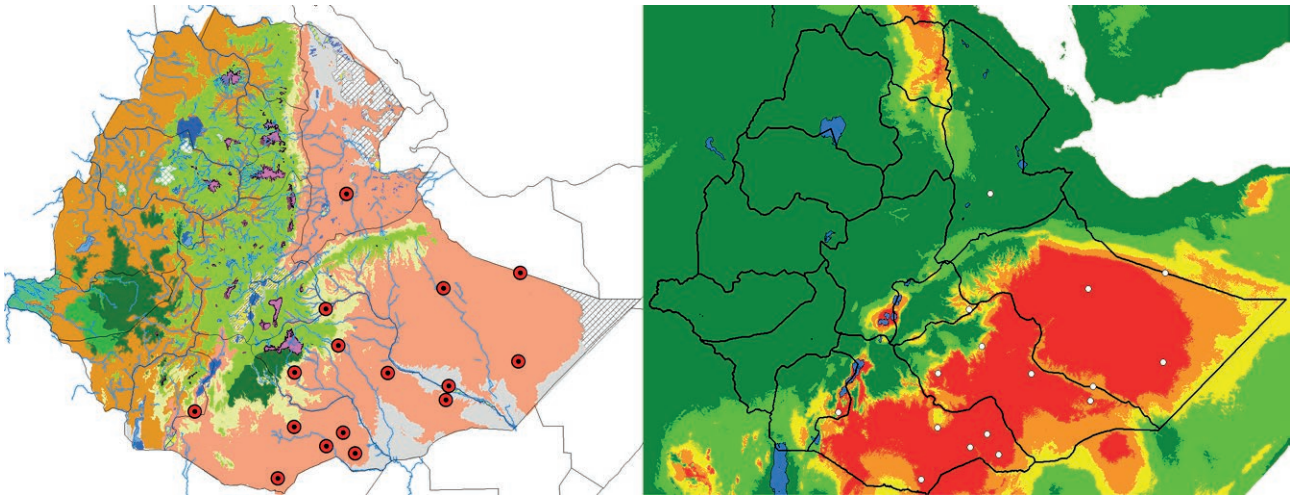

Figure 30. *Commiphora rostrata* Engl. in Ethiopia. Left hand map showing distribution of observed records on the vegetation types in Fig. 1B; right hand map showing modelled suitability of potential distribution areas of the species as defined in Fig. 2, based on climatic parameters. One northern record is outside the predicted area. For text about species, see C22.

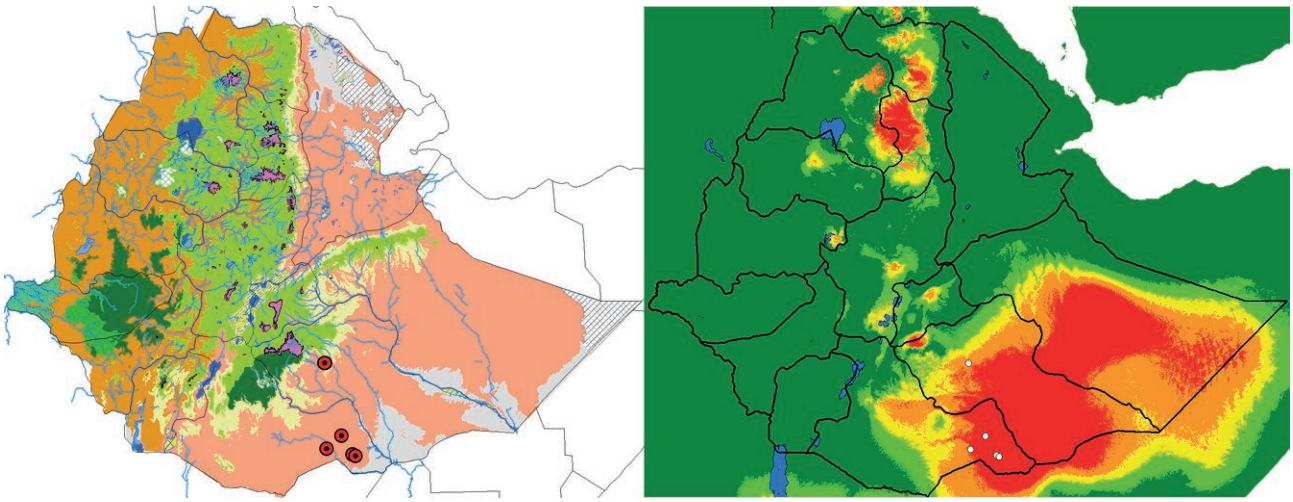

Figure 31. *Commiphora ciliata* Vollesen in Ethiopia. Left hand map showing distribution of observed records on the vegetation types in Fig. 1B; right hand map showing modelled suitability of potential distribution areas of the species as defined in Fig. 2, based on climatic parameters. For text about species, see C23.

Demissew S, Luke WRQ, Mekbib E, Nemomissa S. 2021. *Commiphora ciliata* (errata version published in 2022). The IUCN Red List of Threatened Species 2021: e.T34440A223073030. https://doi.org/10.2305/IUCN.UK.2021-3.RLTS.T34440A223073030.en. The population size is declining, there is a continuing decline in area, extent and/or quality of habitat, and logging & wood harvesting.

C24. ***Commiphora erosa*** Vollesen, Kew Bull. 40: 60. 1985.

Four occurrence points studied. This is not sufficient for reliable modelling; the observed records have all been collected in semi-desert scrubland along the lower reaches of the Genale River (Fig. 32).

In Ethiopia, the species has been reported to grow in *Acacia-Commiphora* bushland on yellowish limestone alluvium and on gypsum hills (Vollesen 1989). In Tropical East Africa (Kenya), it has been found growing in open *Acacia-Commiphora* bushland usually on silty alluvium near perennial rivers (Gillett 1991). In Somalia, it has been known from the central and southern parts, growing in *Acacia-Commiphora* bushland, usually on silty soil (Thulin 1999).

In Ethiopia, Somalia, northeastern Kenya. Not redlisted by IUCN.

C25. ***Commiphora sphaerocarpa*** Chiov., Res. Sci. Somalia Ital. 1: 48. 1916.

Seven occurrence points studied. This is not sufficient for reliable modelling; the observed records are very scattered and far from filling the areas with the highest suitability. A few records occur in *Acacia-Commiphora* bushland proper, but most have been collected in semi-desert scrubland at the Genale and Webe Shebele rivers (Fig. 33).

In Ethiopia, the species has been reported to grow in *Acacia-Commiphora-Boswellia rivae* bushland on rocky limestone and gypsum slopes (Vollesen 1989). In Tropical East Africa (Kenya), it was not yet found when the flora was published but it had been collected from near the Kenya-Somali border (Gillett 1991). In Somalia, the species is known from both the northern, central and southern parts, growing in *Acacia-Commiphora* bushland on limestone or gypsum, often in silty depressions, rarely on sand (Thulin 1999).

Restricted to Ethiopia and Somalia. The extinction risk of the species is considered Least Concern by Alemu S, Alemu S, Atnafu H, Awas T, Belay B, Demissew S, Luke WRQ, Mekbib E, Nemomissa S, Bahdon J. 2021. *Commiphora sphaerocarpa* (errata version published in 2022). The IUCN Red List of Threatened Species 2021: e.T128045093A223075447. https://doi.org/10.2305/IUCN.UK.2021-3.RLTS.T128045093A223075447.en. The trend of the population size is unknown, and nothing is known about decline in area, extent and/or quality of habitat.

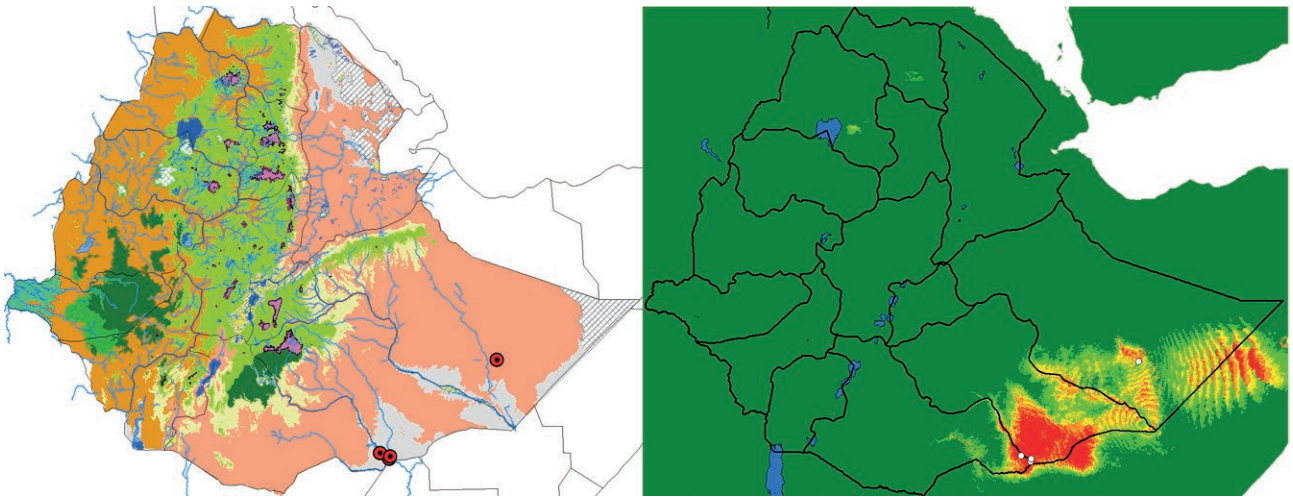

Figure 32. *Commiphora erosa* Vollesen in Ethiopia. Left hand map showing distribution of observed records on the vegetation types in Fig. 1B; right hand map showing modelled suitability of potential distribution areas of the species as defined in Fig. 2, based on climatic parameters. For text about species, see C24.

C26. ***Commiphora mildbraedii*** Engl., Bot. Jahrb. Syst. 44: 145. 1910.

Four occurrence points in two nearly identical locations studied. This is not sufficient for reliable modelling; the observed records are scattered and far from filling areas with the highest suitability. Two records occur at the border between transitional semi-evergreen bushland and *Acacia-Commiphora* bushland proper, and two have been collected in semi-desert scrubland at the Webe Shebele River (Fig. 34).

In Ethiopia, the species has been reported to grow in dense *Acacia-Commiphora* bushland on black cotton soil or rocky limestone slopes (Vollesen 1989). In Tropical East Africa (Kenya, Tanzania), it has been found growing in *Acacia-Commiphora* bushland, especially in rocky places (Gillett 1991).

The species is widespread in Ethiopia, eastern Kenya, Tanzania. The extinction risk of the species is considered Least Concern by Luke WRQ, Musili P, Barasa J, Kalema J, Mathenge J, Nemomissa S, Bahdon J. 2021. *Commiphora mildbraedii* (errata version published in

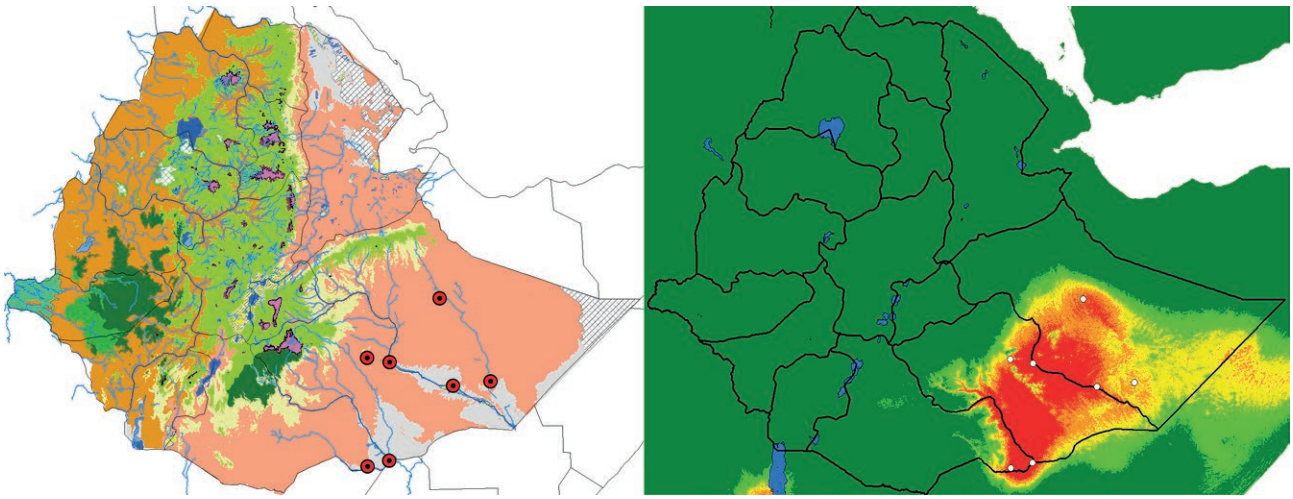

Figure 33. *Commiphora sphaerocarpa* Chiov. in Ethiopia. Left hand map showing distribution of observed records on the vegetation types in Fig. 1B; right hand map showing modelled suitability of potential distribution areas of the species as defined in Fig. 2, based on climatic parameters. For text about species, see C25.

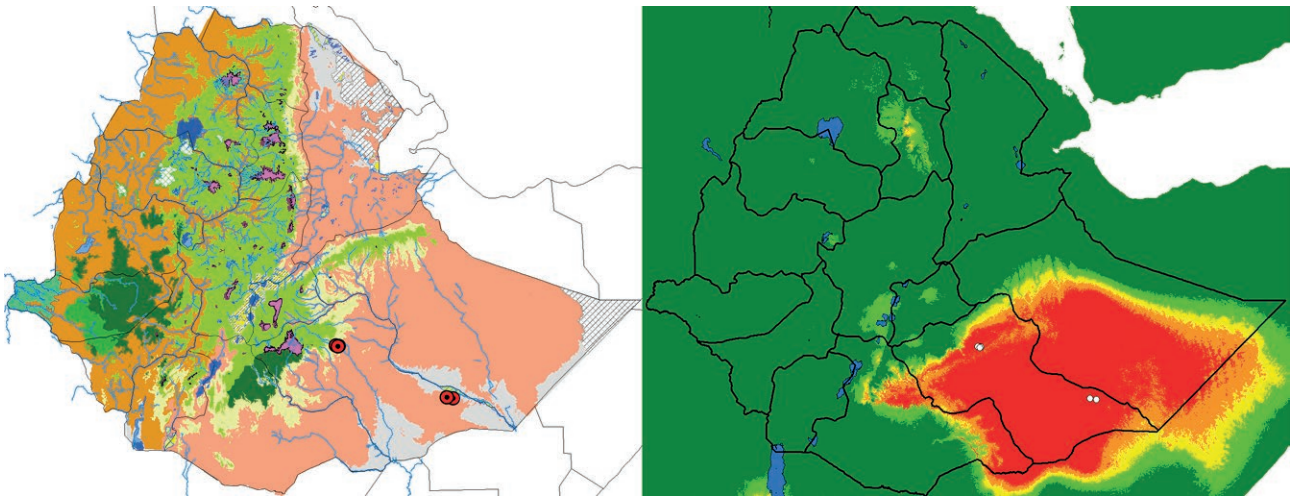

Figure 34. *Commiphora mildbraedii* Engl. in Ethiopia. Left hand map showing distribution of observed records on the vegetation types in Fig. 1B; right hand map showing modelled suitability of potential distribution areas of the species as defined in Fig. 2, based on climatic parameters. For text about species, see C26.

2022). The IUCN Red List of Threatened Species 2021: e.T128048477A223077813. https://doi.org/10.2305/IUCN.UK.2021-3.RLTS.T128048477A223077813.en. The trend in population size is decreasing.

C27. ***Commiphora cyclophylla*** Chiov., Fl. Somala 2: 88. 1932.

(=) *C. lughensis* Chiov., Fl. Somala 2: 105. 1932.

(=) *C. sp.* [= *Gilbert et al. 8170*].

Ten occurrence points from eight locations studied. This is not sufficient for reliable modelling; the observed records are scattered and far from filling the huge areas with highest suitability. Two records occur in the west near the Omo River on the border between semi-desert scrubland and *Acacia-Commiphora* bushland proper, three occurrence points occur in the south in *Acacia-Commiphora* bushland proper, and one occurs in the north in transitional semi-evergreen bushland (Fig. 35).

In Ethiopia, the species has been reported to grow in *Acacia-Commiphora* woodland and bushland on limestone slopes and ridges (this includes information about the material referred to *Commiphora* sp. [= *Gilbert et al. 8170*] (Vollesen 1989)). In Tropical East Africa (Kenya), it has been found growing in *Acacia-Commiphora* bushland on limestone (Gillett 1991). In Somalia, the species is known from the central and southern parts, growing usually on limestone or on gypsaceous ground (Thulin 1999).

Restricted to Ethiopia, Somalia, and northeastern Kenya. The extinction risk of the species is considered Vulnerable B2ab(iii) by Harvey-Brown Y. 2022. *Commiphora cyclophylla*. The IUCN Red List of Threatened Species 2022: e.T183101579A183101581. https://doi.org/10.2305/IUCN.UK.2022-2.RLTS.T183101579A183101581.en. The trend in the population size is unknown, there is a continuing decline in area, extent and/or quality of habitat, and the species is subject to Logging and wood harvesting.

C28. ***Commiphora campestris*** Engl., Bot. Jahrb. Syst. 15: 97. 1893.

Three occurrence points (from two locations) studied. This is not sufficient for reliable modelling; the records are all collected in *Acacia-Commiphora* bushland proper, and they are far from filling the large areas with the highest suitability (Fig. 36).

No records have been observed from the areas with highest suitability in northern Ethiopia.

In Ethiopia, the species has been reported to grow in *Acacia-Commiphora* bushland on rocky lava hills (Vollesen 1989). In Tropical East Africa (Kenya, Tanzania), it has been found growing in *Acacia-Commiphora* bushland and is widespread and very variable (Gillett 1991). In Somalia, the species is known from the central and southern parts, growing in deciduous bushland (Thulin 1999).

In Ethiopia, where it is rare, in eastern Kenya, and northeastern Tanzania, where it is widespread. The

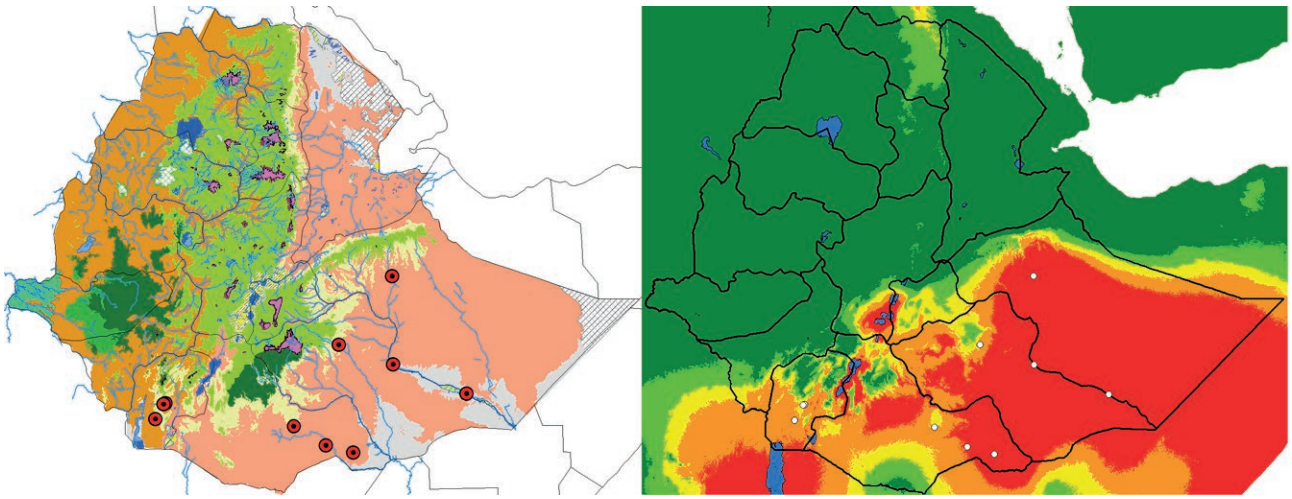

Figure 35. *Commiphora cyclophylla* Chiov. in Ethiopia. Left hand map showing distribution of observed records on the vegetation types in Fig. 1B; right hand map showing modelled suitability of potential distribution areas of the species as defined in Fig. 2, based on climatic parameters. For text about species, see C27.

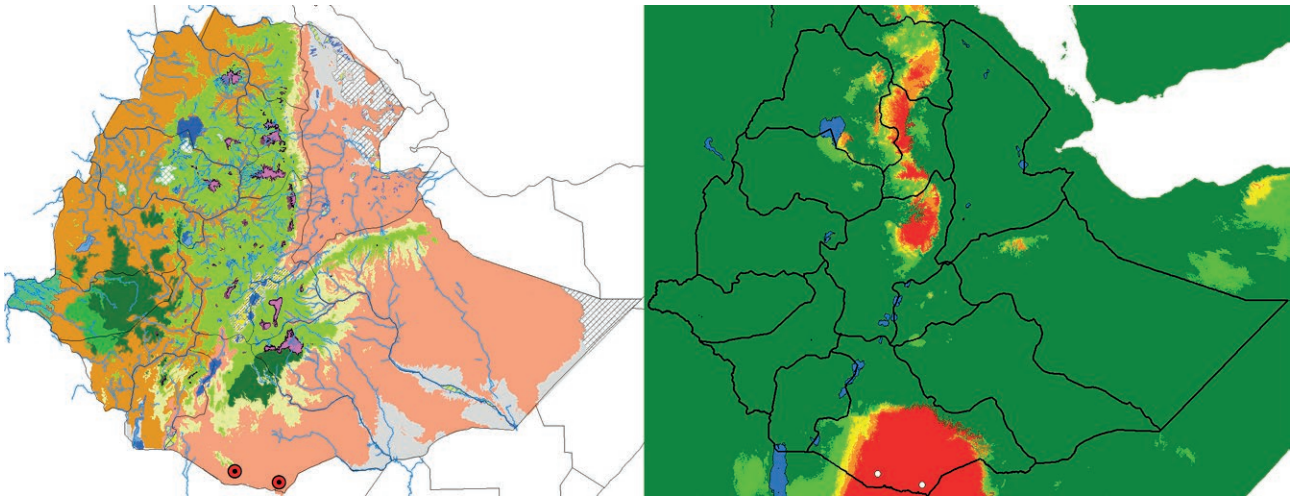

Figure 36. *Commiphora campestris* Engl. in Ethiopia. Left hand map showing distribution of observed records on the vegetation types in Fig. 1B; right hand map showing modelled suitability of potential distribution areas of the species as defined in Fig. 2, based on climatic parameters. For text about species, see C28.

extinction risk of the species is considered Least Concern by Beentje HJ, Gereau RE, Hilton-Taylor C, Howard G, Kindeketa W, Luke WRQ, Maunder M, Mwachala G, Mwangoka M, Ndangalasi H, Njau E-F, Schatz GE, Siro Masinde P, Wilkins VL. 2020. *Commiphora campestris*. The IUCN Red List of Threatened Species 2020: e.T62959A3117144. https://doi.org/10.2305/IUCN.UK.2020-3.RLTS.T62959A3117144.en. The trend in population size is unknown.

C29. ***Commiphora serrulata*** Engl., Bot. Jahrb. Syst. 15: 96. 1892.

Thirty-two occurrence points studied, which we consider sufficient for reliable modelling. The records studied are scattered within the areas with highest suitability, with the highest density in the wetter parts of *Acacia-Commiphora* bushland proper or transgressing into the transitional semi-evergreen bushland. One record has been made at the semi-desert scrubland along the Webe Shebele River (Fig. 37).

No record has been observed from the areas with highest suitability in northern Ethiopia.

The modelled omission rates of *C. serrulata* agree with the expected values, suggesting that the model performs as intended. The highest contribution to the model is provided by Bio4 (temperature seasonality).

In Ethiopia, the species has been reported to grow in *Acacia-Commiphora* woodland and bushland on limestone slopes and slopes of basaltic rocks, on level sandy soil and on black cotton soil (Vollesen 1989). In Somalia, the species is known from the northern parts, growing in semi-evergreen bushland (Thulin 1999).

Restricted to Ethiopia and Somalia. Not red-listed by IUCN.

C30. ***Commiphora gurreh*** Engl., Ann. Bot. (Rome) 7: 17 (1897).

(=) *C. tenuis* Vollesen, Kew Bull. 40: 48. 1985.

Seventeen occurrence points studied. This is sufficient for reliable modelling; the observed records are widely scattered and far from filling the huge areas with highest suitability. Some records occur on the border between transitional semi-evergreen bushland and *Acacia-Commiphora* bushland proper, others in *Acacia-Commiphora* bushland proper, one record was made in *Acacia* wooded grassland of the Rift Valley, and one record was made on the border between semi-desert scrubland and *Acacia-Commiphora* bushland proper (Fig. 38).

No record has been observed from the areas with highest suitability in northern Ethiopia.

In Ethiopia, the species has been reported to grow in *Acacia-Commiphora* woodland and bushland on rocky limestone slopes or black cotton soil (Vollesen 1989). In Tropical East Africa (Kenya), it has been found growing in *Acacia-Commiphora* bushland on various soils (Gillett 1991). In Somalia, the species is widespread in most of the country, where it has been found growing in *Acacia-Commiphora* bushland (Thulin 1999).

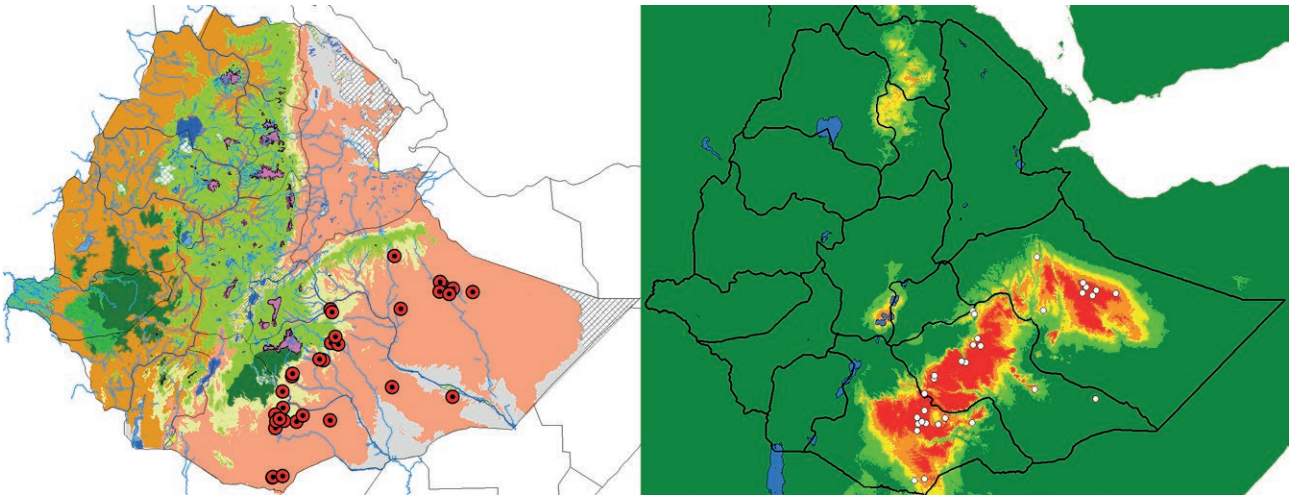

Figure 37. *Commiphora serrulata* Engl. in Ethiopia. Left hand map showing distribution of observed records on the vegetation types in Fig. 1B; right hand map showing modelled suitability of potential distribution areas of the species as defined in Fig. 2, based on climatic parameters. One southeastern record is outside the predicted area. For text about species, see C29.

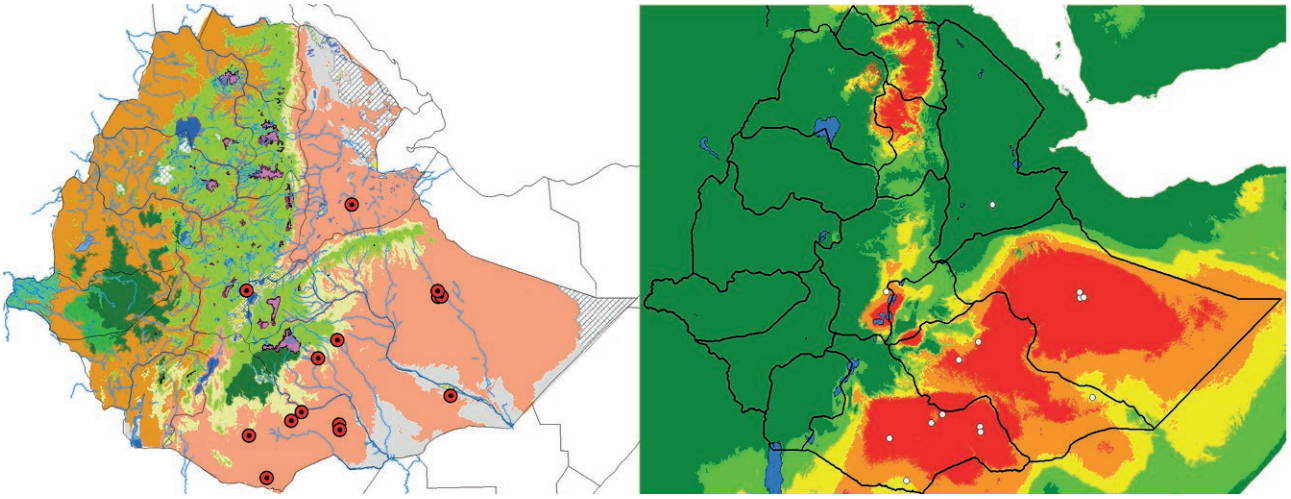

Figure 38. *Commiphora gurreh* Engl. in Ethiopia. Left hand map showing distribution of observed records on the vegetation types in Fig. 1B; right hand map showing modelled suitability of potential distribution areas of the species as defined in Fig. 2, based on climatic parameters. One northern record is outside the predicted area. For text about species, see C30.

Restricted to Ethiopia, Somalia and northeastern Kenya. Not red-listed by IUCN.

C31. ***Commiphora quadricincta*** Schweinf., Bull. Herb. Boissier 7 (App. 2): 283. 1899.

Two occurrence points studied. This is absolutely not sufficient for reliable modelling; the only two observed records are widely scattered and far from filling the huge areas with the highest suitability in the Afar region, southeastern Ethiopia, and Somalia. One record is from *Acacia-Commiphora* bushland proper; another is from true desert (Fig. 39).

In Ethiopia, the species has been reported to grow in *Acacia-Commiphora* bushland, *Acacia-Adansonia* wooded grassland [presumably only recorded from Eritrea] on sandy soil, rocky slopes, and lava hills (Vollesen 1989).

The species is widespread from northern Nigeria and Tchad to eastern Sudan (Darbyshire et al. 2025), Eritrea and Ethiopia; also in Arabia. Not red-listed by IUCN.

C32. ***Commiphora hodai*** Sprague in Hooker's Icon. Pl. 32: t. 3111. 1927.

Five occurrence points (from four locations) studied. This is not sufficient for reliable modelling; the observed records are widely scattered and far from filling the huge areas with the highest suitability. Two records have been made in *Acacia-Commiphora* bushland proper, and two in semi-desert scrubland along the lower reaches of the Webe Shebele River (Fig. 40).

In Ethiopia, the species has been reported to grow in *Acacia-Commiphora* bushland on red sandy soil overlying limestone (Vollesen 1989). In Somalia, the species is recorded from *Acacia-Commiphora* bushland (Thulin 1999).

Restricted to Ethiopia and Somalia. The extinction risk of the species is considered Near Threatened by Thulin M. 1998. *Commiphora hodai*. The IUCN Red List of Threatened Species 1998: e.T35824A9960359. https://doi.org/10.2305/IUCN.UK.1998.RLTS.T35824A9960359.en. The trend in the population size is unspecified and the decline in area, extent and/or quality of habitat is unknown.

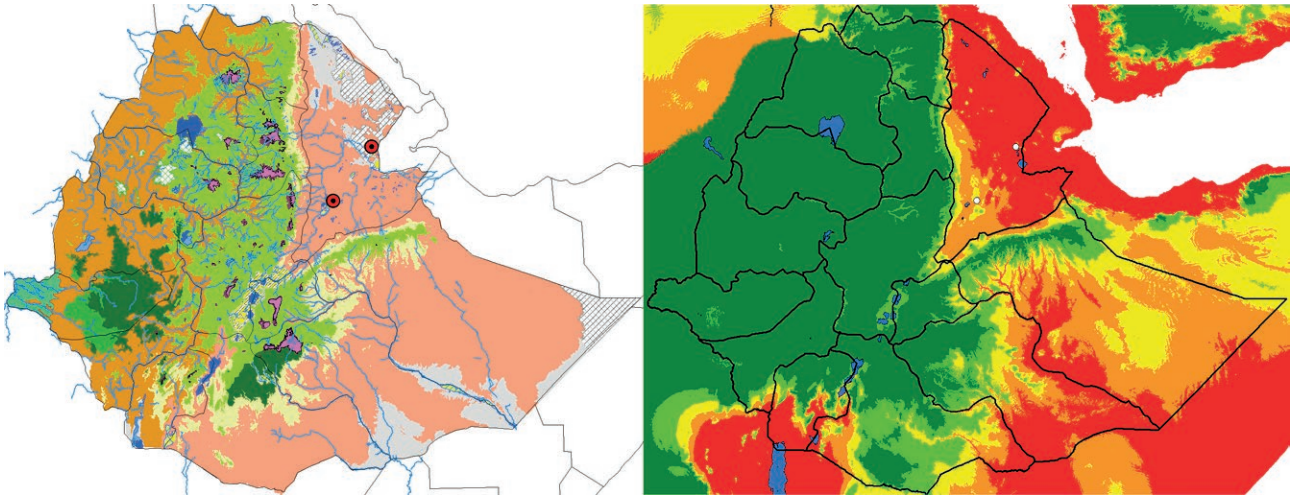

Figure 39. *Commiphora quadricincta* Schweinf. in Ethiopia. Left hand map showing distribution of observed records on the vegetation types in Fig. 1B; right hand map showing modelled suitability of potential distribution areas of the species as defined in Fig. 2, based on climatic parameters. The predicted area is much larger than what the authors expect from field experience. For text about species, see C31.

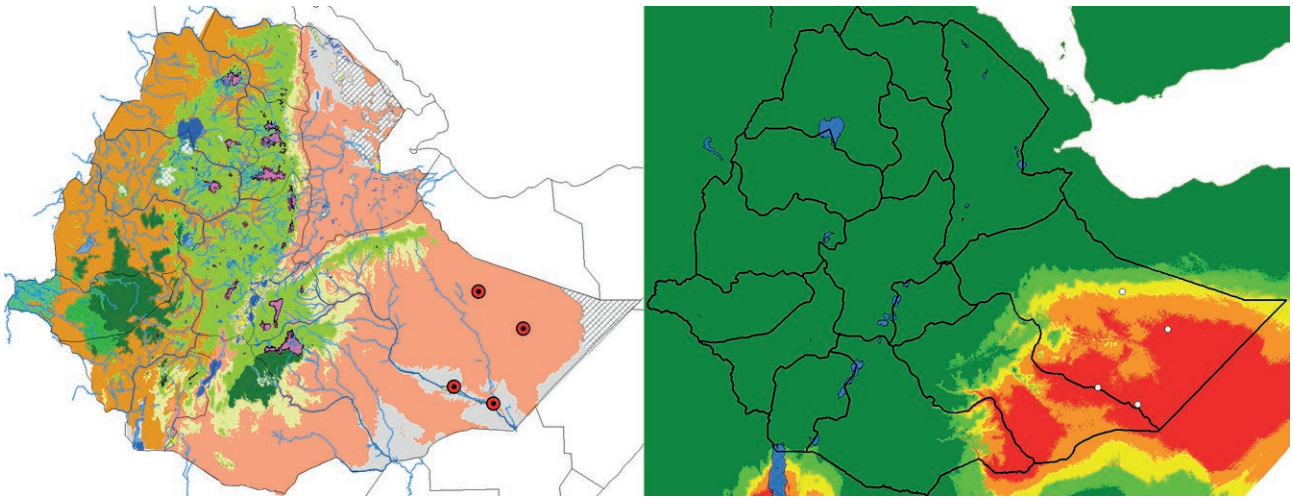

Figure 40. *Commiphora hodai* Sprague in Ethiopia. Left hand map showing distribution of observed records on the vegetation types in Fig. 1B; right hand map showing modelled suitability of potential distribution areas of the species as defined in Fig. 2, based on climatic parameters. For text about species, see C32.

C33. ***Commiphora habessinica*** (O.Berg) Engl. in A.L.P.P. de Candolle & A.C.P. de Candolle, Monogr. Phan. 4: 10. 1883.

(=) *C. dancaliensis* Chiov., Ann. Bot. (Rome) 13: 403. 1915.

(=) *C. assaortensis* Chiov., Fl. Somala 2: 64. 1932.

(=) *C. bruceae* Chiov., Bull. Misc. Inform. Kew 1941: 133. 1941.

(=) *C. gracilispina* J.B.Gillett, Fl. Trop. E. Africa, Burserac.: 18. 1991.

Forty-nine occurrence points studied, which we consider sufficient for reliable modelling. The records studied are densely distributed in the areas with highest suitability in southern Ethiopia, where it occurs in *Combretum-Terminalia* woodland in the west, in *Acacia-Commiphora* bushland proper and in transitional semi-evergreen bushland in the middle, and in *Acacia-Commiphora* bushland proper, in transitional semi-evergreen bushland, and in semi-desert scrubland along the lower reaches of the Genale and Webe Shebele rivers. The species has also been recorded with one occurrence from *Combretum-Terminalia* woodland on the western escarpment of the Ethiopian highlands in Gambela (Illubabor) region, from *Combretum-Terminalia* woodland in the deep Didessa valley in the highlands (rivers running westwards to the Nile), and in transitional semi-evergreen bushland on the eastern escarpment of the Ethiopian highlands (Fig. 41).

The modelled omission rates of *C. habessinica* agree with the expected values, suggesting that the model performs as intended. The highest contribution to the model is provided by Bio3 (isothermality).

In Ethiopia, the species has been recorded to grow in *Acacia-Commiphora* bushland, sometimes with *Terminalia orbicularis*, in *Acacia-Balanites* woodland, *Anogeissus* woodland, on sandy to loamy soil overlying limestone and basement rock, on black cotton soil, and on lava hills; the tree is sometimes planted as hedges (Vollesen 1989). In Tropical East Africa (Uganda, Kenya, Tanzania), it has been found growing in *Acacia-Commiphora* open bushland on alluvium or red sandy loam (Gillett 1991). Thulin (1999) consider *C. habessinica* and *C. kua* as one variable species, and his habitat information is therefore not cited here. The species is widespread in Ethiopia, Eritrea, eastern Sudan, southwards to northern Mozambique and Zambia; also in Arabia. Not redlisted by IUCN.

C34. ***Commiphora sp.*** [= *Corradi 6767, 6768*].

One population studied, and hence the species is not modelled. The two gatherings are from the same population, or highly likely, from the same tree; the vegetation in the area is mixed but should probably be classified as *Acacia-Commiphora* bushland proper, near saline areas around Lake Chew Bahir (Fig. 42).

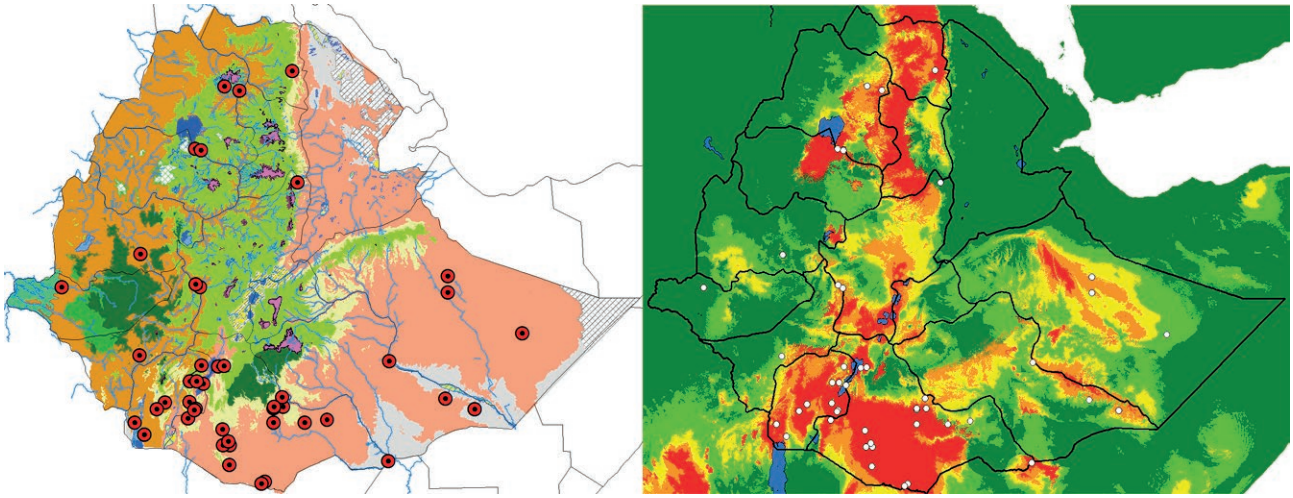

Figure 41. *Commiphora habessinica* (Berg) Engl. in Ethiopia. Left hand map showing distribution of observed records on the vegetation types in Fig. 1B; right hand map showing modelled suitability of potential distribution areas of the species as defined in Fig. 2, based on climatic parameters. The western records (in WG and IL) are from narrow river valleys in the western moderate highlands of Ethiopia and can be expected to have climatic conditions different from the surrounding terrain. For text about species, see C33.

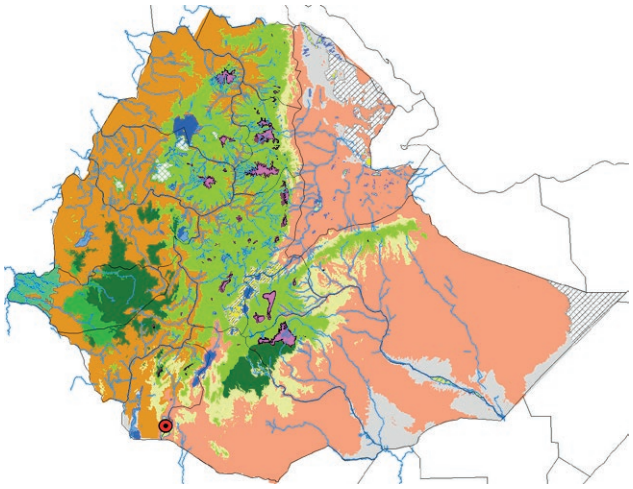

Figure 42. *Commiphora* sp. [= *Corradi 6767, 6768*]. Map showing distribution of observed records on the vegetation types in Fig. 1B. Modelling is not possible based on only one occurrence point. For text about species, see C34.

According to Vollesen (1989), it is known from *Acacia-Commiphora* bushland. Not known elsewhere. Not red-listed by IUCN.

C35. ***Commiphora kua*** (R.Br. ex Royle) Vollesen, Nordic J. Bot. 4: 37 (1984, published 1985).

(=) C. *flaviflora* Engl., Bot. Jahrb. Syst. 34: 304. 1904.

(=) *C. ellenbeckii* Engl., Bot. Jahrb. Syst. 34: 303. 1904.

(=) *C. crenulata* (A.Terrac.) Chiov., Ann. Bot. (Rome) 13: 404. 1915.

(=) *C. incisa* Chiov., Res. Sci. Somalia Ital. 1: 45. 1916.

(=) *C. candidula* Sprague in Hooker's Icon. Pl. 32: t. 3106. 1927.

(=) *C. gowlello* Sprague in Hooker's Icon. Pl. 32: t. 3109. 1927.

Seventy-three occurrence points studied, which we consider sufficient for reliable modelling. The records studied are densely distributed in areas with the highest suitability in southern Ethiopia, where it occurs in *Combretum-Terminalia* woodland in the west, in *Acacia-Commiphora* bushland proper and in transitional semi-evergreen bushland in the middle, and in *Acacia-Commiphora* bushland proper and in transitional semi-evergreen bushland and in semi-desert scrubland to the west of Genale River and along the lower reaches the Webe Shebele River. 3Two records have been made from *Acacia-Commiphora* bushland proper in the southern Afar region (Fig. 43).

The species has also been recorded from *Combretum-Terminalia* woodland in the deep valleys in the northern highlands (Tacazze river and tributaries running westwards to the Nile). The modelled omission rates of *C. kua* agree with the expected values, suggesting that the model performs as intended. The highest contribution to the model is provided by Bio12 (annual precipitation).

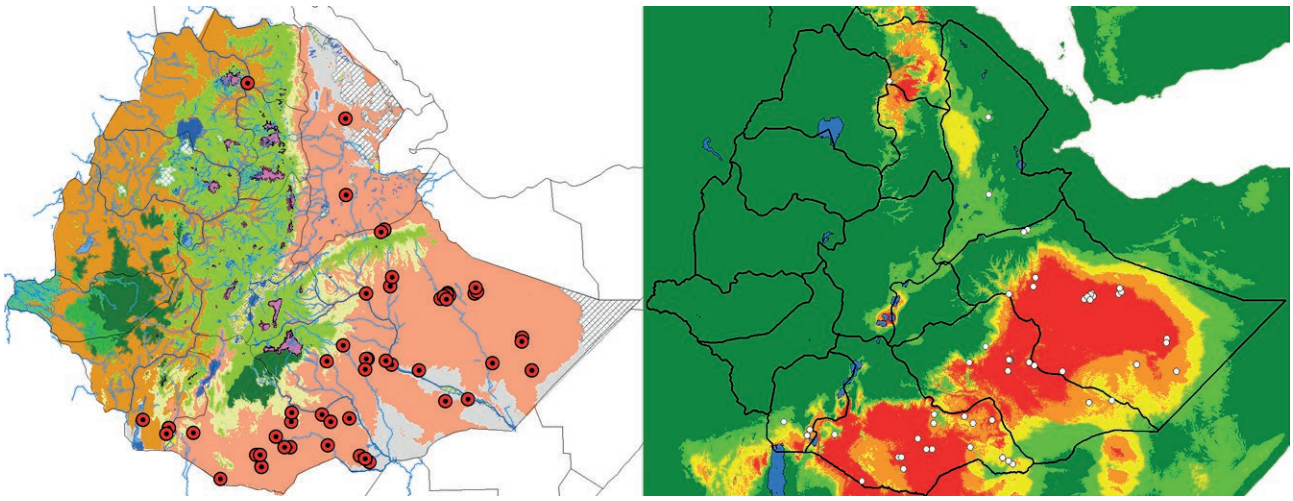

Figure 43. *Commiphora kua* (R. Br. ex Royle) Vollesen in Ethiopia. Left hand map showing distribution of observed records on the vegetation types in Fig. 1B; right hand map showing modelled suitability of potential distribution areas of the species as defined in Fig. 2, based on climatic parameters. For text about species, see C35.

In Ethiopia, the species has been reported to grow in *Acacia-Commiphora* bushland, sometimes with *Terminalia orbicularis*, on yellowish, red to grey sandy or stony soil overlying limestone or basement rocks, on rocky slopes, or alluvial sandy loams in areas of poor drainage; this includes information on *C. ellenbeckii*, *C. incisa*, and *C. gowlello*, as recorded by Vollesen (1989). In Tropical East Africa (Kenya, Tanzania), it has been found growing in open *Acacia-Commiphora* bushland on rocky slopes and red sandy soil (Gillett 1991). Thulin (1999) consider *C. habessinica* and *C. kua* as one variable species, and his habitat information is therefore not cited here.

The species is widespread in Eritrea, Ethiopia, Somalia, northeastern and eastern Kenya; also in Arabia. Not red-listed by IUCN.

C36. ***Commiphora oddurensis*** Chiov., Fl. Somala 2: 71. 1932.

(=) *C. sp.* [= *Friis et al. 3160*].

(=) *C. oddurensis* Chiov. subsp. *suffruticosa* (Teshome) Sebsebe and Friis, Webbia 68: 143. 2013.

Seven occurrence points studied from five locations. This is not sufficient for reliable modelling; the observed records are very far from filling the huge areas with the highest suitability, and the locations fall into two groups, one in transitional semi-evergreen bushland and in *Acacia-Commiphora* bushland proper between Negele and Filtu, which is south of a tributary of the Genale River, and another in semi-desert scrubland along the lower reaches of the Webe Shebele River and one of its tributaries (Fig. 44).

In Ethiopia, the species has been reported to grow in *Acacia-Commiphora* bushland on rocky limestone ridges (Vollesen 1989), in *Acacia-Commiphora* woodland, bushland or open bushland, on rocky limestone slopes, in stony soil over rocks, or on brown, orange and red sand and brown soil. As a whole, the species seems to be associated with limestone or gypsum (Demissew and Friis 2013). In Tropical East Africa (Kenya), it has been found growing in *Acacia-Commiphora* bushland on limestone slopes (Gillett 1991). In Somalia, it grows in *Acacia-Commiphora* bushland on sand or limestone (Thulin 1999).

Restricted to Ethiopia, Somalia, and northeastern Kenya. The extinction risk of the species is considered Least Concern by Kalema J, Musili P, Barasa J, Nemomissa S, Bahdon J. 2021. *Commiphora oddurensis* (errata version published in 2022). The IUCN Red List of Threatened Species 2021: e.T128048544A223077946. https://doi.org/10.2305/IUCN.UK.2021-3.RLTS.T128048544A223077946.en.

Demissew and Friis (2013) also assessed Least Concern for both subspecies and the species as a whole.

Syn.: *C. suffruticosa* Teshome (2006); *C. oddurensis* subsp. *suffruticosa* (Teshome) Sebsebe & Friis (2013).

The author designation "Teshome" in IPNI, etc., refers to Teshome Soromessa, here in the list of references as "Soromessa T." The trend in population size is unknown. There is a continuing decline in the number of mature individuals.

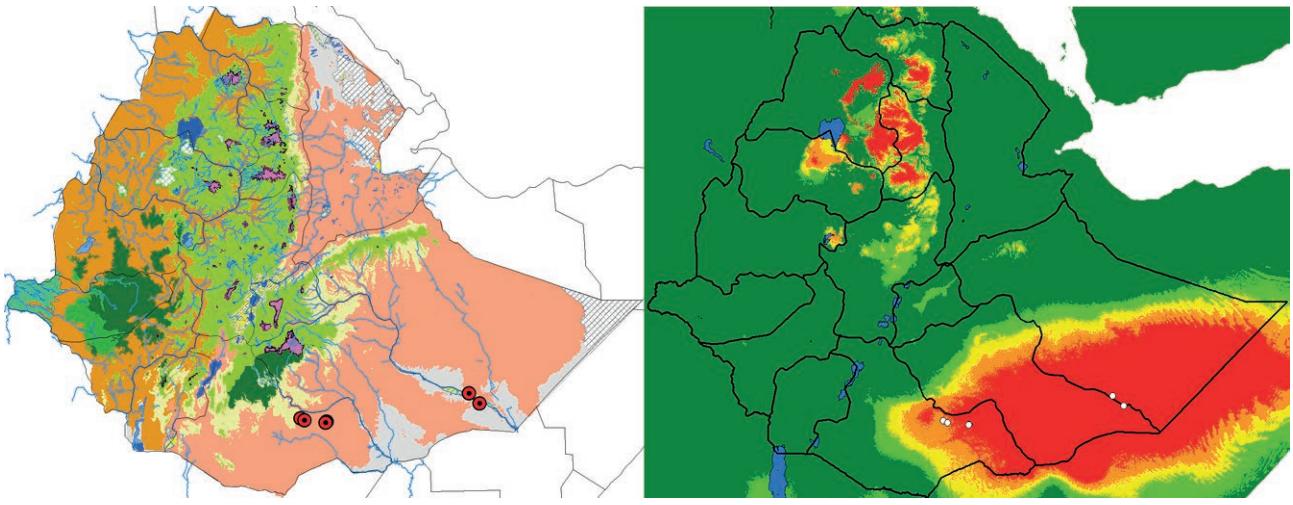

Figure 44. *Commiphora oddurensis* Chiov. in Ethiopia. Left hand map showing distribution of observed records on the vegetation types in Fig. 1B; right hand map showing modelled suitability of potential distribution areas of the species as defined in Fig. 2, based on climatic parameters. For text about species, see C36.

C37. ***Commiphora horrida*** Chiov., Fl. Somala 2: 87. 1932.

Four occurrence points studied. This is not sufficient for reliable modelling; the observed records are far from filling the huge areas with highest suitability. The collections have been made from the driest parts of eastern Ethiopia, from the border between *Acacia-Commiphora* bushland proper and semi-desert scrubland or desert (Fig. 45).

In Ethiopia, the species has been reported to grow in dry open *Acacia-Commiphora* bushland on fine, sometimes shifting, sandy soil overlying limestone (Vollesen 1989). In Somalia, the species occurs in the central and southern parts, growing on sand, sand over limestone, or on gypsum (Thulin 1999).

Restricted to Ethiopia and Somalia. Not red-listed by IUCN.

C38. ***Commiphora boranensis*** Vollesen, Kew Bull. 40: 64. 1985.

(=) *C. sp.* [= *Gilbert et al. 8171*].

Fifteen occurrence points studied. This just sufficient for reliable modelling, but the observed records can hardly fill the huge areas with highest suitability, falling in three groups, one in *Combretum-Terminalia* woodland near the Omo River, one in southern Ethiopia in areas with a mosaic of transitional semi-evergreen bushland and *Acacia-Commiphora* bushland proper, and a third group in the drier parts of *Acacia-Commiphora* bushland in eastern Ethiopia (Fig. 46).

In Ethiopia, the species has been reported to grow in *Acacia-Commiphora* woodland and bushland on rocky limestone slopes and black cotton soil, and on gypsum hills (Vollesen 1989). In Tropical East Africa (Kenya), it has been found growing in *Acacia-Commiphora* bushland (Gillett 1991).

Restricted to Ethiopia and northeastern Kenya. The extinction risk of the species is considered Least Concern by Alemu S, Alemu S, Atnafu H, Awas T, Belay B, Demissew S, Luke WRQ, Musili P, Nemomissa S. 2021. *Commiphora boranensis* (errata version published in 2022). The IUCN Red List of Threatened Species 2021: e.T128044306A223075076. https://doi.org/10.2305/IUCN.UK.2021-3.RLTS.T128044306A223075076.en. The trend in population size is unknown.

C39. ***Commiphora sp.*** [= *Gilbert et al. 7652*].

One occurrence point studied, and hence the species is not modelled. The collection was made from *Acacia-Commiphora* bushland proper, but near semi-desert scrubland along the Genale River (Fig. 47).

In Ethiopia, it has been reported to grow in *Acacia-Commiphora* bushland on stony limestone ridges (Vollesen 1989). Not known elsewhere. Not red-listed by IUCN.

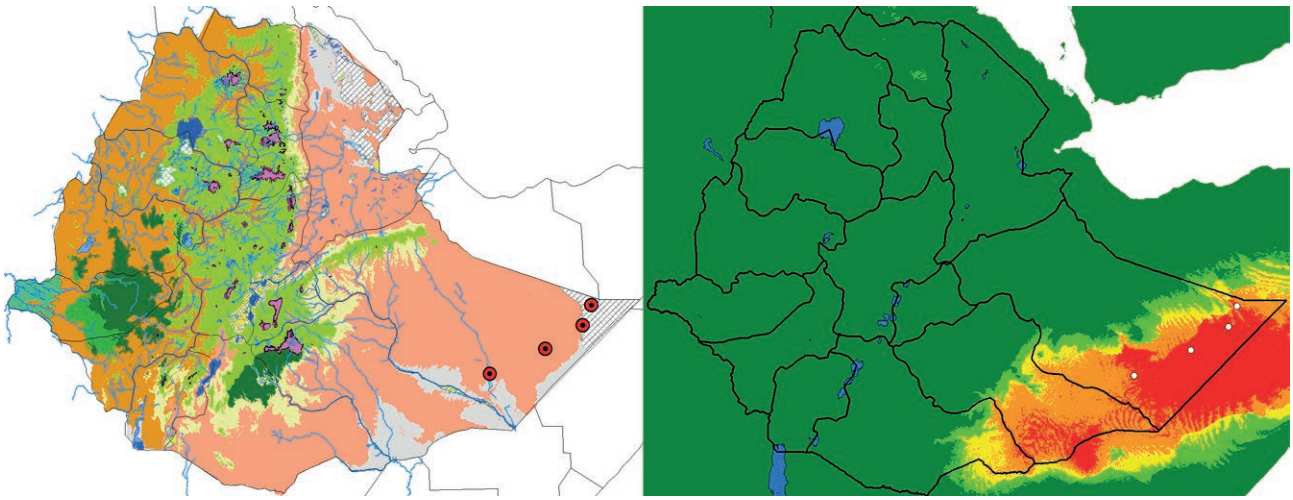

Figure 45. *Commiphora horrida* Chiov. in Ethiopia. Left hand map showing distribution of observed records on the vegetation types in Fig. 1B; right hand map showing modelled suitability of potential distribution areas of the species as defined in Fig. 2, based on climatic parameters. For text about species, see C37.

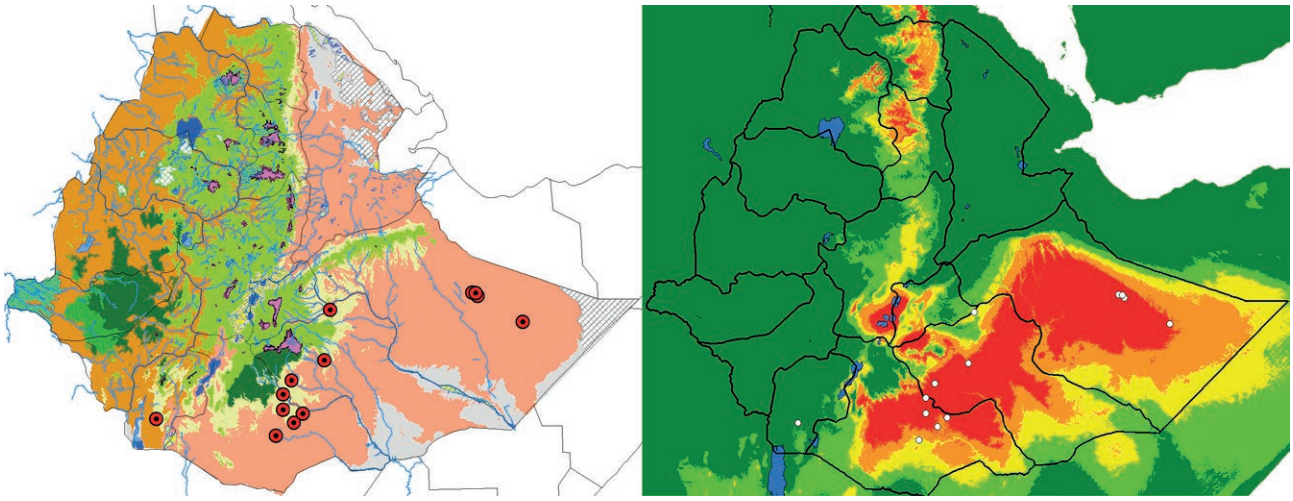

Figure 46. *Commiphora boranensis* Vollesen in Ethiopia. Left hand map showing distribution of observed records on the vegetation types in Fig. 1B; right hand map showing modelled suitability of potential distribution areas of the species as defined in Fig. 2, based on climatic parameters. For text about species, see C38.

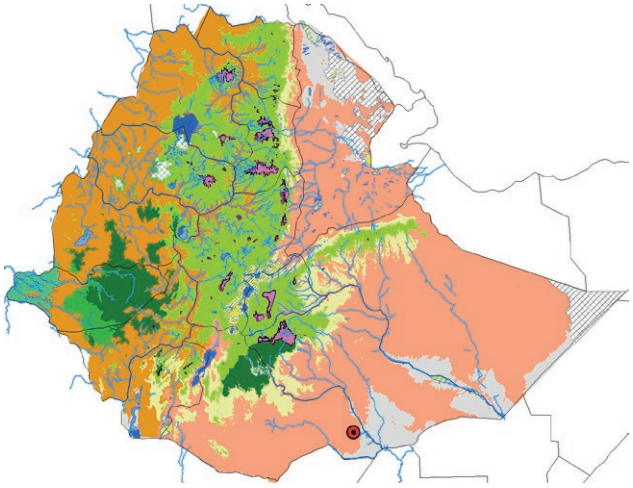

Figure 47. *Commiphora* sp. [= *Gilbert et al. 7652*] Map showing distribution of observed records on the vegetation types in Fig. 1B. Modelling is not possible on only one occurrence point. For text about species, see C39.

C40. ***Commiphora gileadensis*** (L.) C.Chr., Dansk. Bot. Ark. 4(3): 18. 1922.

(=) *C. albiflora* Engl., Bot. Jahrb. Syst. 34: 310. 1904.

(=) *C. velutina* Chiov., Res. Sci. Somalia Ital. 1: 47. 1916.

(=) *C. ancistrophora* Chiov., Fl. Somala 2: 111. 1932.

(=) *C. coronillifolia* Chiov., Fl. Somala 2: 101. 1932.

Nineteen occurrence points studied, which we consider sufficient for reliable modelling. The records studied are scattered in southern and eastern Ethiopia, including the southern part of Afar region, where one northernmost record is outside the predicted area. Collections have been made from *Acacia-Commiphora* bushland proper, but some are from near semi-desert scrubland close to the lower reaches of the Genale and Webe Shebele rivers (Fig. 48).

The modelled omission rates of *C. gileadensis* agree with the expected values, suggesting that the model may perform as intended. The highest contribution to the model is provided by Bio4 (temperature seasonality).

In Ethiopia, the species has been reported to grow in *Acacia-Commiphora* bushland on red to grey sandy soil overlying limestone and basement rocks, on rocky limestone ridges, in semi-desert bushland, often on rocky hills, and on old lava flows (Vollesen 1989). In Tropical East Africa (Kenya), it has been found growing in *Acacia-Commiphora* bushland on limestone hills (Gillett 1991). In Somalia, it grows in *Acacia-Commiphora* bushland and semi-desert scrub (Thulin 1999).

The species is widespread in eastern Sudan (Darbyshire et al. 2015), Eritrea, Ethiopia, Djibouti, Somalia, northeastern Kenya; also in Egypt and Arabia. Not redlisted by IUCN.

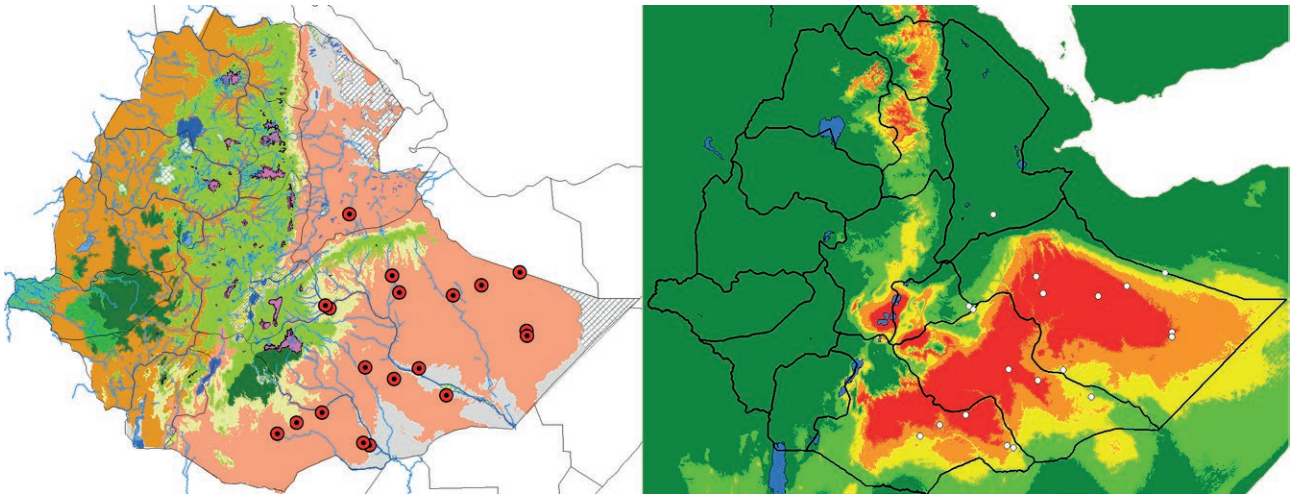

Figure 48. *Commiphora gileadensis* (L.) C. Chr. in Ethiopia. Left hand map showing distribution of observed records on the vegetation types in Fig. 1B; right hand map showing modelled suitability of potential distribution areas of the species as defined in Fig. 2, based on climatic parameters. For text about species, see C40.

C41. ***Commiphora chiovendana*** J.B.Gillett ex Thulin, Nordic J. Bot. 20: 405. 2000 [2001].

(=) *C. sp.* [= *Glover & Gilliland 973*].

One occurrence point studied, and hence the species is not modelled. The collection was made in semi-desert scrub (Fig. 49).

The species has been reported to grow in *Acacia-Commiphora* bushland on red sandy soil overlying limestone (Vollesen 1989). In Somalia, it has been reported from the northern and central parts, growing in *Acacia-Commiphora* bushland on red sandy or silty soil overlying limestone, occasionally gypseous (Thulin 1999).

Restricted to Ethiopia and Somalia. The extinction risk of the species is considered Least Concern by Jama F. 2024. *Commiphora chiovendana*. The IUCN Red List of Threatened Species 2024: e.T215410234A219277318. https://doi.org/10.2305/IUCN.UK.2024-2.RLTS.T215410234A219277318.en. The trend in the population size is unknown; the species is only marginally present in Ethiopia but occurs as fairly widespread in the northern and central regions of Somalia. The species has an estimated extent of occurrence (EOO) of 242,002 km^2 and an area of occupancy (AOO) of 120 km^2. There is concern due to a decline in area, extent and/or quality of habitat.

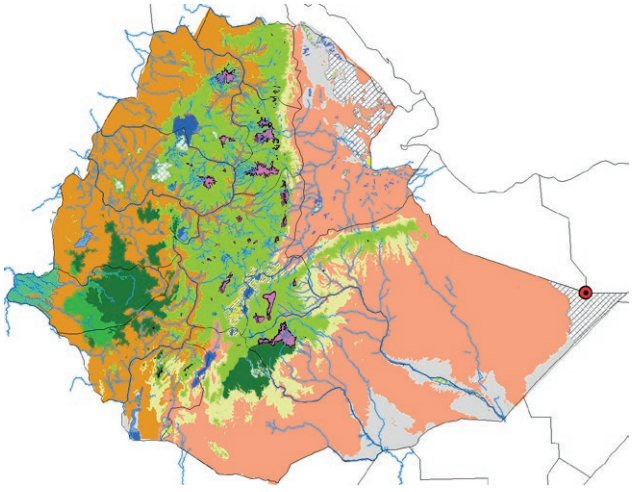

Figure 49. *Commiphora chiovendana* Gillett ex Thulin in Ethiopia. Map showing distribution of observed records on the vegetation types in Fig. 1B. Modelling is not possible based on only one occurrence point. For text about species, see C41.

C42. ***Commiphora multifoliolata*** Gillett ex Thulin, Nordic J. Bot. 20: 407. 2000 [in fact 2001].

One occurrence point studied, and hence the species is not modelled. The collection was made in semi-desert scrubland near the lower reach of the Webe Shebele River, and in saline wetlands along the river (Fig. 50).

In Somalia, it has been known from the southern parts adjacent to the Ethiopian record, growing in *Acacia-Commiphora* bushland on limestone (Thulin 1999).

Restricted to eastern Ethiopia and southern Somalia. Not red-listed by IUCN, but a conservation assessment made on all available material would be desirable.

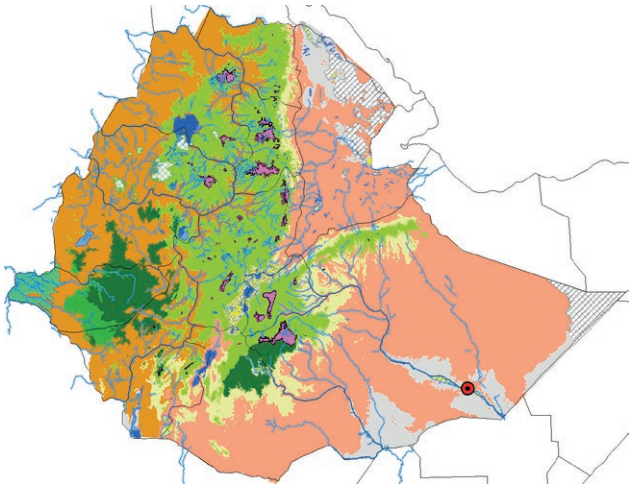

Figure 50. *Commiphora multifoliolata* Gillett ex Thulin in Ethiopia. Map showing distribution of observed records on the vegetation types in Fig. 1B. Modelling is not possible based on only one occurrence point. For text about species, see C42.

THE SPECIES OF BURSERACEAE IN ETHIOPIAN VEGETATION TYPES

The association of Ethiopian Burseraceae species with the vegetation types accepted by Friis et al. (2010, 2022) has been listed in Table 1, based on our interpretation of the left-hand maps in the Figs. 1–50. The recorded observations on the maps in this work are shown as red bird-eye dots. In Table 1, transgressing species are indicated in sharp brackets.

As documented in this account, both in our new observations in this work and in observations recorded in the Flora of Ethiopia [and Eritrea] (Vollesen 1989) in its precursor with taxonomic novelties (Vollesen 1985), Flora of Tropical East Africa (Gillett (1991), and Flora of Somalia (Thulin 1999), it is almost consistently stated that all the Ethiopian species of *Commiphora* occur in *Acacia-Commiphora* bushland and woodland (or, when the taxonomic splitting of *Acacia* is applied in the description of vegetation types, referred to as *Senegalia-Vachellia-Commiphora* woodland or bushland). Here, we confirm that the species are very often associated with limestone rocks, limestone with gypsum, and red or grey sand overlying limestone or gypsum. Occasionally, a few species of Burseraceae may also grow in *Acacia-Commiphora* bushland and woodland on sand over basement or granite rocks (*Boswellia neglecta*, *Commiphora edulis* subsp. *boiviniana*, *C. samharensis*, *C. schimperi*, *C. confusa*, *C. kataf*, *C. habessinica*, *C. kua*, and *C. gileadensis*).

Only *Commiphora staphyleifolia*, *C. unilobata*, and *C. erosa* have been reported to grow on alluvial soil, but again, these are probably derived from limestone or gypsum. A number of species that grow in *Acacia-Commiphora* bushland and woodland penetrate into transitional semi-evergreen bushland at their upper distributional limits (see Table 1).

Some widespread species (*Boswellia neglecta*, *Commiphora edulis* subsp. *boiviniana*, *C. samharensis*, *C. schimperi*, *C. africana*, *C. confusa*, *C. kataf*, *C. habessinica*, *C. kua*, and *C. boranensis*) grow in *Acacia-Commiphora* bushland and woodland, but frequently or often penetrate into *Combretum-Terminalia* woodland. Only *Boswellia papyrifera*, *B. pirottae*, and *Commiphora pedunculata* have their main distribution in *Combretum-Terminalia* woodland. A hardy group of species occur in semi-desert scrubland, desert, and in saline wetlands (see Table 1).

POTENTIAL DISTRIBUTIONS OF THE ETHIOPIAN BURSERACEAE BASED ON CLIMATIC PARAMETERS AND OBSERVED DISTRIBUTION

In Table 2 there is a survey based on our interpretation of the right-hand maps in the Figs. 3–9, 11–41, and 43–48. In these maps the observed distributions, shown as white dots, have been superimposed on the modelled suitability based on climatic parameters, as described in Materials and Methods.

Names of species that according to our estimate partly fill the area of highest predicted suitability on climatic parameters in some part of the predicted area, but not in the whole area, are indicated in sharp brackets. In Table 3 we have listed the species that according to climatic parameters are predicted to occur in northern Ethiopia. Among the species with high probability of occurring in northern Ethiopia, particularly along the eastern escarpment of the highlands, we have separately listed those that that have been and those that have not been recorded from there. We can offer no explanation for these patterns; some may erroneously have been predicted to occur in northern Ethiopia because of insufficient data, others may be restricted from northern Ethiopia due to unobserved environmental factors or for historical reasons.

The modelled patterns vary, particularly if the number of observed locations is lower than 12–13. For the following species we find a characteristic modelled pattern which is similar for a number of fairly widespread species listed here (Table 2): *Boswellia neglecta*, *B. microphylla*, *Commiphora myrrha*, *C. samharensis*, *C. hildebrandtii*, *C. corrugata*, *C. kataf*, *C. serrulata*, [*C. gurreh*], *C. kua*, *C. boranensis*, and *C. gileadensis*. The predicted pattern consists of a large area in HA and smaller, but

Table 1. Species that are recorded from the potential vegetation types proposed by Friis et al. (2010) and Friis et al. (2022) and recognized in this paper. Species marginally transgressing species into vegetation types without being widely distributed in these vegetation types are indicated in sharp brackets. B: *Boswellia*, C: *Commiphora*.

Potential vegetation type	Species in potential vegetation types and marginally transgressing into vegetation types without being widely distributed there [indicated in sharp brackets]. B. stands for *Boswellia*; C. for *Commiphora*	Number of species
Acacia wooded grassland of the Rift Valley	*C. schimperi*; [*C. gurreh*]	One species of *Commiphora* as widespread in the vegetation type; one species of *Commiphora* as marginal intruder
Acacia-Commiphora woodland and bushland proper	*B. papyrifera*; *B. rivae*; *B. neglecta*; *B. microphylla*; *B. neglecta*; *B. microphylla*; [*C. erlangeriana*]; [*C. paolii*]; *C. edulis* subsp. *boiviniana*; *C. sphaerophylla*; *C. myrrha*; *C. samharensis*; *C. schimperi*; *C. obovata*; *C. africana*; *C. hildebrandtii*; *C. ogadensis*; *C. corrugata*; *C. truncata*; *C. confusa*; *C. kataf*; *C. rostrata*; *C. ciliata*; [*C. sphaerocarpa*]; [*C. mildbraedii*]; *C. cyclophylla*; *C. campestris*; *C. serrulata*; *C. gurreh*; *C. quadricincta*; *C. hodai*; *C. habessinica*; *C. sp. = Corradi 6767, 6768*; *C.* kua; *C. oddurensis*; *C. horrida*; *C. boranensis*; *C. sp. = Gilbert et al. 7652*; *C. gileadensis*	Seven species of *Boswellia* and thirty-one species of *Commiphora* as widespread in the vegetation type; four species of *Commiphora* as marginal intruders
Combretum-Terminalia woodland and wooded grassland	*B. papyrifera*; *B. pirottae*; [*B. neglecta*]; *C. edulis* subsp. *boiviniana*; *C. schimperi*; *C. africana; C. pedunculata*; [*C. confusa*]; [*C. cyclophylla*]; *C. habessinica; C. kua*; *C. boranensis*	Two species of *Boswellia* and seven species of *Commiphora* as widespread in the vegetation type; one species of *Boswellia* and two species of *Commiphora* as marginal intruders
Desert	[*B. rivae*]; *B. ogadensis*; *C. quadricincta*; *C. horrida*; *C. chiovendana*	One species of *Boswellia*, and three species of *Commiphora* as widespread in the vegetation type; one species of *Boswellia* as marginal intruder
Saline wetland	[*B. rivae*]; *B. ogadensis*; [*B. microphylla*]	One species of *Commiphora* as widespread in the vegetation type; two species of *Commiphora* as marginal intruders
Semi-desert scrubland	[*B. rivae*]; *B. ogadensis*; [*B. microphylla*]; [*B. microphylla*]; *C. erlangeriana*; *C. staphyleifolia*; *C. unilobata*; *C. guidottii*; [*C. paolii*]; *C. myrrha;* [*C. samharensis*]; *C. africana*; [*C. truncata*]; [*C. confusa*]; *C. kataf*; *C. erosa*; *C. sphaerocarpa*; [*C. mildbraedii*]; [*C. serrulata*]; [*C. gurreh*]; *C. hodai*; *C. habessinica*; *C. kua*; *C. oddurensis*; [*C. sp. = Gilbert et al. 7652*]; [*C. gileadensis*]; *C. multifoliolata*	Fifteen species of *Commiphora* as widespread in the vegetation type; ten species of *Commiphora* as marginal intruders
Transitional semi-evergreen bushland	[*B. rivae*]; [*B. neglecta*]; [*B. microphylla*]; [*B. neglecta*]; [*B. microphylla*]; [*C. guidottii*]; [*C. edulis* subsp. *boiviniana*]; [*C. sphaerophylla*]; [*C. myrrha*]; [*C. samharensis*]; [*C. obovata]*; [*C. africana*]; *C. monoica*; *C. ogadensis*; [*C. corrugata*]; [*C. confusa*]; *C. alaticaulis*; [*C. kataf*]; [*C. rostrata*]; [*C. ciliata*]; [*C. mildbraedii*]; [*C. cyclophylla*]; [*C. serrulata*]; [*C. gurreh*]; *C. habessinica*; *C. kua*; [*C. oddurensis*]; [*C. boranensis*]	Four species of *Commiphora* as widespread in the vegetation type; five species of *Boswellia* and nineteen species of *Commiphora* as marginal intruders

usually coherent areas in BA and SD, reaching as far as or into GG. Just to describe the outline of this pattern, it might be tempting to compare it with the outline of a large quadruped waking on its hind legs, with small forelimbs and a large head. This may agree with a particular pattern of climatic parameters suitable for *Commiphora*. The predicted pattern of *C. gurreh* does not agree as well to this outline as the other species in the list. A similar pattern with less clearly defined outlines is suggested by the model for all species shown in Fig. 2.

We cannot satisfactorily suggest why the observed distribution of some species do not fill the modelled distribution based on climatic parameters. It can be due to insufficient collecting activity or due to lack of observed environmental factors that limit the distribution of the species, but have not been incorporated into our models.

Table 2. Species of Burseraceae filling, partially filling and far from filling their modelled area of distribution; species with a modelled distribution that forms a repeated pattern with a large area in HA and connected but more restricted areas in BA and SD, stretching to GG. B: *Boswellia*; C: *Commiphora*.

Species which approximately fill the area of highest suitability predicted on climatic parameters	*B. papyrifera*; *B. pirottae*; *B. rivae*; [*B. ogadensis*]; *B. neglecta*; *B. microphylla*; *C. edulis* subsp. *boiviniana*; [*C. africana*]; [*C. pedunculata*]; [*C. confusa]*; *C. serrulata*; *C. habessinica*	Five species of *Boswellia* approximately filling the area of highest suitability predicted on climatic parameters; one species of *Boswellia* filling the area of highest suitability predicted on climatic parameters well in part. Two species of *Commiphora* approximately filling the area of highest suitability predicted on climatic parameters; three species of *Commiphora* filling the area of highest suitability predicted on climatic parameters well in part.
Species which far from fill the area predicted on climatic parameters	*C. erlangeriana*; *C. unilobata*; *C. guidottii*; *C. paolii*; *C. sphaerophylla*; *C. myrrha*; *C. samharensis*; *C. schimperi*; *C. obovata*; *C. monoica*; *C. hildebrandtii*; *C. corrugata*; *C. truncata*; *C. alaticaulis*; *C. kataf*; *C. rostrata*; *C. ciliata*; *C. sphaerocarpa*; *C. mildbraedii*; *C. cyclophylla*; *C. campestris*; *C. gurreh*; *C. quadricincta*; *C. hodai*; *C. kua*; *C. oddurensis*; *C. horrida*; *C. boranensis*; *C. gileadensis*	Twenty-nine species of *Commiphora* far from filling the area predicted on climatic parameters.
Species with a modelled distribution that forms a characteristic repeated pattern in several species (with a large area in HA and connected but more restricted areas in BA and SD, stretching to GG; some of these species have predicted area in northern Ethiopia)	*B. neglecta*; *B. microphylla*; *C. myrrha*; *C. samharensis*; *C. hildebrandtii*; *C. corrugata*; *C. kataf*; *C. serrulata*; [*C. gurreh*]; *C. kua*; *C. boranensis*; *C. gileadensis*	Two species of *Boswellia* and ten species of *Commiphora* with similar and repeated predicted distribution patterns; one species of *Commiphora* not quite typical.

Table 3. Species of *Commiphora* with main distribution in southeastern distribution in Ethiopia but predicted also to occur in northern Ethiopia. The species that actually occur in northern Ethiopia and those that do not occur there are listed separately.

Species predicted on climatic parameters to occur in northern Ethiopia and do occur there	*C. schimperi*; *C. africana*; *C. habessinica*; *C. kua*	Four species of *Commiphora* predicted on climatic parameters to occur in northern Ethiopia and do occur there
Species predicted on climatic parameters to occur in northern Ethiopia but do not	*C. samharensis*; *C. obovata*; *C. monoica*; *C. pedunculata*; *C. hildebrandtii*; *C. ogadensis*; *C. corrugata*; *C. confusa*; *C. alaticaulis*; *C. kataf*; *C. rostrata*; *C. ciliata*; *C. campestris*; *C. serrulata*; *C. gurreh*; *C. oddurensis*; *C. boranensis*	Sixteen species of *Commiphora* predicted on climatic parameters to occur in northern Ethiopia and do not occur there

RICHNESS AND DIVERSITY OF THE ETHIOPIAN BURSERACEAE IN RELATION TO DENSITY OF OBSERVATIONS

In the Figs. 51–54, we have on a grid of one-degree squares summarized the total number of observed occurrence points (Fig. 51), the observed species richness indicated simply as the number of species in each square (Fig. 52), the observed species richness per square estimated with Jackknife resampling (Fig. 53), and Shanon-Wiener diversity per square calculated from the data in this work (Fig. 54).

The estimated richness with Jackknife resampling suggests a slightly more even representation of richness than simple richness recorded as number of species, suggesting that some squares are undercollected if we assume that equal environmental parameters in adjacent squares would produce equal number of recorded species. The method also suggests a slightly lower score for the well-collected squares, such as the one that includes

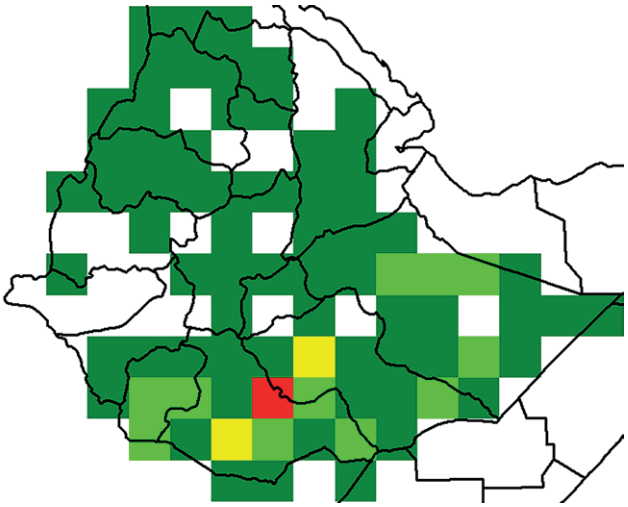

Figure 51. Number of occurrence points studied for this work (= number of locations of identified species of Ethiopian Burseraceae) on one-degree squares. Dark green: 1–20. Pale green: 21–40. Yellow: 41–60. Orange: 61–80. Red: 81–100.

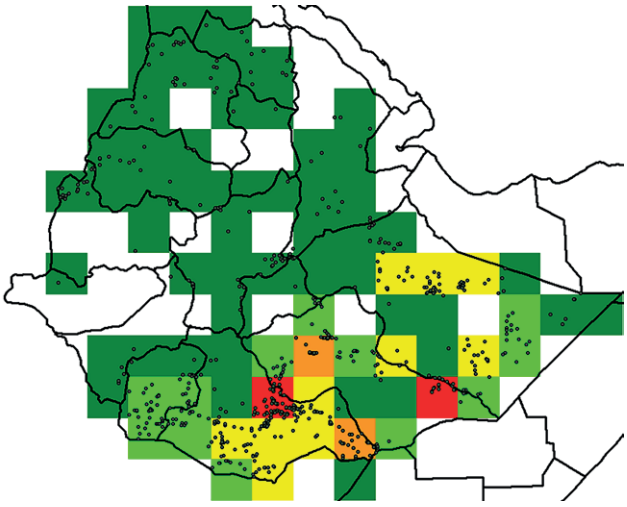

Figure 52. Observed species richness for the species of Burseraceae (richness = number of species per one-degree square), shown on one-degree squares and calculated from the data in this work. Dark green: 1–5. Pale green: 6–10. Yellow: 11–15. Orange: 16–20. Red: 21–25. The dark dots are the occurrence points.

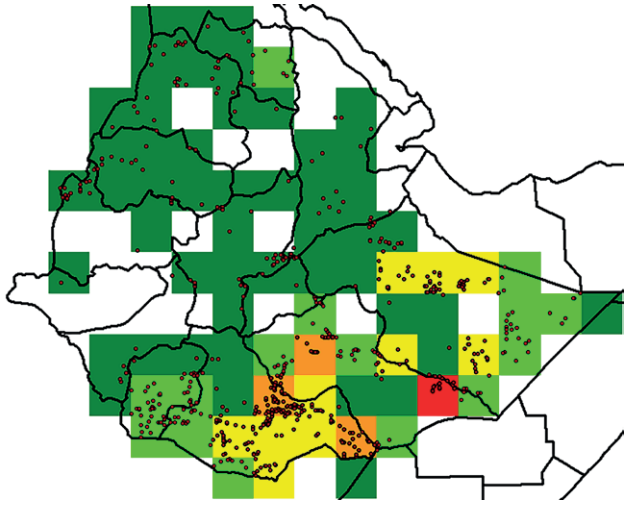

Figure 53. Expected species richness estimated with Jackknife resampling of the number of Burseraceae species per one-degree square and shown on one-degree squares. Dark green: 1–8. Pale green: 9–16. Yellow: 17–24. Orange: 25–32. Red: 33–40. The dark dots are the occurrence points.

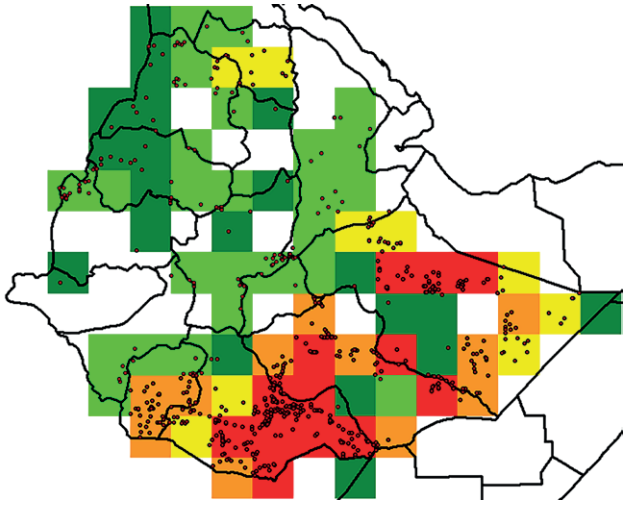

Figure 54. Shanon-Wiener diversity of the Burseraceae species per one-degree square and shown on one-degree squares. Dark green: 0.1–0.57. Pale green: 0.58–1.14. Yellow: 1.15–1.71. Orange: 1.72–2.28- Red: 2.29–3.00. The dark dots are the occurrence points.

the town of Negele, a square that is particularly well-collected.

Similarly, the calculated Shanon-Wiener diversity suggests a more evenly representation of species in the southeastern lowlands than richness simply recorded as number of species, and that the differences between the squares with regard to richness in that part of Ethiopia may be due to collecting intensity.

The collecting intensity is clearly highest around the town of Negele, lower, but still fairly high around the smaller towns of Dolo and Bogol Mayo, all three in SD; lower still to the west of Imi in BA, along the lower reach of the Webe Shebele River on the border between BA and HA, and in areas around Dire Dawa and Harar in HA, but even here higher than in the most poorly collected squares.

REVIEW OF RED-LISTED BURSERACEAE IN ETHIOPIA

In Table 4 we have summarised the general assessments made up to now and as published in the IUCN Red List of Threatened Species (https://www.iucnredlist.org/). Two species have been assessed as critically endangered, seven species as near threatened, six species as vulnerable, sixteen species as least concern, while the status of fifteen species is still unsettled.

CONCLUSIONS

The family of Burseraceae in Ethiopia includes six species of *Boswellia* and forty-two species of *Commiphora*, all either associated with deciduous woodlands and bushlands in the western lowlands of Ethiopia (*Combretum-Terminalia* woodland), the eastern lowlands (*Acacia-Commiphora* woodland and bushland and semi-desert scrub), or in the woodlands in the deep river valleys in the highlands, all vegetation types of which they form important elements. Our studies confirm that two species of *Boswellia* and one species of *Commiphora* are found in the western lowlands. Four species of *Boswellia* and forty-one species of *Commiphora* are found in the *Acacia-Commiphora* woodland and bushland and in the semi-desert scrub to the south and southeast of the highlands, mainly in the lowlands of the GG, SD, BA, and HA floristic regions according to the regions used in the Flora of Ethiopia and Eritrea, with few species in the Afar lowlands (AF). The Omo Valley forms a fuzzy border between the western and eastern groups of species. While the species of *Commiphora* are closely associated with *Acacia-Commiphora* woodland and bushland and limestone rocks or sand derived from limestone, the more detailed ecological preferences are still not clear.

To the east of the highlands and in the deep river valleys in the highlands running eastwards, fifteen species are widespread and fill their modelled climatic envelope, while sixteen have limited distributions, not filling their modelled climatic envelope (but this is also because they are represented by few collections). The latter species may be restricted to specific geological formations or be significantly undercollected, but much more collecting activity and further field studies are necessary to establish what is the reasons behind these limitations. The most narrowly distributed species are found along the southern part of the border between BA and HA, demarcated by the lower Genale and the lower Webe Shebele rivers before they enter Somalia.

The remaining seventeen species, distributed to the southeast of the highlands, have moderately wide distributions with varying climatic conditions, but do not fill their potential climatic envelope. Their ecological preferences are not yet adequately known.

Comparisons have been made of the number of observations and the richness and diversity of the species in one-degree squares. The comparisons suggest striking similarity between number of observations and richness, as well as differences between adjacent areas in which patterns of topography and climate would seem similar. Squares which are easily accessible to the travelling of plant collectors, before or now, have both higher number of observations and higher diversity than the less accessible adjacent squares. The latter must therefore be assumed to be poorly collected, particularly in the SE lowlands. Both the species that do not fill their climatic envelope and the species with irregular pattern of collecting activity make it difficult to distinguish between rare, narrow endemics and poorly collected species.

The number of independent observations (= occurrence points) of the directly observed species richness of all Ethiopian Burseraceae on one-degree squares, the species richness of *Commiphora* species on one-degree squares estimated with Jackknife, and the Shanon-Wiener diversity of *Commiphora* on one-degree squares all

Table 4. Assessment of conservation status of Ethiopian Burseraceae species in the IUCN classification units used in the IUCN Red List of Threatened Species (https://www.iucnredlist.org/). B: *Boswellia*; C: *Commiphora*. Unnamed species (only identified by reference to one or a few collections) are not listed.

Not yet red-listed	*C. paolii*; *C. myrrha*; *C. samharensis*; *C. rostrata*; *C. erosa*; *C. serrulata*; *C. gurreh*; *C. quadricincta*; *C. habessinica*; *C. kua*; *C. horrida*; *C. gileadensis*; *C. multifoliolata*	Thirteen species
Least concern	*B. rivae*; *B. neglecta*; *B. microphylla*; *C. edulis* subsp. *boiviniana*; *C. schimperi*; *C. africana*; *C. pedunculata*; *C. hildebrandtii*; *C. confusa*; *C. kataf*; *C. sphaerocarpa*; *C. mildbraedii*; *C. campestris*; *C. oddurensis*; *C. boranensis*; *C. chiovendana*	Sixteen species
Vulnerable	*B. papyrifera*; *B. pirottae*; *C. erlangeriana*; *C. guidottii*; *C. alaticaulis*; *C. cyclophylla*	Six species
Near threatened	*C. unilobata*; *C. sphaerophylla*; *C. obovata*; *C. corrugata*; *C. truncata*; *C. ciliata*; *C. hodai*	Seven species
Critically endangered	*B. ogadensis*; *C. monoica*	Two species
Data deficient	*C. staphyleifolia*; *C. ogadensis*	Two species

point to the highest values for approximately the same squares. The authors cannot give fully adequate reasons for this. The well collected squares group together with those with high species richness and diversity, and these, on one hand, cannot yet easily be fitted into a pattern with the poorly collected squares. It is to be hoped that much more even collecting activity will point to a clearer pattern of distribution in southeastern Ethiopia with regard to Burseraceae-species.

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AUTHORS' CONTRIBUTIONS

Both authors have gathered data in form of herbarium specimens, but during the later years mostly Sebsebe Demissew, who is responsible for the identity of the specimens after ca. 2020. For this work, Ib Friis has done most of the georeferencing and mapping of the species, and he has drawn the phytogeographical conclusions and produced the first draft of the manuscript. Both authors have worked on and approved the final and published version of the manuscript.

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